THE ORIGINS OF THE CIVILIZATION OF ANGKOR

VOLUME TWO

THE EXCAVATION OF NOEN U-LOKE AND NON MUANG KAO



The Fine Arts Department, Thailand

THE ORIGINS OF THE CIVILIZATION OF ANGKOR

VOLUME II

THE EXCAVATION OF NOEN U-LOKE AND NON MUANG KAO

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FOREWORD

In 1992, a major research project was initiated in the Amphoe Non Sung, Changwat Nakhon Ratchasima, entitled "The Origins of the Civilization of Angkor". It was conceived by Professor Charles Higham of the University of Otago, New Zealand, and Dr Rachanie Thosarat, of the Thai Fine Arts Department. The Fine Arts Department has been pleased to be associated with this research project and to be able to publish this, the second report of a series which promises to contribute a great deal to our understanding of Thai prehistory.

While it might be argued that the upper Mun Valley is relatively remote from the centre at Angkor, two important facts must be stressed. The first is that the Mun Valley, and particularly the area of Phimai, ancient Vimayapura, gave to the kingdom of Angkor its greatest kings in Suryavarman II and Jayavarman VII. These rulers belonged to the Mun Valley dynasty of Mahidharapura. At all times, the Mun Valley was a focus of major cultural developments leading to the early states of Angkor, as seen in the rich prehistoric cultures of the area, the early brick temples of Phimai, Phanom Rung and Phanom Wan, and the number of Chenla period monuments and inscriptions.

It is also noted that in the early 1990s, when this project was being formulated, it was impossible to envisage extensive archaeological fieldwork in Cambodia. The adjacent parts of Northeast Thailand, however, afforded a splendid opportunity to pursue this important topic.

Noen U-Loke and Non Muang Kao were the second and third of four major excavations undertaken as part of this project, the others being at Ban Lum Khao and Ban Non Wat. They both provide evidence for Iron Age occupation of the upper Mun Valley. Noen U-Loke was occupied for at least eight centuries, and is the longest and most detailed recorded Iron Age site in Thailand. The excavation of Non Muang Kao was on a much smaller scale, but has yielded important information on the nature of domestic structures and their relationships with inhumation burials. Full archaeological reports for sites such as Noen U-Loke are rare in Southeast Asia. I am happy to take this opportunity of welcoming this volume as an important addition to the literature on Thailand's rich cultural heritage. Professor Higham and Dr Thosarat, together with their colleagues, are thanked for their tireless efforts to analyse and bring to our attention the finds from these important prehistoric settlements, which through this volume, will take their place alongside Ban Na Di, Ban Lum Khao, Khok Phanom Di and Nong Nor as excavated sites in Thailand that have been brought to full publication.



Arak Sunghitakul
Director General
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PREFACE

This is the second volume reporting on our research project entitled "The Origins of the Civilization of Angkor". In 1992, when one of us (R.T.) was appointed to the Phimai office of the Fine Arts Department, we resolved to consider the enigma presented by the many large, moated and banked settlements that are so prolific in the upper Mun Valley. Our initial model saw these sites as dating to the Iron Age, and as such, the immediate precursors to the early states of this area. Our first concern was that the prehistory of this area had been the subject of a lengthy period of research by David Welch and Judith McNeill, and we did not wish to venture into the area where they had been active. With their goodwill, we therefore selected an area immediately to the west of theirs, and began several seasons of site surveys. The moated sites are densely distributed, and we mapped many. In 1995, we decided to begin our excavations at the site of Ban Lum Khao which is, paradoxically, one of the unmoated settlement so far examined. Our choice reflected the clear field evidence for a Bronze Age cemetery, a period we felt it necessary to consider as the precursor to any cultural changes noted in the ensuing Iron Age. Subsequently, we have excavated at Prasat Phimai and he moated sites of Non Muang Kao, Noen U-Loke and Ban Non Wat.

The purpose of this volume, is to report the results of our two seasons at Noen U-Loke, and the single season of research at Non Muang Kao. It is a step towards the realisation of our goal, to illuminate the prehistoric societies of the upper Mun Valley during the two millennia of cultural changes that led ultimately to the swift transition to the state as represented at Phimai and beyond, to the civilization of Angkor itself. Future volumes will consider the much larger excavation of Ban Non Wat, at which point, we plan to synthesise all our findings made during 12 years of excavations. We are most grateful, therefore, to our colleagues for contributing their current findings in this part of our report series.

Our research at Noen U-Loke proceeded with a permit issued by the National Research Council of Thailand, for which we are indebted. The backing of the Thai Fine Arts Department was also a vital prerequisite to our research. We are most grateful to all our colleagues who worked with us in the field, and who have contributed to this report. Without the good will of the villagers of Ban Nong Na, we could not have worked in their community, and we thank them for their welcome and cooperation. I (C.H.) formatted this publication using the Indesign II program.

The Fine Arts Department of Thailand has been most supportive of this research programme, and we are most grateful to Khun Arak Sanghitakul, the Director-General, for authorising the publication of this volume.

This research was funded by the Marsden Fund of the Government of New Zealand, and in part by the generous support of the Earthwatch Institute.

PART ONE. THE PALAEOENVIRONMENT

I. GEOARCHAEOLOGICAL LANDSCAPE MODEL OF THE IRON AGE SETTLEMENTS OF THE UPPER MUN RIVER FLOODPLAIN

W.E. BOYD AND J. HABBERFIELD-SHORT

This chapter describes the evidence for, and implications of, the surficial geology in the area of Noen U-Loke and Non Muang Kao, providing a palaeogeographical model for the evolution of the landscape in the study area especially during the Holocene. This allows the archaeological sites and their settlement history to be put into an environmental context of changing climatic conditions and the impacts of these changes on the physical and hydrological conditions affecting the sites and the natural resources to which prehistoric people had access. The palaeogeographic model comprises six phases, the key phases for prehistoric human settlement at Noen U-Loke and neighbouring sites being Phases 4 and 5.

- Phase 1: The Mesozoic to Tertiary establishment of the region's landforms.
- Phase 2: The Pleistocene period of aridity and erosion, and the formation of the basis of the prehistoric landscape.
- Phase 3: The Late Pleistocene to early Holocene development of the floodplain under increasingly humid conditions, and the establishment of environmental conditions into which people would move.
- Phase 4: The early to mid-Holocene climatic optimum, providing the conditions for the earliest settlers in the study area.
- Phase 5: The mid-to-late Holocene onset of drier and variable hydrological conditions, and the main period of human settlement; this phase is characterised by three sub-phases.
- Sub-phase A: *c.* 3,500-2,500 BP; deep single-channel rivers; human settlement favoured elevated positions close to rivers.
- Sub-phase B: *c.* 2,500-2,200 BP; multiple narrow and shallow channels, reflecting runoff reduction and the onset of marked seasonal variation; human floodplain settlement and landscape management flourished.
- Sub-phase C: *c.* 2,200-1,500 BP; rivers modified or, later, channels constructed (the "moats"); socio-cultural intensification; period of decline in regional water availability and reliability of supply, linked to the subsequent changes in the settlement pattern in the region.
- Phase 6: The late Holocene onset of the present drainage pattern.

This history of landscape change provides the framework for understanding that the social responses to natural resource availability were specific to particular conditions prevailing at certain times. The establishment of the circum-site channels (the "moats") during the Iron Age, in particular, appears to have been a response to changes in water availability, especially the reliability of that supply. Earlier settlement, on the other hand, had flourished under richer conditions of natural resource availability, which had determined the nature of settlement on the floodplain. Site location, for example, extended back to a previous period of greater hydrological certainty, and would have reflected the access to well-watered environmental conditions on the floodplain from well before the Iron Age. This account supports a model of eventual site abandonment related to the increasingly difficult management of declining water supply to the sites. The palaeogeographical model, therefore, provides an account of human responses to natural resource availability that focuses now as much on optimal conditions as, importantly, on the effects of environmental changes, and thus stress on natural resource availability, as stimuli for social change and innovation.

INTRODUCTION

The aim of this account is to understand the relationships of the prehistoric mounds of the upper Mun floodplain, and especially the mounded sites of Noen U-Loke and Non Muang Kao, to their local and regional environmental settings. By assessing of the relationship between archaeological and natural sediments, we provide an understanding of the stratigraphic, sedimentary and chronological relationships between the settlement sites and the regional physical landscape. Thus we can define the physical environment into which the prehistoric communities entered, within which they lived, and, which they ultimately abandoned (Boyd *et al.* 1996). This analysis also yields indications of the physical site processes that operated before, during and after site occupation.

To approach these relationships, we have examined individual sediment sequences that represent the range of sedimentary environments on and around the floodplain. The reason for this is that these sedimentary environments contain the evidence for past environmental conditions, which in turn reflect the interactions between natural

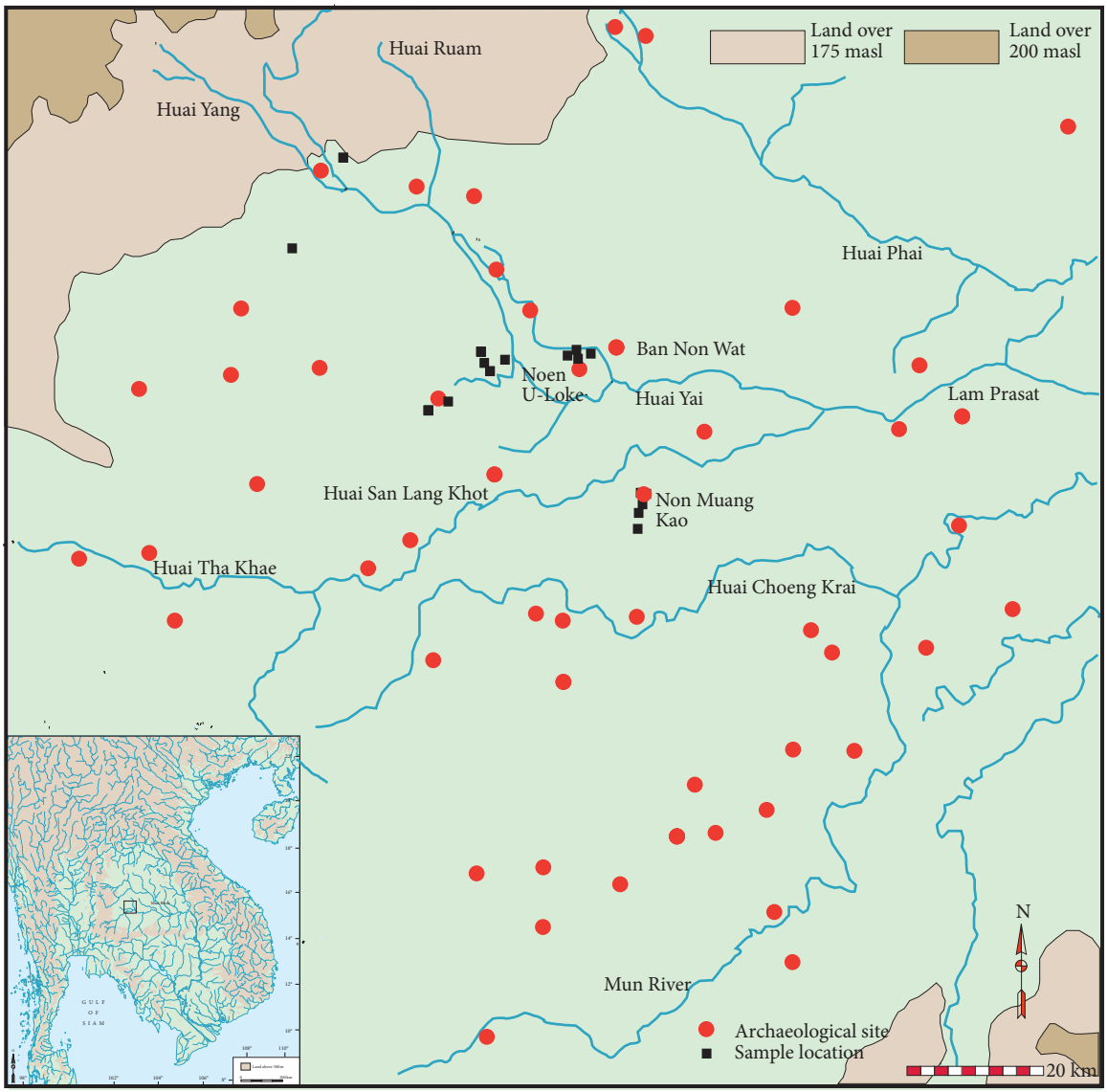


FIG. 1:1 Location map, showing the main sites excavated on the upper Mun River floodplain, including Noen U-Loke and Non Muang Kao, together with other prehistoric sites and the present river drainage of the floodplain

and human processes on the floodplain. The vertical and horizontal relationships between sediments and soils, the contacts between them, and the stratigraphic relationships between a site and its surrounding sediments, all record the temporal and spatial record of deposition, erosion and landscape stability – i.e. the environmental history – before, during and after the occupation of a site (Boggs 1995, Reading 1996, Waters 1996). These sedimentary considerations are important because they allow us to document the likely sources of an archaeological site's matrix, and to place the archaeological site within a regional landscape and natural palaeo-resource context. This chapter, therefore, describes the relevant regional geology, and any inferred palaeoenvironmental conditions, the palaeogeographic chronology of the study area, and any archaeological implications derived from our understanding of the palaeogeography.

THE REGIONAL GEOLOGY AND ITS ASSOCIATED PHYSICAL AND CLIMATIC CONDITIONS

The sedimentary composition of archaeological sites is intimately associated with the geology of the immediate region. The geology of the Noen U-Loke area comprises three three main formations – the Mahasarakham Formation of the Mesozoic Khorat Group, weathered Plio-Pleistocene sediments blanketing the bedrock on topographic highs, and Quaternary (mainly Holocene) floodplain sediments (Table 1:1). Underlying the floodplain, and exposed in peneplains on denuded topographic rises, is the undulating weathered Mesozoic Khorat Group red siltstones, sandstones, shales, claystones and mudstones. In the uplands and on topographic rises within the floodplain this is overlain by a Plio-Pleistocene surfi-

TABLE 1:1 *Summary of geological stratigraphy, chronology and associated physical environmental and climatic conditions for the upper Mun River valley. This summary is based on regional studies published by: Boonseneer 1977; Loeffler* et al. *1983; Takaya* et al. *1984; Satarugsa 1987; Chong 1988; Nutalaya* et al. *1989; Udomchoke 1989; McGrath and Boyd 2001*

	Mesozoic	Plio-Pleistocene	Early Holocene 9500-7500 BP	Mid Holocene 7500-3500 BP	Mid-Late Holocene 3500-2000 BP	Late Holocene 3000 BP to present
Geology	Mahasarakham Formation: Red siltstones, claystones, sandstones, shales and mudstones. Weathered beds rich in iron oxide and kaolinite clays	Weathered residual soils, saprolites and weathered rocks, with surface beds of iron oxides and goethitic, limonitic, montmorilanite and kaolinite clays; non-organic polycrystalline sands and gravels; red and yellow loess soils	Old Alluvium: Grey brown loam with small iron oxide pisoliths	Lake and Swamp sediments: 1 m thick grey to pale brown sandy stiff clay with grey organic clay or peat	Aeolian sand: Fine quartz sand sheets	Recent wash and Young Alluvium: Yellow to pale brown clean medium sands, clayey and sandy silts, reddish brown or greyish brown silty or sandy clay, clayey sand, interbedded clay, sand and gravels
Environmental Conditions	? Turbidity current deposits	High runoff associated with the erosion of deep valleys into the Mahasarakham Formation, high bed load riverine conditions	Amelioration of floodplain conditions to lower energy braided rivers	Reduction in runoff and energy conditions, continuation of riverine and alluvial processes	Significant reduction in precipitation, benchmark change in riverine conditions to low flow sinuous channels	Seasonality in rainfall, temperature gradients and floodplain inundation. Low energy sinuous riverine conditions
Climatic Changes	?	? Warmer and more humid than at present, high runoff	? Climatic amelioration. Reduction in precipitation but warm and humid conditions prevail	Warmer and more humid than at present	Onset of drier conditions than at present, including reduced precipitation and aeolian reworking of alluvial deposits	Dry conditions prevail, and continuation of warm conditions

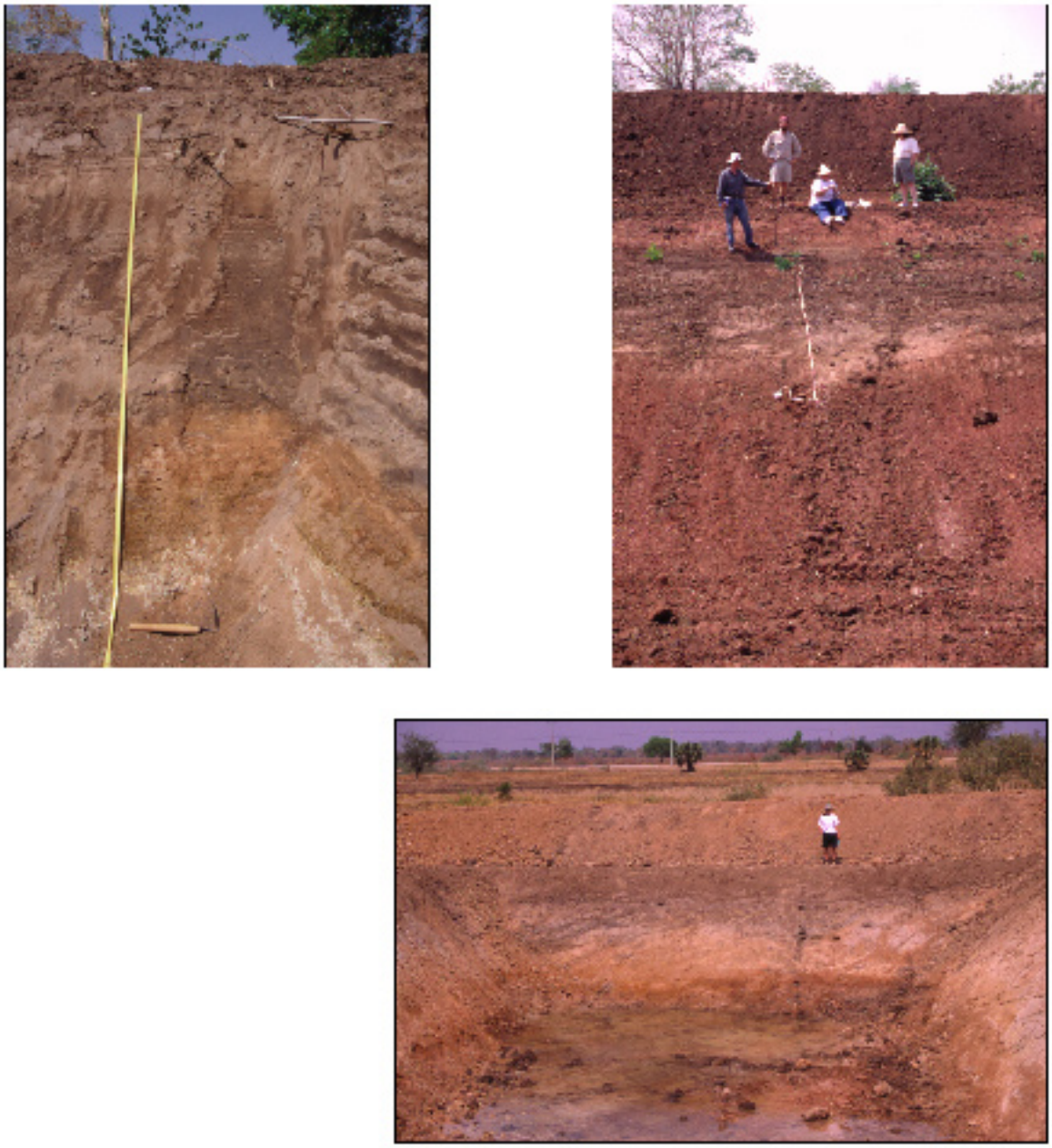


FIG. 1:2 Typical sediment exposures in the area around Noen U-Loke: top left, Location 25; top right, Location 8; bottom, Location 2 (photographs: J. Habberfield-Short)

cial layer of deeply weathered residual soils, saprolites and weathered rocks, with surface beds of bedded iron oxides and goethitic, limonitic, montmorilanite and kaolinite clays (Boonseneer 1977, Takaya *et al.* 1984, Satarugsa 1987, Chong 1988, Udomchoke 1989).

From the perspective of Noen U-Loke and Non Muang Kao, the most significant geology comprises the Holocene surficial sediments. In the region these largely reflect past variability in environmental conditions, in particular climatic conditions, that prevailed since the last glacial maximum. These surficial sediments are shallow, being rarely more than 5m thick, and comprise four main types: alluvium, flood deposits, windblown sand, and lake and swamp sediments (Table 1:1). Of the alluvial sediments, it is possible to distinguish between an older alluvium and more recent alluvium. The alluvium is derived from upland weathered Plio-Pleistocene sequences, and includes extensive spreads of sands, silts and clays deposited in the valleys of the Mun and Chi Rivers and their tributaries. The recent alluvium ("Young Alluvium") forms beds of up to 5m thick on the lowest lying plains (below 190 m above mean sea level) and modern floodplains, and is variously described: yellow to pale brown clean medium sand, sometimes with interbedded clay and gravels, and with a salt crust in places (Boonseneer 1977); clay and clayey and sandy silt (Loeffler *et al.* 1983, Tuckson *et al.* 1983); clay or

sandy loam overlying sand or gravel, both with mottles (Wongsomsak 1987); reddish brown or greyish brown silty or sandy clay, clayey sand (Satarugsa 1987); interbedded clayey sand, sandy clay and silty clay (Udomchoke 1989). There are a few records of "Old Alluvium". In some cases it occurs as both a remnant on elevated bedrock rises and underlies the more recent alluvial deposits. The Old Alluvium may represent an early Holocene phase, and is described as being a 2m-thick deposit of grey to brown loam with small iron oxide pisoliths (2-3mm diameter) (Boonseneer 1977). In terms of dating, Loeffler *et al.* (1983) and Tuckson *et al.* (1983) indicate that the alluvium dates from throughout the period from the end of the last glacial maximum to present; Udomchoke (1989) quotes a radiocarbon age of 1,850±65 years BP. Radiocarbon dating by McGrath and Boyd (2001) suggests an early to late Holocene origin for the Old Alluvium, and an interpolated date of approximately 2,000 years BP for the onset of recent or Young Alluvium sedimentation.

Underlying the Young Alluvium, and lying within the Old Alluvium, are various lake and swamp sediments. These are described (Boonseneer 1977, Chong 1988, Udomchoke 1989) as *c.* 1m-thick grey to pale brown sandy stiff clay with soft grey organic clay at the top, peat or a dark grey organic clay. Whereas Boonseneer (1977) places these late in the sequence, Chong (1988) and Udomchoke (1989) suggest that they were deposited after the middle Holocene; Udomchoke's stratigraphic evidence is supported by four radiocarbon dates (7, 650±120 BP, 6,540±140 BP, 5,490±500 BP and 5,230±130 years BP) implying an early to middle Holocene age. Climatic conditions are inferred to have been warmer and more humid than at present. Udomchoke (1989) concludes, from the evidence of these lake and swamp deposits and the numerous large abandoned river channels in the floodplains, that the larger-than-present ancient rivers were responsible for the formation of the large floodplains of the present rivers.

Lying stratigraphically between the lake and swamp deposits and the Young Alluvium are two units representing very different environmental and depositional conditions. The lower unit is aeolian sand described from north of Khon Kaen (Boonseneer 1977, Chong 1988, Udomchoke 1989), and the upper unit comprises massive poorly-sorted flood deposits on the floodplain of the Mun and Chi Rivers (Satarugsa 1987, Chong 1988, Nutalaya *et al.* 1989, Udomchoke 1989). The former represents drier conditions than at present. Its stratigraphic position and one radiocarbon date from near Khon Kaen (3,490±160 years BP) suggests that the sand dates from 4th millenium BP (Chong 1988, Nutalaya *et al.* 1989, Udomchoke 1989). Local aeolian reworking of alluvium under drier conditions and reduced stream flow is presumed to have provided a source of fine sands for wind erosion and redeposition. There is some discussion regarding the interpretation of the upper unit as evidence of catastrophic flooding (Satarugsa 1987, Chong 1988, Nutalaya *et al.* 1989, Udomchoke 1989). The primary evidence for such flooding are the numerous ancient settlement mounds on the floodplain; they have been identified as massive and poorly-sorted flood deposits, comprising up to 5m of unconsolidated sand, silty fine sand and clays, with interspersed gravels, shells, bones and artefacts. Nutalaya *et al.* (1989) discuss such examples, using three radiocarbon dates (2,270±70, 1,900±100 and 1,850±650 years BP), derived from archaeological excavations at Non Chai, to date the period of flooding from 2300 to 1700 years BP. Non Chai has been demonstrated to consist of the remains of an Iron Age occupation dating from 400 BC to 200 AD (Bayard *et al.* 1986), and it is very likely that the presumed flood deposits are, in fact, ancient settlement deposits, and therefore are unlikely to be the product of flooding.

Removing the putative flood deposits from the sequence places greater focus on the chronology of the aeolian unit, and suggests the possible presence of drier conditions in the middle of the Holocene, stratigraphically between the Old Alluvium and the Young Alluvium. This timing suggests that the prehistoric settlement in the region is intimately related to a dynamic period of both physical environmental and climatic amelioration. The timing also implies that the physical environment of upper Mun River valley was under the effect of climatic change since the time of first human settlement. The wide multi-channel river system that Boyd *et al.* (1999a) associate with the Iron Age may better reflect the earlier and wetter conditions which were probably present when Neolithic or Bronze Age people first settled in the area.

SPATIAL AND STRATIGRAPHIC DISTRIBUTION OF SEDIMENTARY UNITS IN UPPER MUN RIVER VALLEY

The details of the physical setting of Noen U-Loke are based on evidence from sediment sequences both in the archaeological sites and in the surrounding landscape (Fig. 1:1). These comprise three main groups (Table 1:2, p. 21): exposures of natural sediments in river cuttings, quarries, water holes and surface exposures; inter-fingering archaeological and floodplain sediments exposed in trenches at archaeological site margins; and anthropogenic sediments from archaeological sites. Locations represent the range of spatial and stratigraphic sediment distributions within the area of Noen U-Loke and Non Muang Kao, allowing an appreciation of the archaeological sites both within their wider geological and environmental setting, and in terms of the formation history of the sites themselves (Davidson and Shackley 1976, Renfrew 1976, Stein and Farrand 1985, Rapp and Gifford 1986, Lasca and Donohue 1990, Waters 1996, Rapp and Hill 1998).

Archaeological excavation from 1996 to 1998, through the highest part of the mound at Noen U-Loke, exposed 60m of sections over a 220m^2 area to a maximum depth of 5.2m, and at Non Muang Kao, 20m of sections were

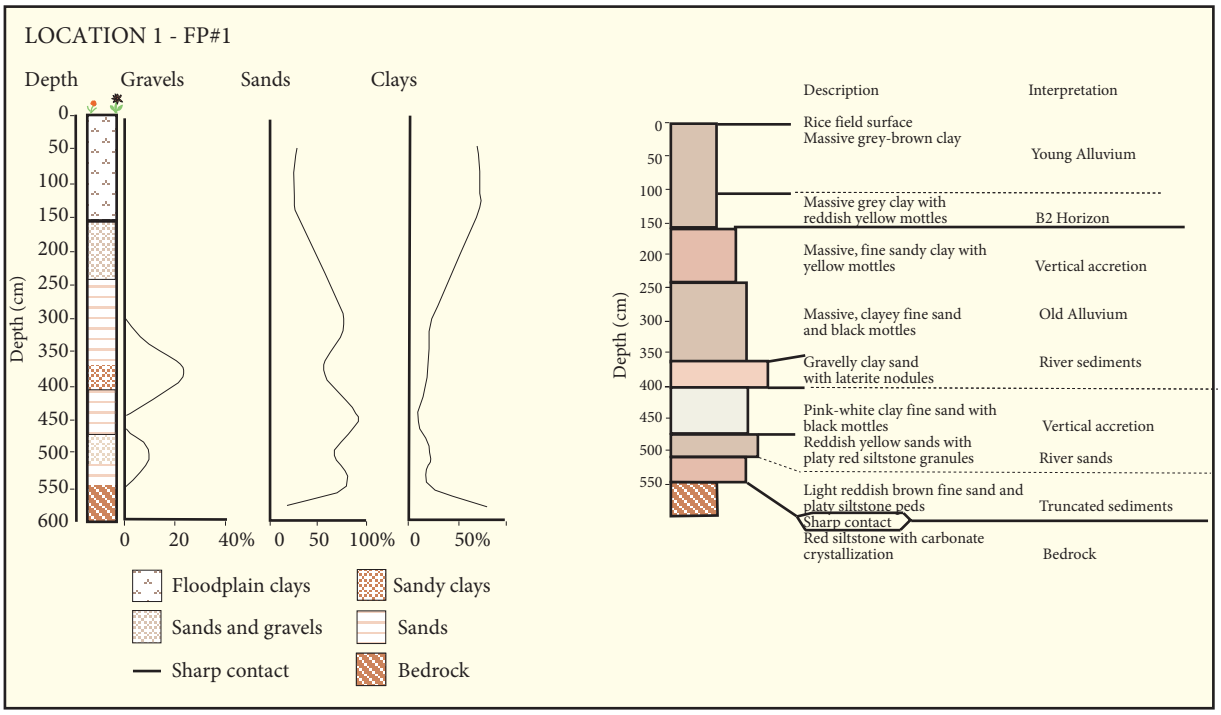


FIG. 1:3 Location 1 sediment stratigraphy and sediment characteristics (FP#1 refers to the field notes; fish pond no. 1)

exposed over a 25m² area to a maximum depth of 3.7m; these exposures allowed detailed examination and mapping of lithology, stratigraphy and morphology of the archaeological sediments. The site of Ban Non Wat was excavated in later field seasons; at the time this account was compiled, a 25x4m area, excavated to a depth of *c.* 4m, had exposed over 230m² of sections. Fieldwork to examine the floodplain and neighbouring sediments recorded sediment exposures available in river banks, reservoir cuttings and quarries (Fig. 1:2). The data collected in this survey will be defined in terms of sedimentary units that, in turn, define region-wide stratigraphic units based on sedimentary sequences or facies (Moore 1949, Teichert 1958, Middleton 1978, Walker 1984, Reading 1996), defined as a "sedimentary environment ... characterised by a particular suite of physical, chemical, and biological parameters that operate to produce a body of sediments characterised by specific textural, structural and compositional properties" (Boggs 1995, 290). In the following site descriptions, the site-specific sedimentary units are abbreviated to "unit/s"; the stratigraphic units are introduced later.

THE NATURAL SEDIMENTS OF THE NOEN U-LOKE AND NON MUANG KAO AREA

Location 1: Water hole 3km NW of Noen U-Loke; 15°16'N 102°14'E; recorded by Habberfield-Short. This is a 6m-deep 30x10m water hole in floodplain sediments. Particle size analysis and field observations suggest eight units (Fig. 1:3). The contact between the basal and overlying is sharp. The former is a soft indurated red claystone and the latter consists of light brown fine sand with platy red indurated clay fragments. It grades into unit 3, a well-sorted coarse sand with pisolithic iron nodule gravels. Unit 4 is composed of well-sorted medium to coarse sands with white clays and black mottles and shares a gradational contact with the overlying and underlying units. Unit 5 is clay sand with iron nodule gravels, and unit 6, sitting unconformably on it, is well-sorted fine clay sand. It grades upwards to a sandy clay (unit 7) with yellow mottles, occasional iron nodules and concretions. The upper-most unit is massive grey clay with a lower B2 horizon characterised by reddish yellow mottling. These sediments have a gradational contact with the underlying units. The basal red clays at this location are weathered Mahasarakham bedrock. These sediments are similar in texture, colour and bedding to sediments identified by Boyd *et al.* (1999b) as bedrock, and those variously described by Boonseneer (1977), Takaya *et al.* (1984), Satarugsa (1987), Chong (1988) and Udomchoke (1989). Resting unconformably on this are coarse sediments interpreted as Old Alluvium and associated with lateral and vertical floodplain accretion. The coarse nature of these sediments and their massive structure imply higher energy sedimentary conditions than at present, conditions of a hydrological precursor to the current landscape. The clays of the upper-most unit are interpreted to be Young Alluvium; they are similar in texture and stratigraphic position to the Young Alluvium documented by Wongsomsak (1987) and Satarugsa (1987). The gradational contacts between the alluvial sequences represent a gradual reduction in the energy of the sedimentary environments.

Location 2: Freshly excavated 30x10m waterhole, 50m southeast of Location 1; 15° 16'N 102° 14'E; recorded by

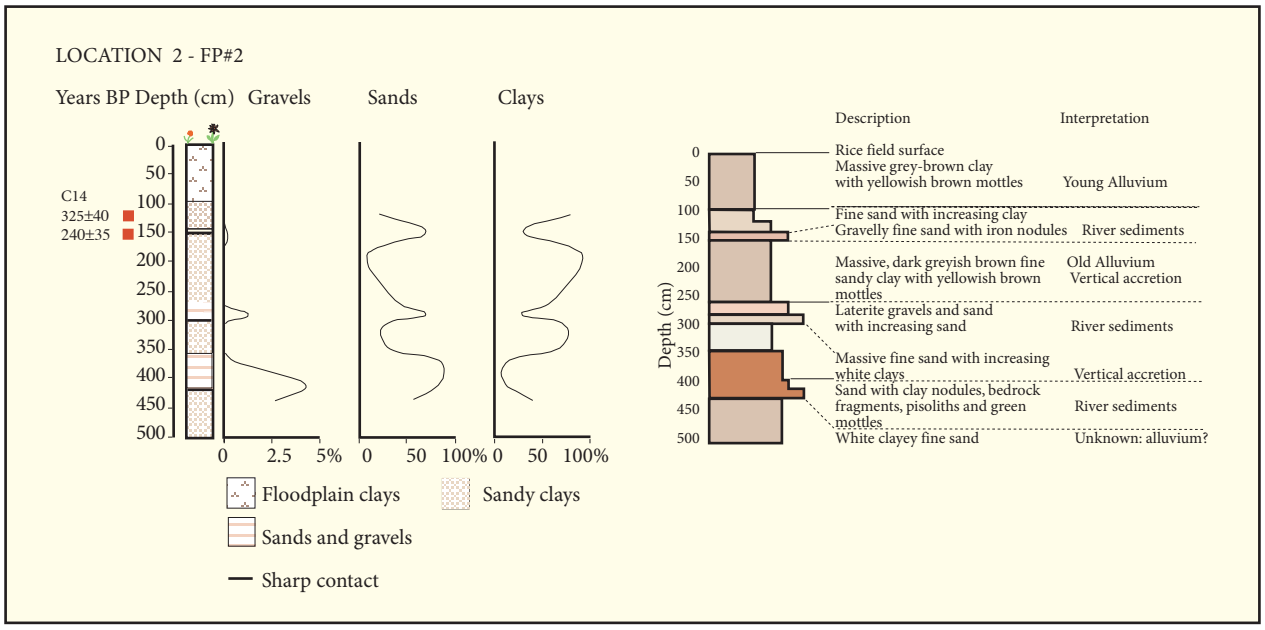


FIG. 1:4 Location 2 sediment stratigraphy and sediment characteristics (FP#2 refers to the field notes; fish pond no. 2)

Habberfield-Short. The sediment sequence is slightly shallower than at Location 1 (Fig. 1:4). The stratigraphic sequence and particle size analysis shows a vertical succession of seven units that are graded, each separated by gradational contacts: clayey fine sand; gravely clay sand to clay sand; sandy clay; gravely clay sand; clay sand to sandy clay; gravely clay sand; and clay. The gravels contain laterite nodules as well as coarse sand. All but the upper two units extend across the entire section; the upper two units occur within an in-filled saucer shaped unit less than 10m wide, and cut from unit 1 into unit 3. AMS radiocarbon determinations come from within the gravely clay sand at 1.6m depth (OZE190: 240±35 C14 years BP) and slightly higher within the clay at 1.3m depth (OZE191: 325±40 C14 years BP). The base of the unit is characterised by a thin unstratified lens of well-sorted sand containing laterite

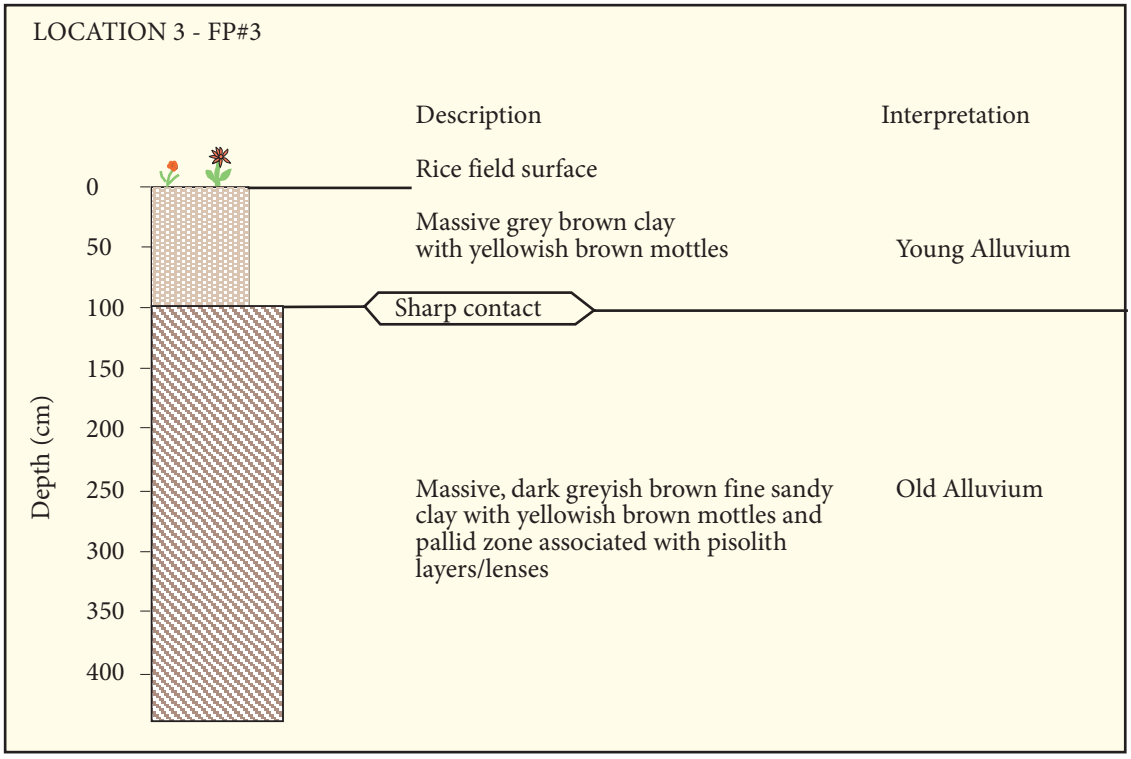


FIG. 1:5 Location 3 sediment stratigraphy and sediment characteristics (FP#3 refers to the field notes; fish pond no. 3)

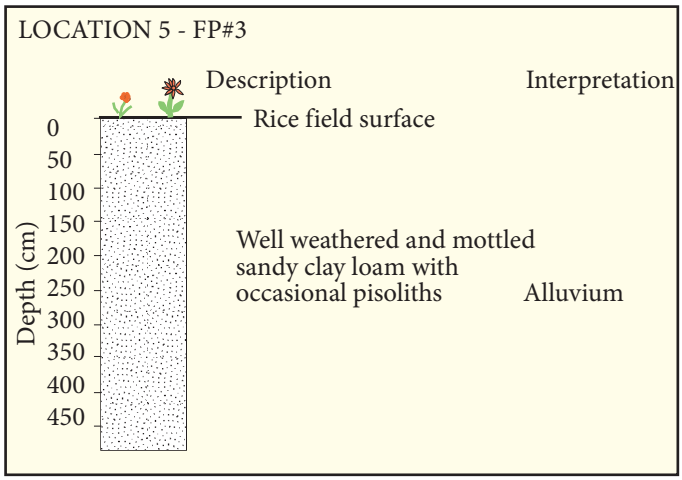


FIG. 1:6 Location 5 sediment and sediment characteristics (FP#5 refers to the field notes; fish pond no. 5)

nodules. This grades upwards to blocky, stiff pinkish grey-to-grey clay with typical podsolic weathering. The lowest unit is interpreted to be approximately contemporaneous with unit 4 at Location 1. The top gravely clay sand and clay is associated with the infill of a small channel. The whole sequence shows a grading set of alluvial strata, and, as at Location 1, implies a gradual lessening in the energy of the local sedimentary environment. The upper unit is contemporary with the upper one at location 1.

Locations 3 and 4: Freshly excavated water holes; location 3 is 300m west of Location 1 (15° 16'N 102° 14'E), and Location 4 is 90m south of Location 3 (15° 16'N 102° 14'E); recorded by Boyd and Habberfield-Short. Location 3 is one of two 30x10m fishponds. Two units are separated by a gradation contact (Fig. 1:5): the lower is dark greyish brown sandy clay with yellowish brown mottles and a pallid zone associated with pisolite layers and lenses; the upper is a thin unit of grey clay that also contains a clay-filled channel cut in south face within the grey clay facies. Location 4 is similar, but also contains a large channel in-filled with grey clay on the east face within a clay unit, and is lined at the base with laterite nodules. The clay overlies a clay sand facies with laterite nodules and mottles. These sequences represent floodplain alluvium. Two periods of accumulation suggest gradual decline in energy of depositional conditions. The earlier period is probably associated with the sandy clay at Location 1 and Location 2. Deposition of the clay is associated with the clay in-filled channel in the southern profile, and probably represents overbank alluvium associated with a low flow system.

Location 5: Freshly excavated water hole; NW of Location 4; 15° 16'N 102° 14'E; recorded by Habberfield-Short. This is a water hole in an area of sandy loam. The entire sequence comprises weathered mottled sand clay alluvium with occasional laterite nodules, similar to Old Alluvium at Locations 1 and 2 (Fig. 1:6). The presence of small clay-filled channels in the surface beds at Locations 1 to 4 suggests these sediments are derived from levee or overbank contexts. Location 5, however, is closer to the floodplain edge, and the absence of the finer sediments suggests that this location is at a slightly higher elevation or does not receive normal overbank sedimentation.

Location 6: Freshly excavated water hole; 500m west of Location 5; 15° 16'N 102° 14'E; recorded by Boyd and

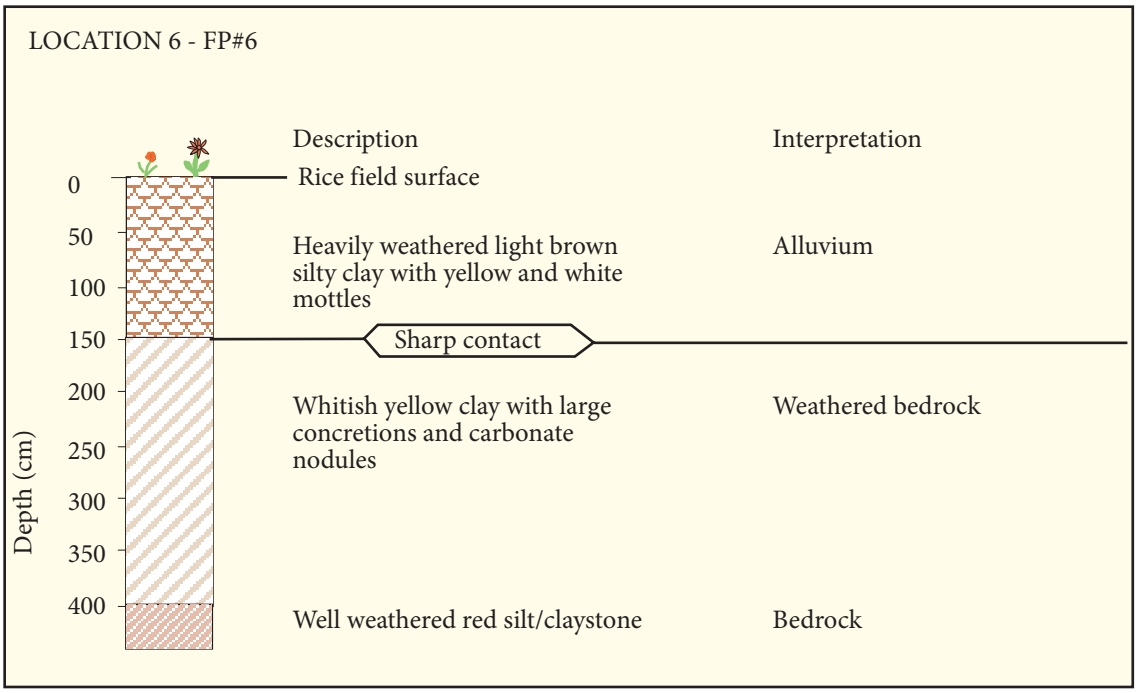


FIG. 1:7 Location 6 sediment stratigraphy and sediment characteristics (FP#6 refers to the field notes; fish pond no. 6)

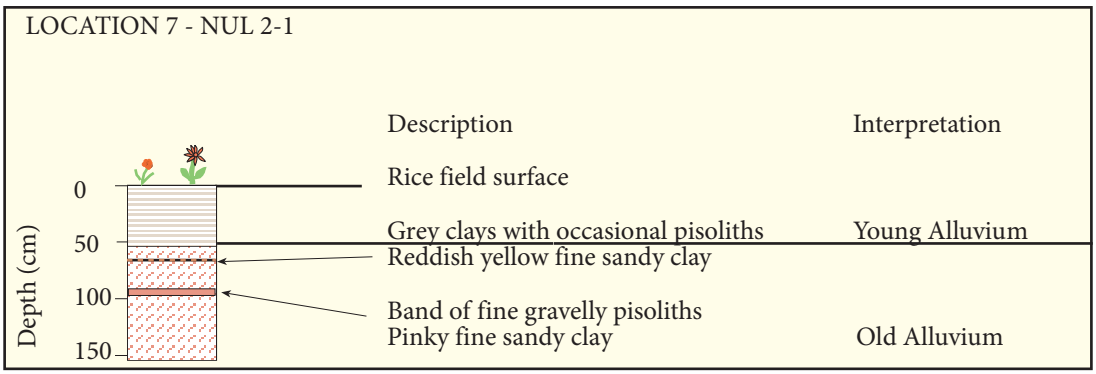


FIG. 1:8 Location 7 sediment stratigraphy and sediment characteristics (NUL 2-1 refers to the field notes; excavator trench no. NUL 2-1)

Habberfield-Short. This sequence contains three units (Fig. 1:7): the lowest is an soft indurated red clay and is overlain abruptly by a thick unit of weathered whitish yellow clay that contains large concretions and carbonate nodules; the uppermost unit comprises a thin veneer of heavily weathered silty-clay with yellow and white mottles to 1.5m below the surface. An abrupt contact exists between the lower and middle units. This sequence is interpreted, as at Location 5, as being on the floodplain edge, with bedrock and ancient alluvium dipping to the south. Here the recent channel deposits and grey clays found at Locations 1 to 4 are absent, but replaced by older, more weathered alluvium directly on weathered bedrock. The bedrock is also closer the surface than at the previous locations; the floodplain edge lies westwards and northwards.

Location 7: Excavated trench near Noen U-Loke (NUL 2-1); 500m northeast of Noen U-Loke; 15° 16'N 102° 16'E; recorded by McGrath and Habberfield-Short. This sequence (Fig. 1:8) comprises four units: reddish pink clay with carbonate nodules; fine reddish yellow silty-clay sand with occasional small iron nodules; gravely iron nodules; and grey clays with occasional iron nodules. All boundaries are gradational, except for the band of iron nodules, which rests abruptly between the uppermost unit and lower clay sand. This sequence is notable for the absence of the gravely alluvial unit present at previously-described locations. The lowest unit is similar to the claystone found at Locations 1 and 6, although it is not indurated. The overlaying silty-clay sand is similar to the clay sand alluvial at Locations 1 to 4, and thus probably represents alluvium. The uppermost clay is, likewise, similar to the equivalent unit at Location 1 to 4, and is also argued to be recent alluvium. This site is notable for the banding of laterite nodules, although the origin of the iron nodules unit is unknown. Bands of iron nodules form in soils affected by water table fluctuations (Zonn 1986, Fritsch and Fitzpatrick 1994, McGrath 2001); the gravely units containing iron nodules at previous locations are composed of both sand and clay sediments, but here the gravely unit is formed almost exclusively of the iron nodules themselves. Whereas at Location 6 the gravely unit is interpreted as channel sediments, their lithology and position here implies in-situ formation due to weathering and precipitation of iron (McGrath 2001).

Location 8: Canal exposure; upper catchment north of the study area; 15° 20'N 102° 11'E; recorded by Habberfield-Short. This loamy upland (over 200m a.s.l.) sequence (Fig. 1:9) represents weathered bedrock, and is located within a stable landscape zone of near to horizontal relief. It is exposed in a canal cut through a soil sequence to a depth of over 5m. The lowest horizon consists of reddish brown sandy clay with blocky structure, and is overlain by a massive layer of reddish brown silty clay containing an oxic zone of white calcareous mottles and ferric concretions. This grades into an A2 horizon that contains dark grey to dark reddish grey sandy silt-clay and calcareous clasts. The A1 horizon is characterised by very dark grey fine sandy clay loam with dark reddish brown mottles, with a crumbly structure. This sequence is interpreted as a skeletal soil with deep oxic weathering of the red mudstone bedrock (Gale and Hoare 1991). The sequence is notably different from the floodplain sequences in that there are no iron laterite nodules but much carbonate accumulation. The latter reflects different water table conditions, but together with the location in this upland zone suggests the profile is older than floodplain sediments. Erosion of this material is a likely source for floodplain sediments.

Location 9: Water hole; NW of Noen U-Loke; 15° 16'N 102° 16'E; recorded by Boyd. This sequence is located within a former channel associated with a modern meandering river, and comprises five units (Fig. 1:10). The uppermost comprises blue grey stiff clay with red mottling, and sits abruptly on a unit that grades upwards from a lens of orange yellow silty sand containing red mottling and small nodules to an orange silty sand with dark brown mottles. This unit overlies mottled pink-grey and blue-grey clayey sand with occasional orange mottles, and also contains a lens of iron nodules towards its lower boundary. Unit 4 consists of well-sorted red sand with no structures, and grades downwards to blue sand. The basal unit consists of blue silty clay grading at 1.3m depth into

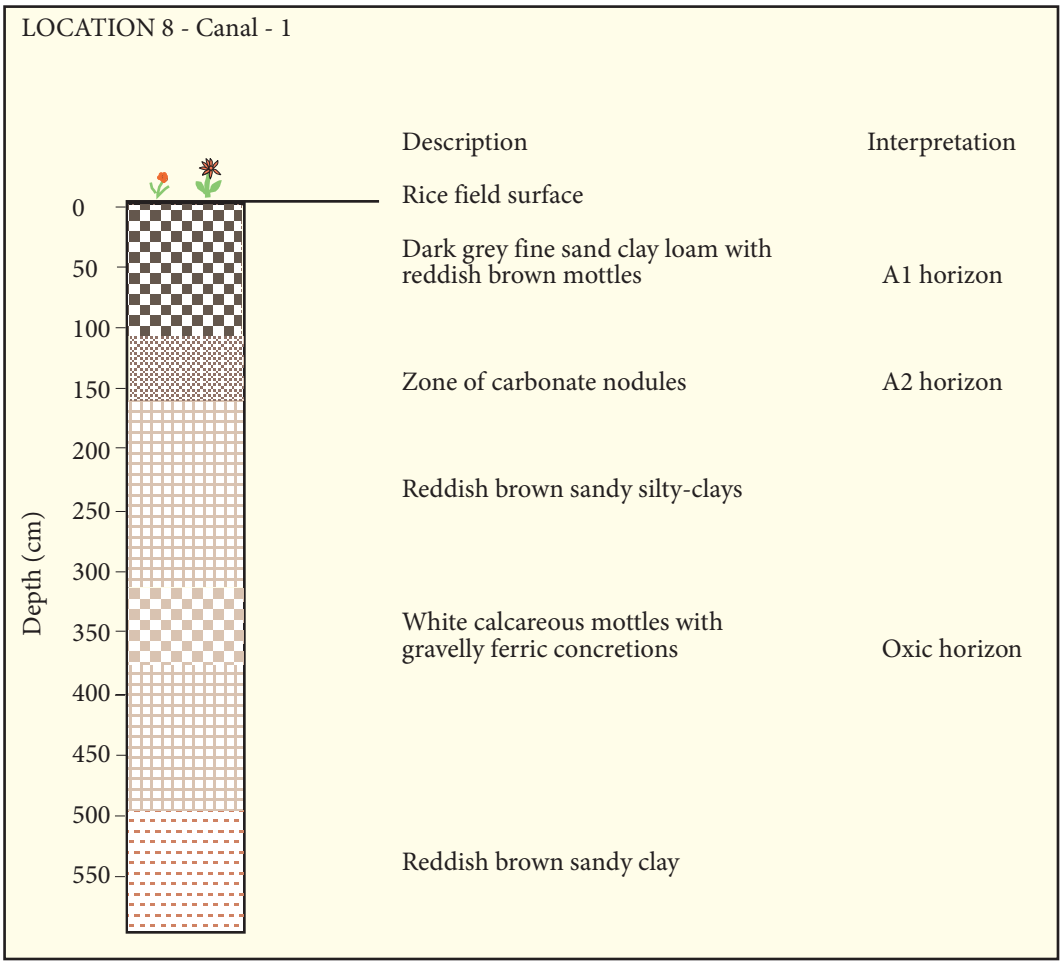


FIG. 1:9 Location 8 sediment stratigraphy and sediment characteristics (Canal-1 refers to the field notes; canal no. 1)

pink clay with black nodules. The clays at the base of the sequence bear some resemblance to the red clay at the base of Location 7 (eroded bedrock). The overlying well-sorted sand is probably channel sediment. The coarser basal sediments in the overlying clayey sand and silty sand are probably also associated with channel sediments. The fining upwards sequence in each of the latter are probably levee sediments. The uppermost clay bed is interpreted as overbank alluvium. The sequence is suggests a gradual reduction in the energy of the depositional environment similar to Locations 1 to 4 and 7.

Location 10: Water hole; 0.5km east of river trench (Location 11) at Ban Non Ngui; 15° 15'N 102° 14'E; recorded by Boyd and McGrath. This is 3.5m-deep sequence consists of three units (Fig. 1:11): sandy silt clays to silty clays; thick black clays and coarse well-sorted, coarse polycrystalline sand (depth unknown). The sand consists of quartz, shale, slate, calcareous rock and other metamorphic rock fragments, shell fragments and laterite nodules. The sandy silt clays grade downwards into the black clays, which rest sharply on the underlying sand unit. The sequence indicates at least three periods of sedimentation. The black clay is alluvial, interpreted as channel infill sediments. The abrupt contact between this and the lower sand units suggest the clay sediments are derived from a significantly different sedimentary environment and may be considerably younger than the sandy unit. The oldest (lowermost) unit is associated with high energy and high flow channel conditions, while the younger two are associated with lower energy conditions. The uppermost unit is similar to, if slightly sandier than, the clay unit at Locations 1 to 4 and Locations 7; the sandiness of the top unit here probably reflects local variation of the top units at the other locations.

Location 11: Excavation trench exposure; in-filled river channel south of the site of Ban Non Ngui; 15° 15'N 102° 13'E; recorded by McGrath. This excavated trench transects a *c.* 30m-wide in-filled river channel. Sediment analyses have been reported in McGrath (2001); the sediment unit summary and interpretations presented here are by Habberfield-Short. The sequence comprises six units (Fig. 1:12): well-sorted polycrystalline sand; silty-clay sand; sandy silt-clay; silty clay with sand; sandy silt clay and silty clay with sand. The boundary between the well-sorted polycrystalline sands and the overlying unit is abrupt, whereas the boundaries between all other units

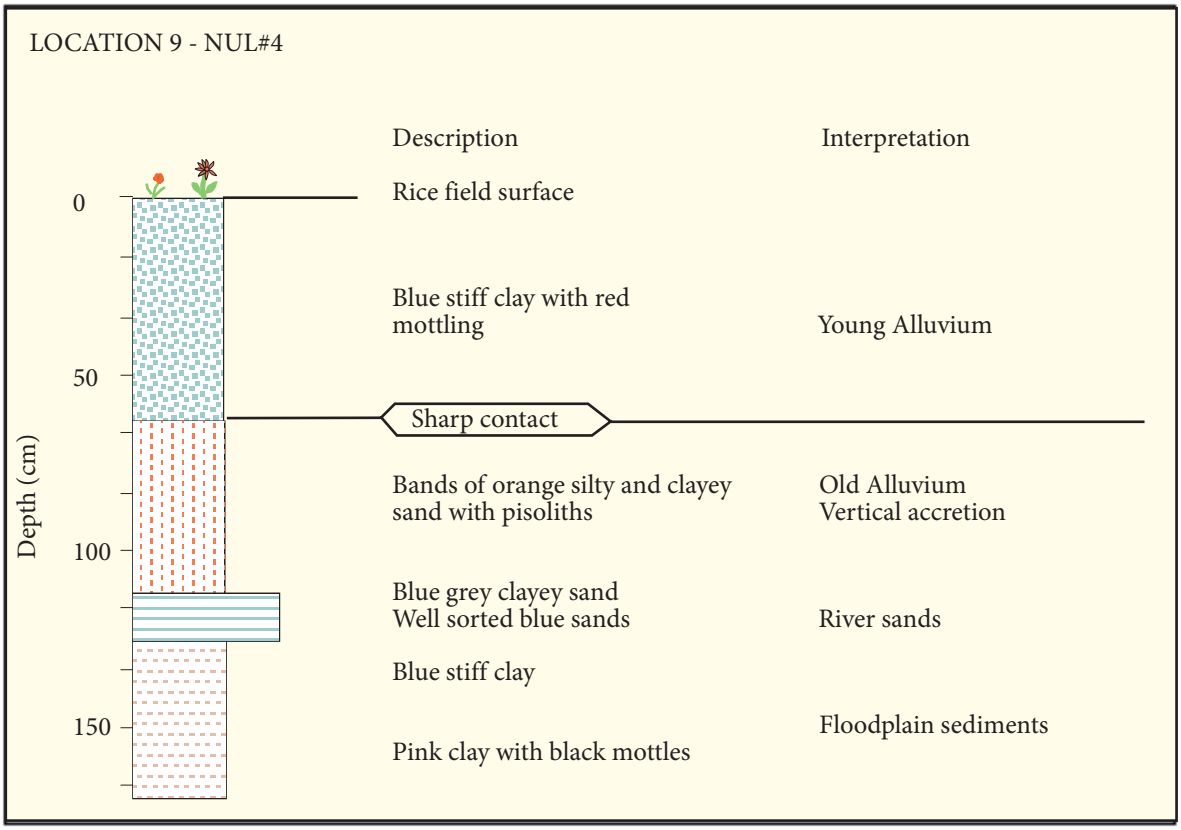


FIG. 1:10 Location 9 sediment stratigraphy and sediment characteristics (NUL#4 refers to the field notes; Noen U-Loke sediment site no. 4)

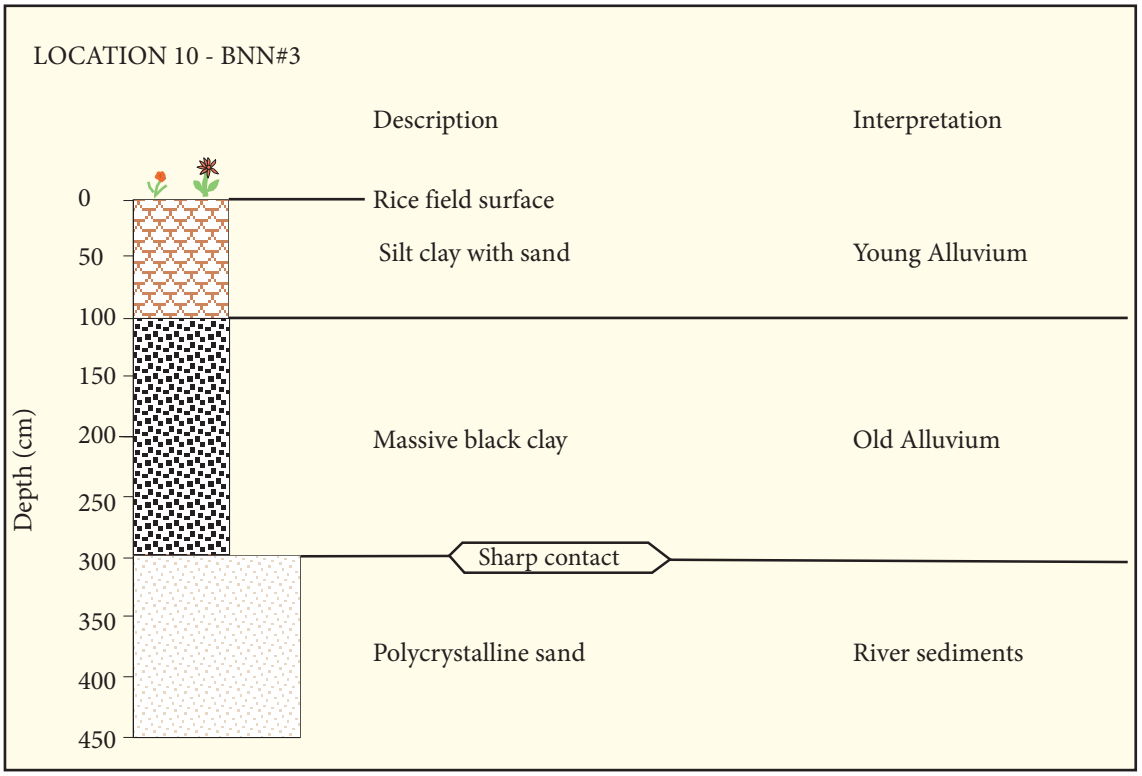


FIG. 1:11 Location 10 sediment stratigraphy and sediment characteristics (BNN#3 refers to the field notes; Ban Non Ngiu sediment site no. 3)

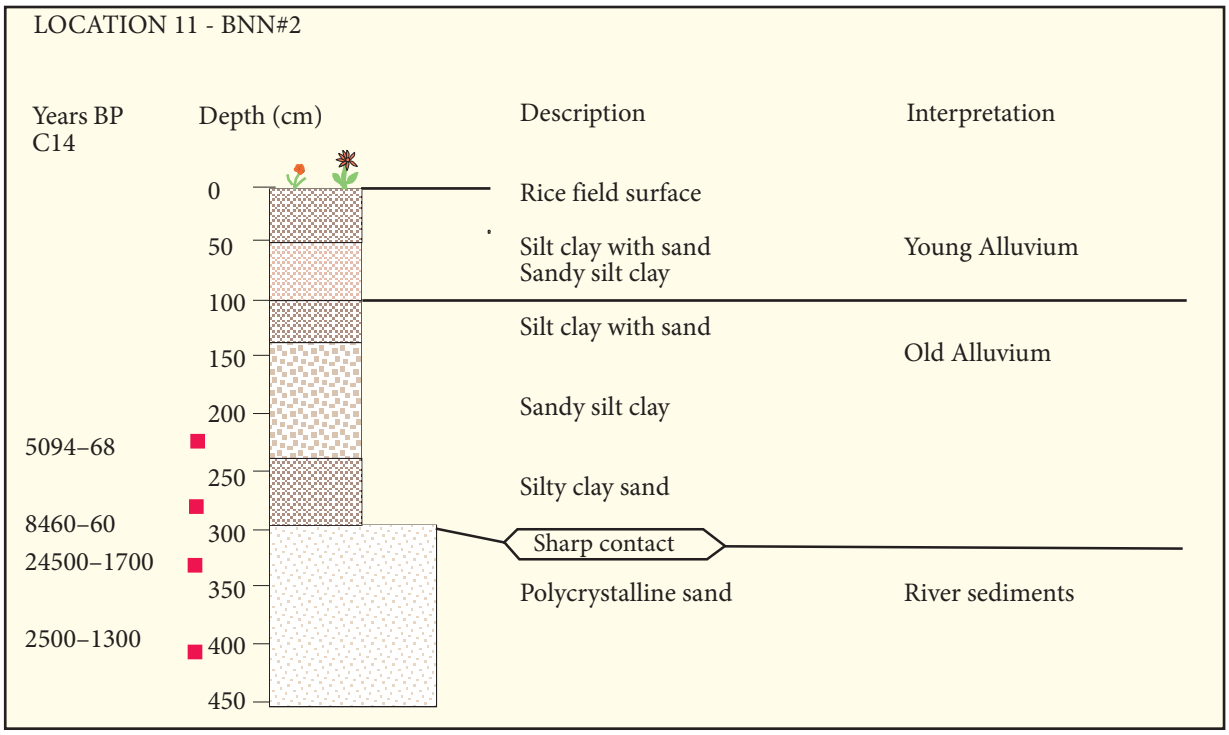


FIG. 1:12 Location 11 sediment stratigraphy and sediment characteristics
(BNN#2 refers to the field notes; Ban Non Ngiu sediment site no. 2)

are gradational. The sandy unit is composed of well-sorted polycrystalline coarse sand similar to the basal unit at Location 10; these sediments unconformably overlie the bedrock at the trench margins. The bedrock undulates between from 3m to > 4m depth. This site represents a local variation on Location 10. Two AMS radiocarbon dates (WK-6753, WK-6754) and two thermoluminescence (TL) dates (W-2818, W-2819) are available (McGrath and Boyd 2001). The silt clay unit has been radiocarbon dated to 5,094±68 C14 years BP at 2.2-2.3m below the surface, and the silty clay sand units dates to 8,460±60 C14 years BP at a depth of 2.8-2.9m. The polycrystalline sand facies is TL dated to between 24,500±1700 years BP at 3.3-3.42m depth, and 25,100±1300 years BP at 4.0-4.1m depth. The sands at the base of this sequence are interpreted as a channel bed-load, and are overlain by alluvium infill. Gradational contacts within the sandy and clay units imply that the alluvium is graded; the alluvial unit formed under normal floodplain processes associated with channel migration and avulsion. The AMS dating effectively place the infill of the channel within the early to mid-Holocene and suggest an interpolated date of approximately 2,000 years BP for onset of sedimentation in the uppermost unit (McGrath and Boyd 2001). The facies sequence represents a reversion from Late Pleistocene high energy and runoff floodplain conditions to early to late Holocene lower energy conditions. The TL dates suggest a Pleistocene age for the polycrystalline sands also found in basal units at Location 10, and the AMS dates may imply an early to late Holocene age for the sandy and clay alluvium at other locations.

Location 12: Quarry section; 500m S of Non Muang Kao; 15° 13'N 102° 18'E; recorded by Habberfield-Short. This sequence is south of the archaeological site of Non Muang Kao, and contains two units (Fig. 1:13). The upper comprises massive brownish sandy clay, and conformably overlies a clayey sand unit containing bands of clayey and sandy sediments with polycrystalline sediments and laterite gravels. The polycrystalline sediments include quartz, shale, slate, calcareous rock and other metamorphic rock fragments. In places sandier lenses appear to represent 10-15m-wide channel in-fills. This sequence represents a graded alluvial sequence. Importantly an upper blue grey clay unit is absent. The basal unit is similar to the polycrystalline sediments at Locations 10 and 11, and is probably of a similar age.

Location 13: Water hole; *c.* 100m NW of the mound at Non Muang Kao, 50 m east of the railway line; 15° 13'N 102° 18'E; recorded by Boyd and Habberfield-Short. This 38x18m waterhole exposes floodplain sediments to a depth of 2m (Fig. 1:14). The sediments comprise mostly horizontally layered sandy and silty clay with iron nodules, whitish concretions, and angular well-worn polycrystalline gravely sands at depth. In the western face there is a 4m-wide and 45cm-deep channel, in-filled with stiff yellowy brown silty clay, which cuts into the surface of a silty and sandy clay unit. A second channel cuts into the surface of the silty and sandy clay unit, but is much narrower (c. 1m wide 1m deep). It is also filled with stiff yellowy brown silty clay. The fields north and south of the outer moat at Non Muang Kao contain very little surface blue-grey clay.

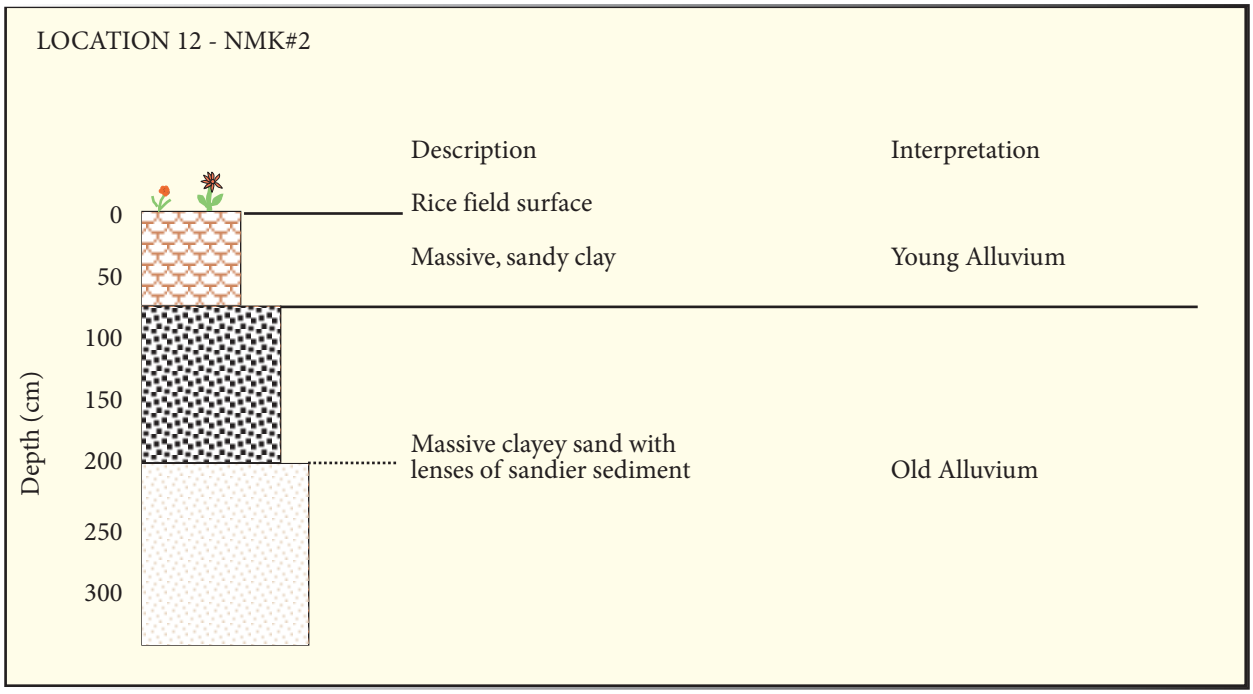


FIG. 1:13 Location 12 sediment stratigraphy and sediment characteristics (NMK#2 refers to the field notes; Non Muang Kao sediment site no. 2)

A typical section at this location consists of four units: a hard brown grey dried silty-clay with yellow flecks, black nodules, and surface salts; green/yellow grey silty and sandy clay with light brown sand, some iron nodules, and white concretions; pale white grey sandy clay with yellow flecks and iron nodules; and clays containing white concretions, iron nodules (often cemented) and polycrystalline gravels similar to those at Locations 10, 11 and 12. The upper surface of the lowest unit is sharp and all others are gradational. This sequence represents a graded alluvial sequence, with the basal unit probably being contemporaneous with the basal well-sorted sands at Locations 10 11 and 12. The white sandy clay is equivalent to the lower unit at Locations 1 to 4. Importantly, however, the upper silty clay unit bears little resemblance to the upper units at Locations 1 to 4, 10 or 11, but shares some resemblance to the surface brown sandy clay alluvial unit at Location 12. The blue grey clay unit encountered at the northern margin of the study area is also absent at this location.

Location 14: Auger hole; base of archaeological site at

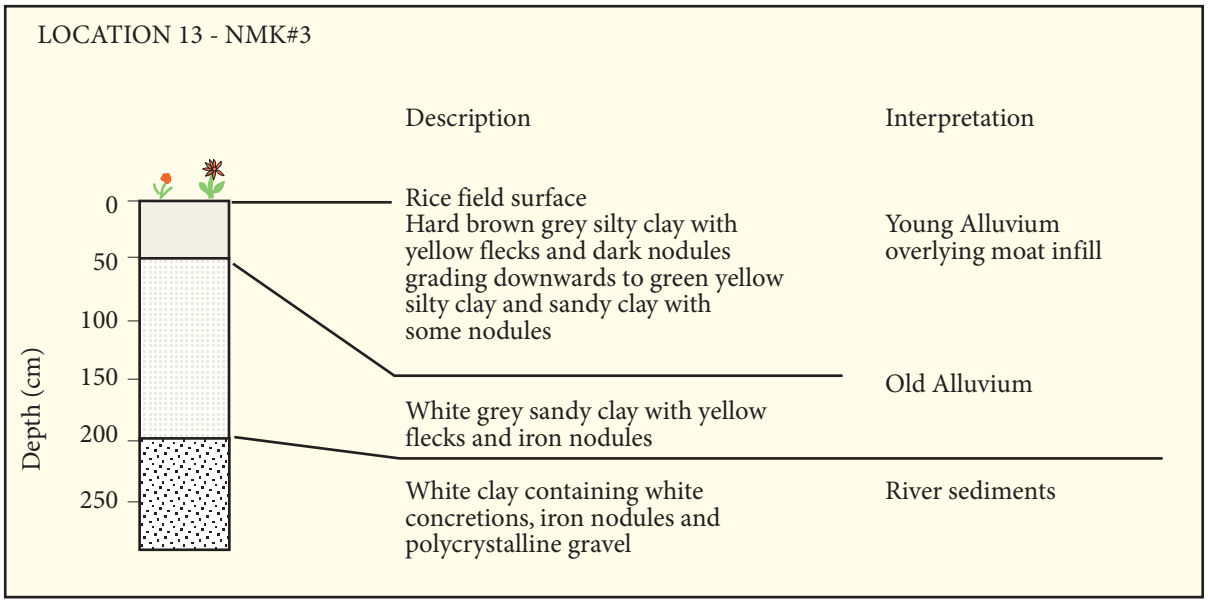


FIG. 1:14 Location 13 sediment stratigraphy and sediment characteristics (NMK#3 refers to the field notes; Non Muang Kao sediment site no. 3)

Noen U-Loke; 15° 16'N 102° 16'E; recorded by Boyd. This section consists of the top 50cm of the natural sediments underlying the anthropogenic (archaeological) mound sediments of Noen U-Loke. It consists of sandy clays containing occasional white/yellow mottles, with increasing (with depth) fine grey to pink clay and black mottles. This represents the B2 horizon of a young podsol, developing on silty clay floodplain alluvium (Bridges 1970).

Location 15: Sandstone bedrock outcrop; in area of Location 8; 18° 13'N 102° 10'E; recorded by Habberfield-Short. This rock outcrop comprises loosely cemented, medium, and well-sorted orange quartz sandstone. It is located in the hills north of the study area, and is interpreted as a regional variation on the bedrock exposed at the base of the floodplain facies.

INTER-FINGERING FLOODPLAIN AND ANTHROPOGENIC SEDIMENTS IN THE AREA OF NOEN U-LOKE AND NON MUANG KAO

Location 16: Hole (field notes site NMK-1.1) on north edge of the mound of Non Muang Kao; 15° 13'N 102° 18'E; recorded by Boyd. This sequence comprises of four units within the inner moat at Non Muang Kao. The lowest unit (1.5-5.0m depth) comprises red clay and pale green to white mottles and small concretions in layers and lenses. At depth this unit grades into softly-indurated red clay forming shale-like blocks. Brown grey clay (1.1-1.3m depth) rests abruptly on the red clay unit, and grades upwards into the surface bluish grey clay unit (0.0-1.1m depth). The red clay is typical of the red claystone underlying other locations, and is the Mahasarakham formation. The red and brown clay sequence represents floodplain alluvium. Importantly, no polycrystalline gravels or laterite are found within this sediment, unlike at Locations 12 and 13; the lowest sandy clay units at Locations 12 and 13 are associated with river channel sediments. The most notable characteristic of this sequence is the blue clays, absent at Location 12 and 13, that comprise the moat infill.

Location 17: Water hole (field notes site NMK-5) within inner moat on S side of Non Muang Kao; 15° 13'N 102° 18'E; recorded by Boyd. This sediment exposure cuts across the middle bank and outer moat. It is a 20x20m water hole exposing a sequence that comprises a surficial unit (0-0.5m) of yellow brown silty clay with iron nodules, overlying the basal indurated red unit (0.5-1.05m depth). The southern sequence lies within the moat and exposes the surficial unit (0-0.5m) of grey clay, as at Locations 12 and 13, that lies conformably over yellow silty clay sediments with iron nodules. The weathered bedrock underlies the entire sequence at a depth of 0.5m. The similarity of the clay infill with the upper unit at Location 16 suggest they are contemporary, and are associated with moat infill. Importantly the bedrock rises within 0.5m of the surface, implying that the bedrock is easily accessible from the surface. The deeper position of the bedrock to the west may be related to erosional sedimentary conditions associated with the unit bearing the gravels and sands at Locations 12 and 13.

Location 18: 15° 13'N 102° 18'E; recorded by Boyd. This is 55m-long trench cut through a depression between the larger and smaller rises at Non Muang Kao, and comprises four units. The lowest is indurated soft red clay (*c.* 2.7-2.5m depth), which weathers along fracture planes to black and white clays. The fracturing and weathering decreases to the unit surface, and is divided into a clay-rich upper horizon and a blocky lower horizon. The surface of this unit undulates, and is cut by deep pits filled with reddish brown clays containing pottery and snails. Overlying the bedrock abruptly and infilling these hollows (0.0-2.7m depth) is a unit comprising lenses and layers of a mixture of local sediments, including reddish brown sandy and silty clays, bones, shell and pottery, overlain conformably by a saucer-shaped surface unit consisting of blue grey clay and occasional pottery. Wedged between the bedrock and the reddish brown clay at the western end of the trench are crumbly slightly reddish brown clays with occasional flecks of yellow brown sediment (1.95-2.35m depth). Two radiocarbon ages are available from this exposure: one is within a pit cut into the bedrock surface (2.11m depth), 45m from the east end of the trench (OZC911: 2,120±210 C14 years BP); the other lies at 2.25m at the base of the reddish brown clays, 46.2m from the east end (OZC912: 2,000±60 C14 years BP). This location represents the base of the Non Muang Kao archaeological site. The red indurated clay is the bedrock typical of previous locations, which here lies only 2.5-2.7m below the surface. Importantly, the alluvial sediments overlying the bedrock at Locations and 12 and 13 are absent. Instead, a mixture of anthropogenic and reddish brown clay sediments (similar to the alluvium at Locations 12, 13, 16 and 17) rest unconformably, and in places cut into, the bedrock surface; this represents human modification of alluvial sediments. The C14 dating denotes a late Holocene age for the onset of anthropogenic deposition. The similarity of the blue-grey clay with the clay channels infill at Locations 16 and 17 implies a younger than 2,000 years BP age for this phase of sedimentation.

Locations 19 and 20: Surface exposure and salt-making mounds (field notes sites Salt-1 and Salt-2); 1.5 km W of Noen U-Loke; 15° 16'N 102° 13'E; recorded by Habberfield-Short. This location comprises two small mounds used in the past for the reduction of salt brine. The sediments are largely sandy and, at Location 20 clayey sand; extensive salt flats lie to the south and bedrock outcrops slightly to the north. Phimai Black pottery, shells, bone, burnt clay and hearths erode out of the mounds in places. These sites indicate that either salt is near the surface or else it is washed in from the bedrock rises. The presence of Phimai black indicates that the area was used during the

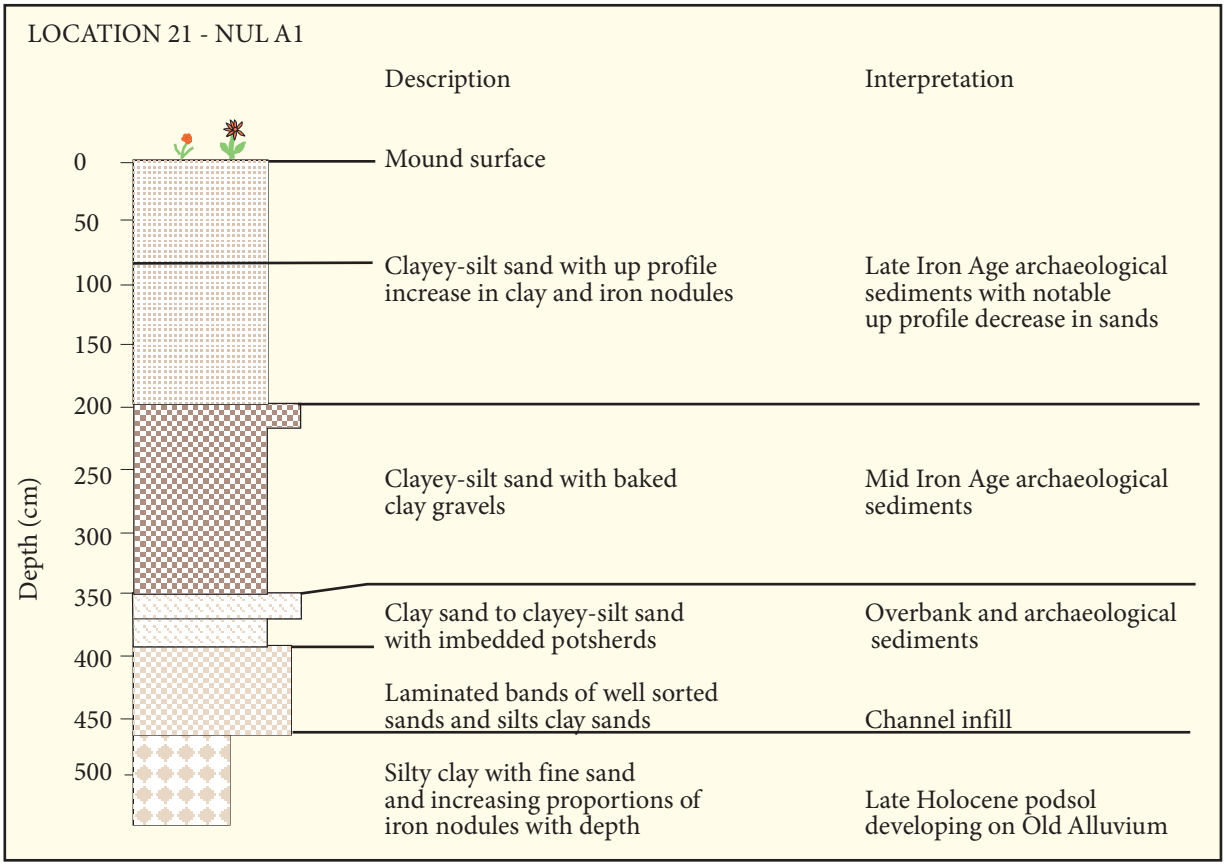


FIG. 1:15 Location 21 (Noen U-Loke) sediment stratigraphy and sediment characteristics (NUL A1 refers to Noen U-Loke archaeological site A1).

Iron Age.

ANTHROPOGENIC SEDIMENTS

Location 21: Section in archaeological exposure; Noen U-Loke archaeological mound; 15° 16'N 102° 16'E; recorded by Habberfield-Short. This sediment facies sequence comes from the northern section of unit A1 of a 15x14m and 4.7m deep archaeological excavation at the centre of the occupation mound. The mound rises approximately 4m above the floodplain and comprises six layers associated with human occupation spanning the late Bronze Age to the early Historic period. The mound and substrate sediments reflect a sequence of seven units (Fig. 1:15). From the base upwards these are: compacted pinkish sandy silt-clay with orange mottles; laminated sands (light red) and clays (dark brown); compacted dark brown clay-silt sand; light brown clay-silt sand with orange mottles; dark brown gravely clay-silt sand; brown gravely silt-sand; and hard yellow gravely silt-sand. Unit 1, at a depth of 4.6-5.25m, is the substrate on which the archaeological sediments sit. It contains fine lateritic pisoliths, whitish-yellow concretions, and light orange and black mottles in silty clay sediments (at *c.* 5.05m depth) and is characterised by an increase in the proportion and size of iron nodule and concretions with depth. This unit grades upwards into unit 2, which forms a saucer-shaped unit cut from within unit 3, in-filled with laminated sands and clays. The upper surface of unit 3 grades into unit 4, which the contact between units 4 and 5 is sharp; the latter is massive. Unit 6 sits sharply on unit 5, and is also massive. Lastly, unit 6 grades upwards into unit 7. The sequence can be defined in terms of the distribution of iron nodules; they are present throughout the sequence, although in the lower units (1-5) are finer, becoming gravely and abundant in the upper facies. Unit 5 is also distinguished by many gravely and sandy clasts of orangey-red baked clay. Ceramics, ash, charcoal, shell, slag and bone are found throughout the sequence except in the lowest unit, and unit 3 contains many burrows filled with well-sorted pink sands and a lens of horizontally bedded ceramics in its upper surface. In unit 2, rounded and weathered potsherds are imbedded into the base where it sits on the surface of unit 1. Phimai black pottery is abundant in units 5 and 6.

Seventeen AMS radiocarbon dates provide an chronology for occupation at this site (Fig. 1:16). Charred rice within unit 3 at 4.2m depth dates to 1,010-790 cal years BC (WK-5365: 2,720±60 C14 years BP) (note: AD/BC dates in the following are calibrated years AD or BC, and measured (BP) dates are in C14 years). Three others are from the same context: at 3.75-4.1m depth, 800–200 BC (WK-5363: 2,360±60 BP), 390-90 BC (WK-6148: 2,180±45 BP)

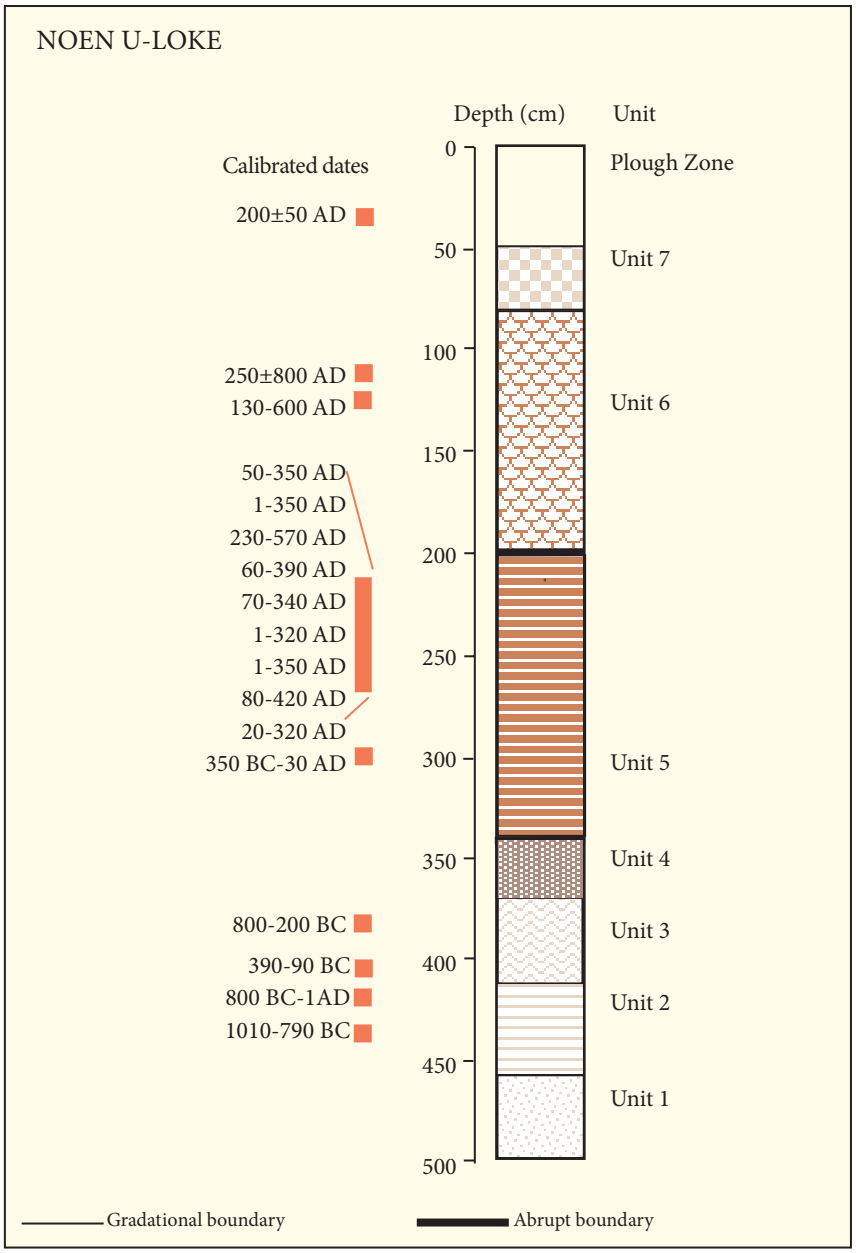


FIG. 1:16 Location 21 (Noen U-Loke) C14-based chronology, showing calibrated ages and the facies stratigraphy

and 800 BC-AD 1 (WK-5364: 2,280±130 BP). Ten dates are associated with unit 5: at 2.0-3.15m depth: 50-350 AD (WK-5359: 1,840±60 BP); 1-350 AD (WK-5354: 1,850±70 BP); 70-340 AD (WK-5358: 1,830±50 BP); 230-570 AD (WK-5362: 1,650±70 BP); 80-240 AD (WK-5360: 1,770±60 BP); 60-390 AD (WK-5351: 1,820±60); 1-350 AD (WK-5355: 1,850±70 BP); 20-320 AD (WK-5357: 1,870±50); 1-320 AD (WK-5361: 1,880±60 BP); and 800-200 BC (WK-5356: 2,090±50 BP). Two charcoal samples from unit 6, at depths of 1.05 and 1.15m, date to 250-800 AD (WK-5353: 1,470±120 BP) and 130-600 AD (WK-5352: 1,680±90 BP) respectively, while date from a hearth at 0.5m depth is recent (WK-6147: 200±50 BP).

The mottles, fine iron nodules and clay texture in the deepest unit are probably associated with soil formation and a high water table (Bridges 1970). The sediments represent a low energy back swamp or low-lying alluvial environment present before people settled at Noen U-Loke. The first archaeological settlement is associated with units 2 and 3; the laminated unit 2 sediments are interpreted as channel infill, which formed and in-filled during the deposition of unit 3. The laminated sand and clays imply that this channel was periodically filled with standing or slow-moving water; units 3 and 4 were deposited in a similar low energy environment. Units 5, 6 and 7, however, represent slightly different depositional conditions associated with periods of occupation; the overlapping unit 5 dates suggest a short but intense occupation period, and upper unit 6 occupation was likewise short lived. The abrupt contacts between these units and between units 4 and 5 imply short periods of hiatus as the mound formed. These periods of intense occupation are also typified by different sediments to earlier. The sequence suggests that the mound sediments were sourced from different local sedimentary zones. The units (2 to 4) containing fine iron nodules and dark brown to whitish silty sand are most likely to have been sourced from recent alluvium (cf. the uppermost at Locations 1 to 4 and 7), while the upper units (6 and 7) have a gravely alluvial source (e.g. lateritic facies at Location 7 and deeper units at Locations 1 to 7): the unit 5 source is harder to identify, since it contains both coarse iron nodules and dark silty sandy sediments and archaeological sediments (baked clays), and probably represents sources, including archaeological deposits, floodplain alluvium, and lateritic sediments.

Location 22: Section in archaeological exposure; Non Muang Kao archaeological mound; 15° 13'N 102° 17'E; recorded by Habberfield-Short. This sequence comes from a 5x5m 3.7m-deep archaeological excavation at the centre of the occupation mound; the details are from the eastern section of unit A1 (O'Reilly 1999). The mound at Non Muang Kao rises 7m above the floodplain, and

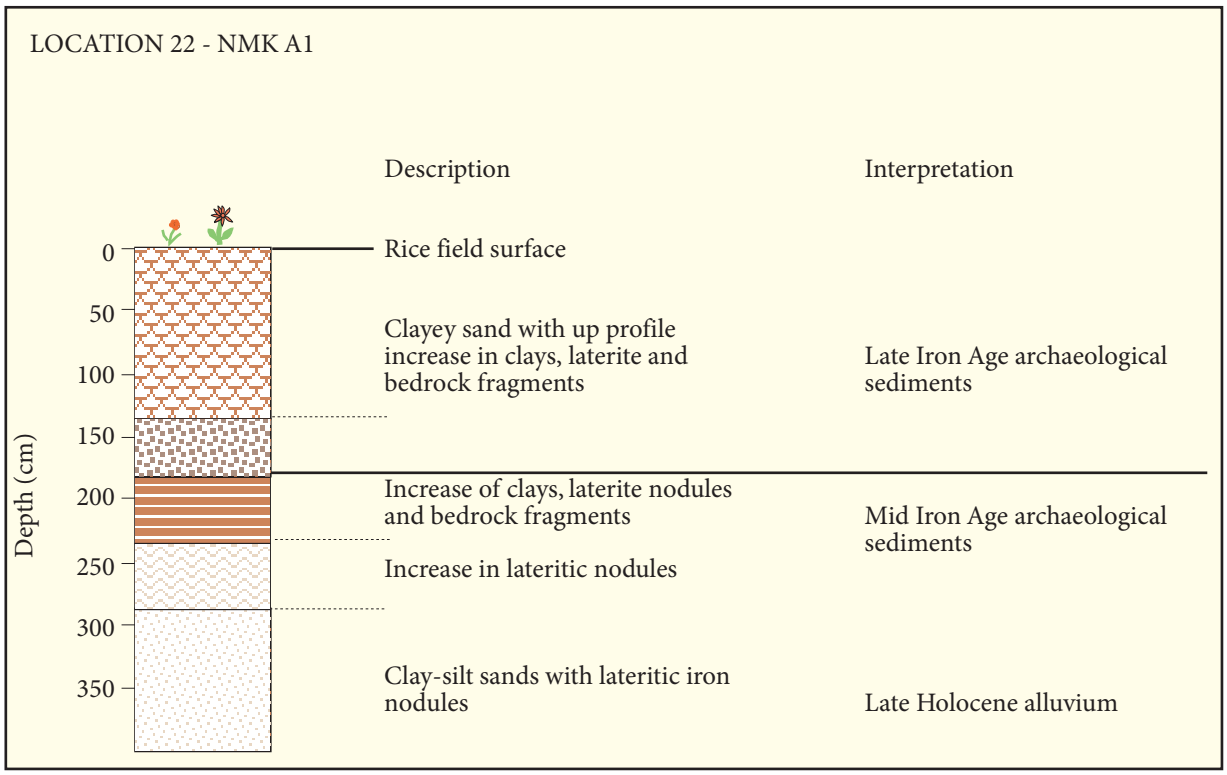


FIG. 1:17 Location 22 (Non Muang Kao) sediment stratigraphy and sediment characteristics (NMK A1 refers to Non Muang Kao archaeological site A1)

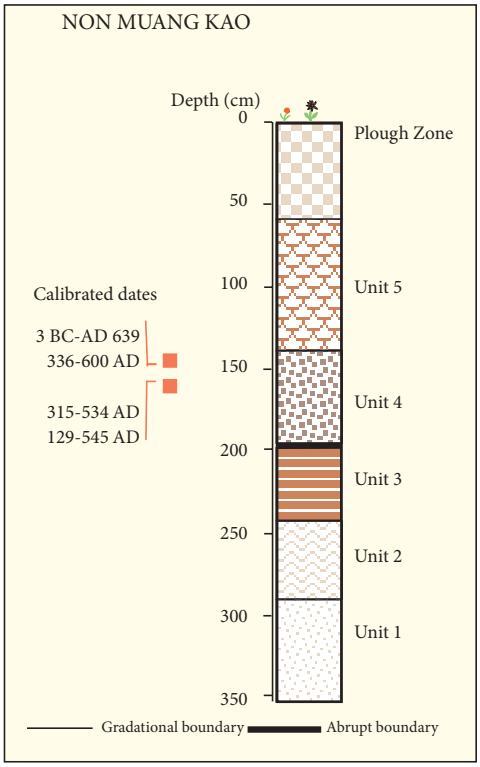


FIG. 1:18 Location 22 (Non Muang Kao) C14-based chronology, showing calibrated ages for the archaeological occupation during the deposition of Facies 4, and the facies stratigraphy for the full recorded sediment exposure

comprises a complex structure due to disturbance by many laminar clay lenses (clay floors), pits, hearths and postholes (O'Reilly 1999). The sequence comprises four archaeological layers, dating from the early Iron Age to early Historic period, over the substrate, to provide five units (Fig. 1:17). The basal unit 1 is characterised by light brown silty (polycrystalline) sand, with sand-sized iron nodules, and grades upwards into unit 2, greyish brown silt sand with abundant pottery, increasing gravely iron nodules towards top. This grades into unit 3, which comprises brown to yellow silt-sands and increasing amounts of gravely iron nodules towards the top. The overlying unit 4 rests unconformably on unit 3, and is characterised by light brown silt sand, with gravely iron nodules at the base increasing to the top. The unit 4-5 boundary is unconformable, with unit 5 comprising red silty-clay sand (lower sand content than the underlying units), and gravely iron nodules increasing to the top; this unit has laminated bands of red clays and small angular fragments of indurated red clay. There are four radiocarbon ages for unit 4, dating prehistoric occupation (Fig. 1:18) (calibrated and C14 years are as for the Noen U-Loke chronology): 336-600 AD (WK-4515: 1,610±60 BP); 315-584 AD (WK-4513: 1,640±70 BP); 129-545 AD (WK-4514: 1,700±90 BP); 3 BC-639 AD (WK-4512: 1,750±160 BP). The ages all overlap, and provide an age range of 3 BC to 639 AD at 2σ. The deepest unit at this Location is equivalent to the deepest units at Locations 11, 12, and 13, although the

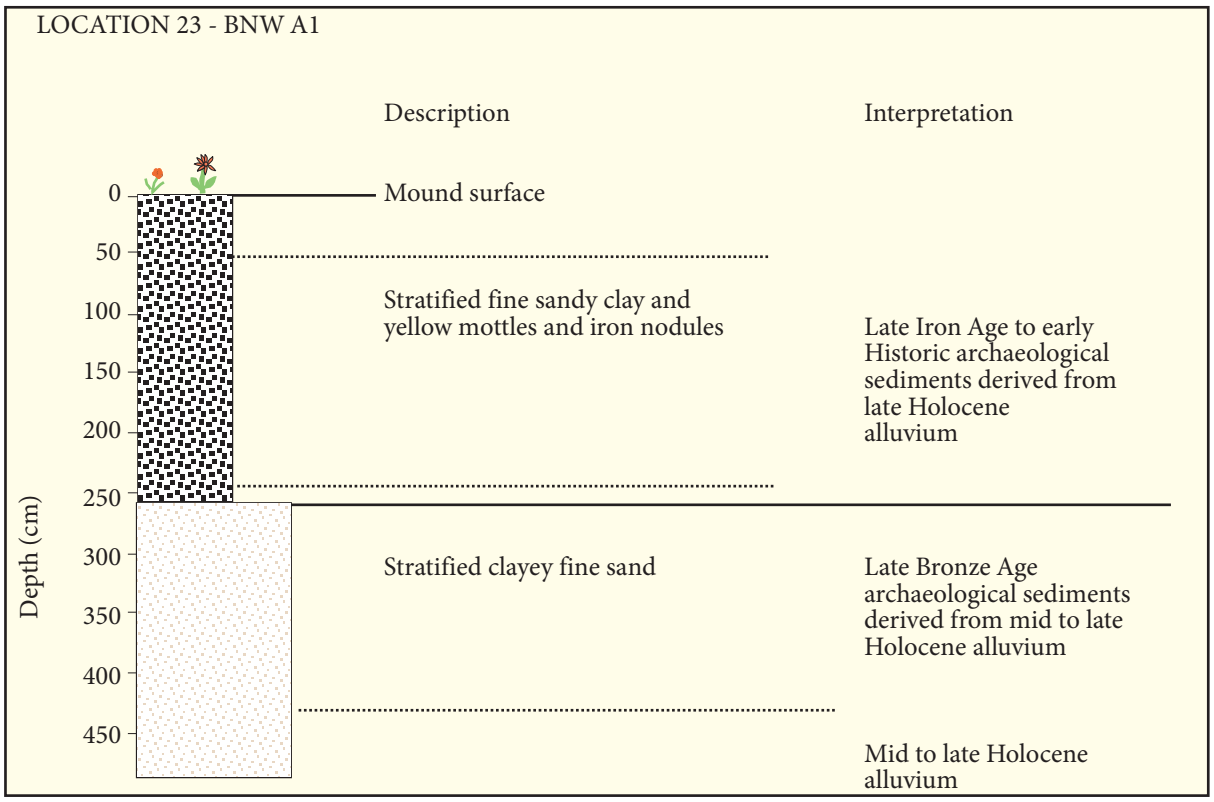


FIG. 1:19 Location 23 (Ban Non Wat) sediment stratigraphy and sediment characteristics (BNW A1 refers to Ban Non Wat archaeological site A1).

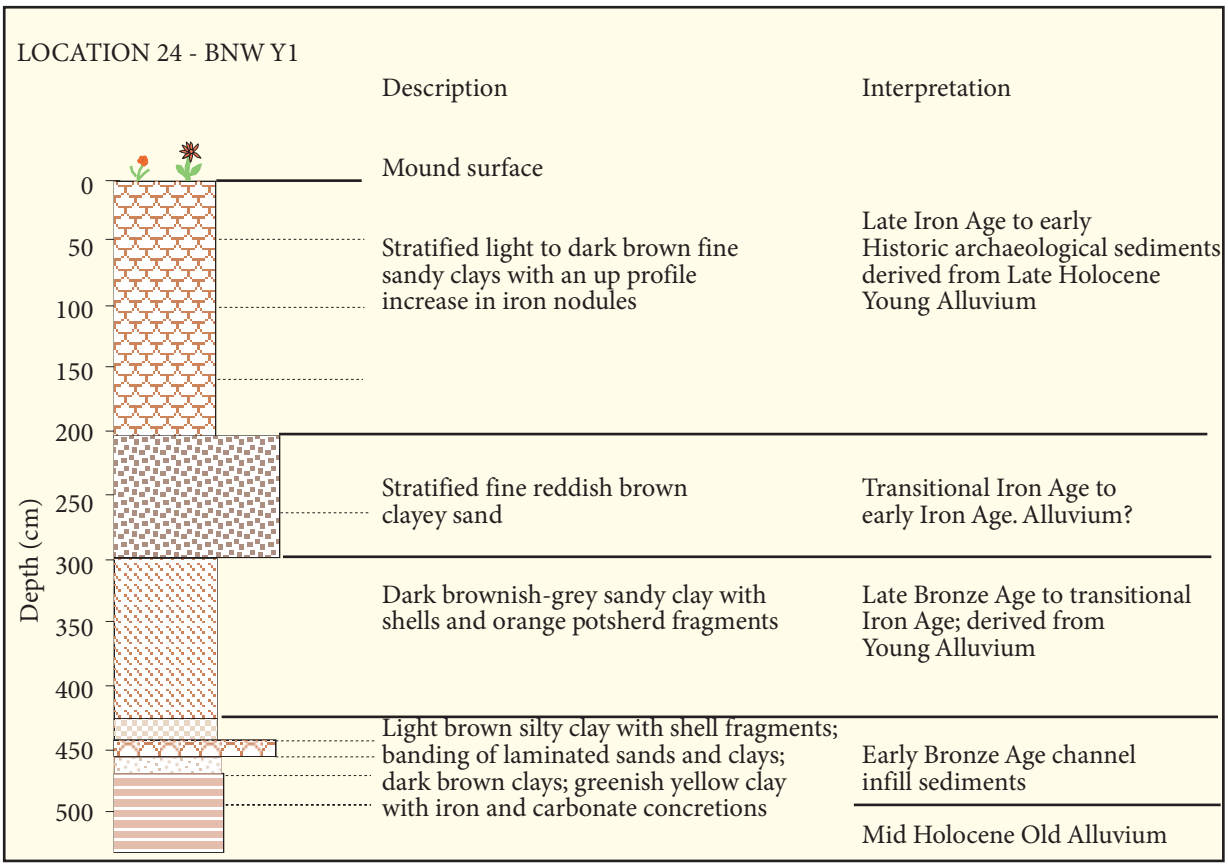


FIG. 1:20 Location 24 (Ban Non Wat) sediment stratigraphy and characteristics (BNW Y1 refers to archaeological site square Y1)

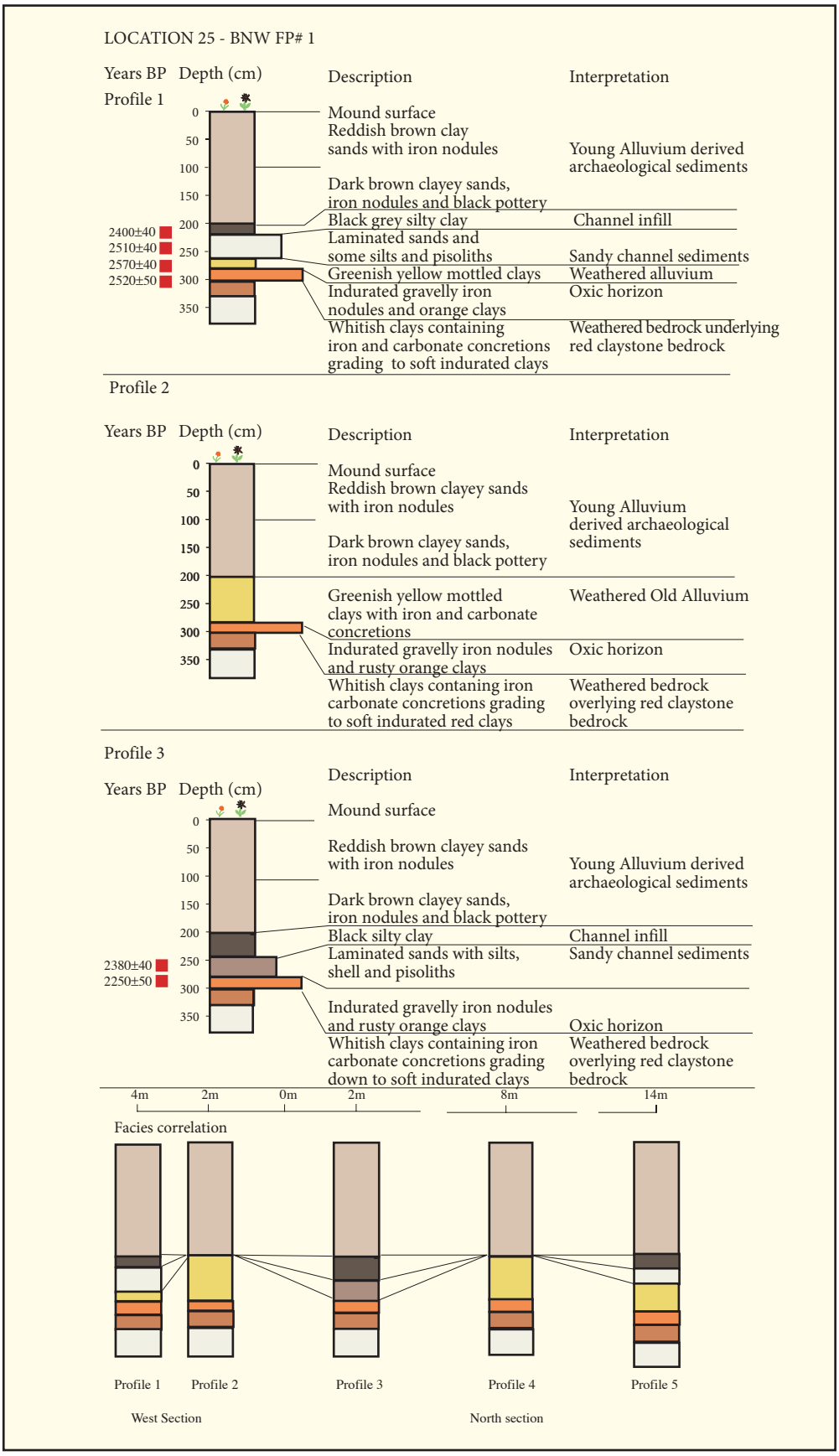


FIG. 1:21 Location 25 sediment stratigraphy and sediment characteristics (BNW FP#1 refers to the field notes; Ban Non Wat fish pond no.1)

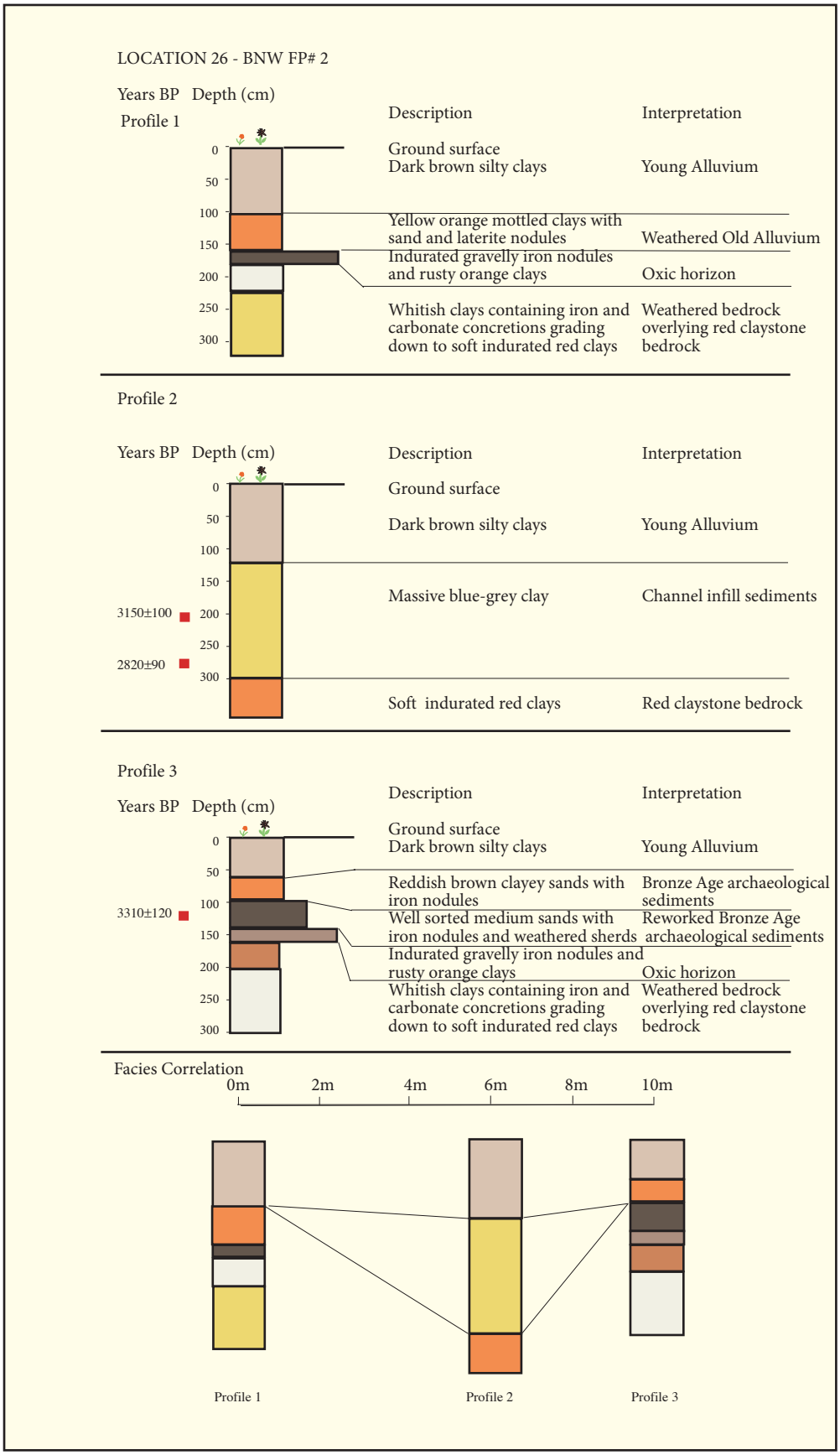
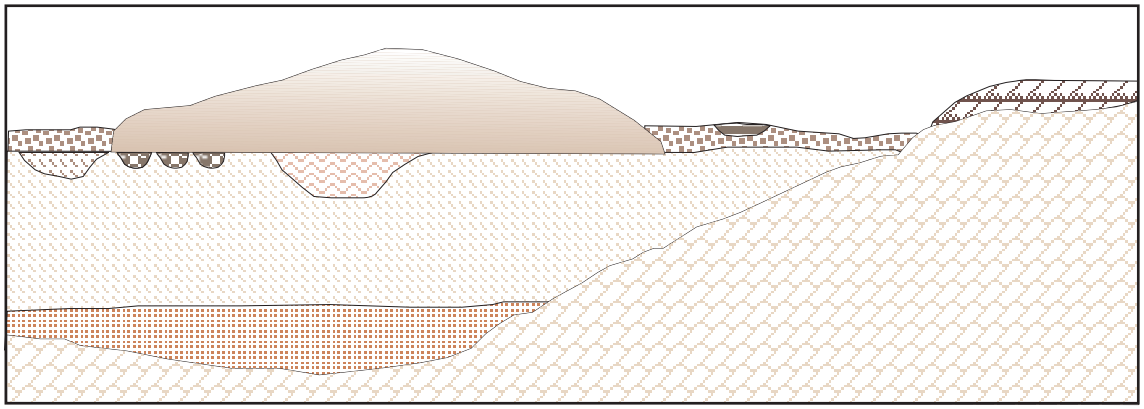


FIG. 1:22 Location 26 sediment stratigraphy and sediment characteristics (BNW FP#2 refers to the field notes; Ban Non Wat fish pond no. 2)



Stratigraphic Units:

Unit 1 Unit 3 Unit 5 Unit 7 Unit 9

Unit 2 Unit 4 Unit 6 Unit 8 Unit 10

FIG. 1:23 Schematic illustration of the stratigraphic units of the floodplain and surrounding areas in the vicinity of Noen U-Loke; unit numbers refer to the stratigraphic units described in the text and listed in table 1:2

overlying sediments from these Locations are notably absent at Non Muang Kao. Importantly, all sandy sediments within the mound suggest a common source to the basal unit. However, some unit differentiation can be based on the gravely iron laterite sediments, the indurated red clay fragments, and the red clay. Iron nodules in the Location 13 units 2 and 3 are similar with those from units 2, 3 and 4 here. The indurated red clay fragments in unit 5 are bedrock gravel; the bedrock lies deep in the floodplain sequence here, and is probably also the source of the red clay in the uppermost unit matrix.

Locations 23 and 24: Sections in archaeological exposure; excavation squares A1 and Y1 at Ban Non Wat archaeological mound; 15° 16'N 102° 17'E 15° 16'N 102° 76'E; recorded by Habberfield-Short. This surface of the Ban Non Wat occupation site rises *c.* 5m above the floodplain floor. In excavation A1, a 25m-long and 4.5m-deep section exposed four occupation layers spanning Neolithic to early Historic times. Mortuary, domestic and industrial remains are abundant including pottery, slags, baked clay, ore, shell and bone. Two units are suggested (Fig. 1:19), the deeper (unit 1) below 2.6m depth characterised by stratified medium brown to orange clayey sands, and the upper comprising compacted dark brownish black to dark grey sand with orange clay and iron nodules. The boundary is sharp and contains many horizontally deposited potsherds embedded in the surface. The base of unit 1 is sandy alluvium, which grades up to sandy alluvium containing archaeological remains. The sandy texture may represent the effect of winnowing, and thus imply aeolian deposition; alternatively the sand may represent high energy alluvial conditions such as a levee or channel (Reading 1996). The presence of clay in unit 2 indicates a change in sediment source; these

TABLE 1:2 *Sedimentary facies for the floodplain and neighbouring areas around Noen U-Loke and Non Muang Kao, and their corresponding stratigraphic units. The stratigraphic units are described in the text*

Facies	Stratigraphic units
Natural sediments	Unit 1. Bedrock Unit 2. Skeletal upland soil Unit 3. Polycrystalline river sediments Unit 4. Old Alluvium Unit 5. Young Alluvium
Inter-fingering archaeological and floodplain sediments	Unit 1. Bedrock Unit 2. Skeletal upland sand Unit 3. Polycrystalline river sediments Unit 4. Old Alluvium Unit 6. Clay channel infill
Anthropogenic sediments	Unit 3. Polycrystalline river sediments Unit 4. Old Alluvium Unit 6. Clay channel infill Unit 7. Laminated sand-silt channel infill Unit 8. Archaeological sediments Unit 9. Sandy and clay channel infill Unit 10. Clay channel infill

sediments also contain Iron Age material. The sediments resemble local alluvium, and there are similarities with the upper units at Noen U-Loke (Location 21). This sequence was recorded early in the excavation of Ban Non Wat, and more sediment is now exposed; detailed stratigraphic study is continuing, and while this will enhance the description provided here, the following site (Location 24) offers a more detailed sediment stratigraphy.

In excavation Y1, a 4x4m 6.4m-deep section exposed nine archaeological layers spanning early Bronze Age to early Historic times, with abundant domestic and industrial remains including living floors, pottery, slag, baked clay, ore, shell and bone. Eight sediment units are recorded (Fig. 1:20). The deepest unit comprises greenish-yellow clays, with mottling and weathering similar to the weathered alluvial units at Location 25. This is cut by channel sediments (units 2 to 5) comprising dark brown clay facies, laminated sandy and clay facies and light brown silty clay facies; the channel is *c.* 5m wide and 1.5m deep. Overlying the channel archaeological sediments comprise dark brownish grey sandy clays with fragmentary shells and gravely to pebbly orange pottery shards and laterite; this unit is also characterised by many lenses of well-sorted orange coarse sands, shell fragments and gravely pottery on occupation surfaces. This unit is overlain unconformably by reddish brown clayey fine sand (unit 7) and, in turn, by a unit of compacted greyish brown fine clay sand with gravely laterite nodules; the unit 7-8 boundary is sharp and contains horizontally-bedded potsherds. The deepest unit represents a local variation of the basal unit at Location 25; its weathered lateritic nature, mottling and colour indicate that the clays are weathered Old Alluvium. The overlying sediments are channel infill and their associated early Bronze Age archaeological fill indicates a *c.* 3,000 years BP age for the infilling of this channel. The texture of the channel infill and the overlying units are similar to Young Alluvium, thus suggesting a maximum age for the onset of conditions associated with Young Alluvium deposition. Importantly, this channel was probably active at the time of the archaeological deposition of Location 23 unit 1, and thus represents the environmental conditions into which the early Ban Non Wat inhabitants entered. Locations 23 and 24 are less than 50m apart, yet the sequence at Location 24 is several metres deeper; the comparison of the basal units at the two locations indicates that Location 23 sits on a natural mound.

Location 25: Water hole; Ban Non Wat village; 15° 16'N 102° 76'E; recorded by Habberfield-Short. This location is a 20x5m 3.5m-deep fish-pond section in the eastern margin of the mound, *c.* 100m SE of Location 24, exposing a basal unit of the red claystone with a surface weathering sequence composed of white clays and large concretions, an oxic horizon containing indurated gravely iron nodules and rusty orange clays, and a thin layer of greenish yellow mottled clays (Fig. 1:21). Three shallow and narrow (<3m wide, 50cm deep) channels are cut into the surface of the alluvium (Profiles 1, 3 and 5), and contain well-sorted laminated sands and silts. The Profile 1 channel infill 1 dates to *c.* 2,500 C14 years BP (OZG027: 2,570±50; OZG025: 2,400±40 C); the Profile 3 infill dates to *c.* 2,300 C14 years BP (OZG024: 2,250±50; OZG022: 2,380±40). A thin lens of silty clay blankets the surface of the alluvium and the channels. Two massive layers of dark brown and reddish brown (Young Alluvium source, probably) archaeological sediments rest unconformably on the infill clays. The basal unit is bedrock and associated weathering that underlies the sediments at most other locations. The overlying unit is the A and E horizons of a buried soil; the oxic sediments represent extreme weathering conditions associated with podzolisation (De Olivera *et al.* 2000). Podzolisation decreases from forest to grassland, and is a possible indicator of vegetation conditions. Birkeland (1984), for example, argues that a change from grassland to forest can be accompanied by the formation of an incipient E horizon at the base of the grassland A horizon; the oxic and alluvial unit here may, therefore, represent soil formation under forest conditions, suggesting that this locality may have been forested when it was first settled. The channel units cutting into the surface of these sediments reflect hydrological conditions associated with the deposition of Young Alluvium. Dating indicates that the oldest channel is closest to the centre of the archaeological mound; the outer moat (*c.* 75 m W) was dated to 2,029±52 C14 years BP (McGrath and Boyd 2001), implying channel migration away from the site with time and the overlapping of the channels by archaeological deposits.

Location 26: Water hole; Ban Non Wat; 15° 16'N 102° 76'E; recorded by Habberfield-Short. This exposure is a 14x5m 3.5m-deep water hole at the northern edge of the mound, which cuts into the edge of the archaeological mound; the northern end cuts into the floodplain. The section consists of seven units (Fig. 1:22). The typical red clay bedrock forms the sequence base, and is overlain by a unit of whitish weathered clays with carbonate and ferruginous concretions. This is overlain unconformably by a band of indurated iron nodules and rusty orange clays, itself overlain by yellow orange clays with occasional sands. Cut into the yellow orange clays and into the bedrock at 1.2m depth is a channel in-fill of homogenous blue grey clays. The channel is 8m wide and 3m deep; two basal radiocarbon AMS dates (Profile 2) indicate an age of c. 3,000 C14 years BP (OZG055: 3,150±100 BP, at 2.0-2.1m depth) and (OZG056: 2,820±90 BP, at 2.7-2.8m). The channel unit cuts a lens of well-sorted archaeological sands to the south, radiocarbon AMS dated to 3,310±120 C14 years BP (OZG058), which is overlain by a thin unit of reddish-brown clayey sand. Blanketing the yellowish orange clays, channel infill and clayey sands is an uppermost unit of dark brown to black silty clays. This location is interpreted as at Location 25: the lowest unit is bedrock and weathered bedrock, overlain by a soil profile on Old Alluvium; a channel cuts both bedrock and Old Alluvium, and is over-

lain by Young Alluvium. Although the dates are inverted, their relative ages suggest an early third millennium BP onset for channel infilling; the archaeological date (c.3,300 BP) provides an terminus ante quem to the establishment of the channel. These dates provide an chronology for the transition between the Old and Young Alluvium, while the sequence indicates that settlement was closely related to the river system in the early Bronze Age.

THE STRATIGRAPHIC UNITS OF THE UPPER MUN RIVER FLOODPLAIN IN THE AREA OF NOEN U-LOKE AND NON MUANG KAO

Of the sediments recorded in the literature as typical of the regional Holocene geology – Old Alluvium, aeolian sand, lake and swamp sediments, flood deposits, and Young Alluvium – only the Old Alluvium and the Young Alluvium are identified in the study area (Tables 1:1 and 1:2). The following stratigraphic units are informed by the observations described above and supported by observations from Boonseneer (1977), Takaya *et al.* (1984), Wongsomsak (1987), Satarugsa (1987), Chong (1988), Udomchoke (1989), Boyd *et al.* (1999b), McGrath and Boyd (2001) and McGrath (2001). Ten stratigraphic units include the soft red siltstone and claystone bedrock, skeletal soils, polycrystalline river sands, Old Alluvium, sandy-clay channel infill, Young Alluvium, archaeological sediments, sandy and silty clay channel infill and recent clay channel infill (Table 1:2, Fig. 1:2).

Unit 1. Bedrock. Bedrock outcrops on low-lying upper catchment interfluvial zones, vary from a soft red siltstone and claystone to loosely-cemented sandstone. The interfluves form low hills at the northern floodplain margin, and are overlain by well-weathered soils (Unit 2). The bedrock undulates from 2m to 6m below the floodplain surface in the study area; to the east it dips to 100m below the surface (Loeffler *et al.* 1983). In the floodplain area it is silty to clay-rich, with an angular to blocky structure, and weathers to red and white clays with white to yellow carbonate nodules and ferruginous concretions (Boyd *et al.* 1999b). The undulating bedrock surface is due to tectonic uplift and down-warping, and erosion during the Pleistocene (Loeffler *et al.* 1983). This unit represents variations of the Mesozoic Mahasarakham Formation of the Khorat Group Formation (Boonseneer 1977, Chong 1988, Satarugsa 1987, Takaya *et al.* 1984, Udomchoke 1989). It contains salt bodies at depth (Utha-Aroon 1993, El Tabakh *et al*. 1998, 1999); the gradual uplifting of these salt bodies is probably important, causing subtle but significant geomorphological changes to the floodplain and its surrounds; as salt bodies rise, they disrupt drainage patterns, and may trigger ground-water salinity changes. Salt tectonics may have strongly influenced the form and patterning of valley-bottom flooding and the quality of available water throughout antiquity.

Unit 2. Skeletal Upland Soils. This comprises deep well-weathered clay loam with fine sand and increasing proportions of calcium carbonate and laterite concretions with depth. The sediments of this unit are typically oxidised, lithologically homogeneous and located on the interfluve bedrock rises at the floodplain margins. The planation of this unit represents a source for the floodplain sediments. This unit may be equivalent to the upland loess documented to the north (Boonseneer 1977, Chong 1988).

Unit 3. Polycrystalline River Sediments. In places on the bedrock surface, incised river channels are filled with crystalline gravels and coarse sand. These sediments are probably derived from the sedimentary bedrocks to the north and west, during a period of high-energy conditions. The coarse sediments suggest that erosion of regolith and incision into bedrock was a significant force in the formation of the floodplain. The sediments may be similar to the inorganic sands that Loeffler *et al.* (1983) identified in Tung Kula Ronghai, associated the incision of deep valleys into the Mahasarakham Formation. Their source is probably upland sequences of Plio-Pleistocene weathered residual soils, saprolites and weathered rocks (Boonseneer 1977, Takaya *et al.* 1984, Satarugsa 1987, Chong 1988, Udomchoke 1989). Dating at Ban Non Ngui indicates a Late Pleistocene age (McGrath and Boyd 2001), and the sediments are probably equivalent to basal river sediments recorded to the west of the divide (Boyd *et al.* 1996).

Unit 4. Old Alluvium. Mantling the Units 1 and 3 is a thick (1-4m) unit of Old Alluvium (Loeffler *et al.* 1983, Satarugsa 1987, Tuckson *et al.* 1983, Udomchoke 1989, Wongsomsak 1987). The base of the Old Alluvium lies unconformably on the upper surfaces of Units 1 and 3, and is characterised by cyclical and grading-upwards sequences of coarse sands to fine sandy clays, silty clays and clays. The thickness and lithology of this unit varies according to the undulating bedrock and surface morphology; mottles, lateritic weathering and the associated concentration of pisoliths (iron nodules) and silicious concretions are a persistent feature of the alluvium. These weathering features often appear at the contact between the weathered bedrock and the alluvium, or within the zone of perched water tables in shallower sequences (McGrath 2001). This unit is the main sedimentary unit for the region with an approximate Late Pleistocene to mid- to late Holocene age (Boonseneer 1977, Boyd *et al.* 1999b, Satarugsa 1987, Tuckson *et al.* 1983, Wongsomsak 1987). It represents different hydrological conditions than at present, and floodplain conditions suitable for human settlement. Importantly, the archaeological sites sit either on or within the upper surface of this unit.

Unit 5. Young Alluvium. The weathered alluvium (Unit 4) is overlain by up to 2m of fresher and less weathered alluvium, the Young Alluvium. Soil on this unit comprises brown-grey clay A horizon and a B horizon with orange and black mottles. The Young Alluvium comprises dark silty-clay, clay-sand, sandy silt and clay (Wongsomsak

1987), and is found throughout the floodplain floor. While it is absent near the northern floodplain margins, where bedrock is closer to the surface, it inter-fingers the uppermost archaeological site sediments. The sequence from coarse Old Alluvium to finer Young Alluvium suggests a gradual decrease in the energy of the sedimentary environment throughout the Holocene.

Unit 6. Clay Channel Infill. This unit comprises wide and deep channel clay infill, found at two locations (24 and 26) near Ban Non Wat, embedded into the surface of the Old Alluvium (Unit 4). It dates from *c.* 3,500 to 2,500 C14 years BP. Deposition of Bronze Age material in the channel suggests that these rivers were contemporaneous with human settlement, and are represent the hydrological environmental conditions under which these peoples lived.

Unit 7. Laminated Silt-Sand Channel Infill. This unit comprises the sediment infill of buried channels cut into the surface of the Old Alluvium (Unit 4), tending to be under or at the margin of the archaeological sites. These are often shallow channels with laminated silt and sand, massive sand or graded beds of iron nodules, sand and silts. The unit is only identified at two locations (Noen U-Loke and Ban Non Wat). The typically sand-rich infill is coarser than Unit 9 and 10 channel infill, and date from at least 2,500 to 2,000 years BP (see also ages recorded by Higham 2000 and McGrath and Boyd 2001).

Unit 8. Archaeological Sediments. These are embedded within the upper horizons of, and overlying, Unit 4, representing localised areas of human occupation, and characterised by distinctive large mounds of deposits. These comprise stratified beds of distinctive anthropogenic and natural lithology, typically containing significant quantities bone, shell, pottery and baked clay, iron laterites, polycrystalline sands, alluvium, laterite and bedrock. They have been demonstrated by excavations at Noen U-Loke, Non Muang Kao and Ban Non Wat to be archaeological sediments. The contacts between beds within this unit vary from unconformable to gradational. At the mound's edge the sediments inter-finger with Young Alluvium (Unit 5) and moat channel infill (Unit 9). The sequences at Noen U-Loke and Ban Non Wat are distinguished by upper and lower zones; the upper zone contains gravely iron nodules and is clay-silt rich, and the lower zone is sandier with fewer iron nodules. Each site has its distinctive sequence; Non Muang Kao, for example, contains zonation, but the sequence comprises an upper zone characterised by bedrock, red clays, large iron nodules and polycrystalline sands, and a lower zone characterised by brown to grey clays, polycrystalline sands and graded beds of iron nodules. Most of these sediments date from *c.* 4,000-1,500 years BP.

Unit 9. Sandy and Clay Channel Infill. This unit represents the sediment infill within the channels ("moats") surrounding the archaeological sites. The channel infill deposits closer to the sites are typically stiff blue/grey clay with lenses of gravel or well-sorted sand at the channel base, while the outer channels tend to be infilled with recognisably reworked alluvium (Boyd *et al.* 1999b). The clays are less weathered than the alluvium (Units 4 and 5) or bedrock (Unit 1), and have few iron nodules. All cut through the alluvium (Units 4 and 6), and in some cases into the bedrock (Unit 1). Examples include the channels encircling the archaeological sites of Non Muang Kao, Noen U-Loke and Ban Non Wat. Their dating (McGrath and Boyd, 2001) indicates that each channel infilled rapidly, and most were hydrologically active during the period 2,100-1,400 years BP.

Unit 10. Clay Channel Infill This unit is characterised by several types of sediments, including stiff blue clay to red grey clay and placer deposits of well-sorted sand and iron nodules. All infill channels cut into the Young Alluvium (Unit 5) and, in some cases, the Old Alluvium (Unit 4). Examples are found in the uppermost units at Locations 2, 3, 4 and 13. The channels are usually narrow and dish-shaped, compared to the older shallow and wide channels (Units 3 and 6) and the site moats (Unit 9). They lie at the top of the floodplain sequence, and yield geologically-modern dates; their young age indicates a relationship to modern drainage and hydrological conditions.

THE CHRONOLOGY OF THE UPPER MUN RIVER VALLEY FLOODPLAIN PALAEOGEOGRAPHY

The stratigraphic units and their chronological relationships provide the basis for a palaeogeographical chronology for the study area. Six phases of sedimentation and landscape development are recognised; these are identified in terms of their age and the sedimentary conditions operating during these periods. They synthesise the sedimentary geology, and provide a basis for a geoarchaeological model for the Noen U-Loke and Non Muang Kao area (cf. Boyd *et al.* 1996).

Palaeogeographical Phase 1: Mesozoic to Tertiary

The landforms in the study area comprise low undulating loess-covered interfluves and peneplains with broad crests and gentle straight slopes separated by broad valleys of low gradient. Where the broad valleys drain south into the central part of the study area, the land surface is a low-gradient floodplain. The surface of the broad valleys and floodplain is cut by many large ancient channels. There are occasional sandy isolated hills and rises. The general relief is in the order of 5 to 20m, and the surface rises between 160 and 180m a.s.l., to distant interfluve areas over 200m a.s.l. Underlying much of the Mun River floodplain and the interfluvial areas are the weathered shales and sandstones of the Mahasarakham Formation. The deposition of this phase dates from the Mesozoic era and represents turbidity current deposits. The later geomorphic development of this phase is influenced by two sets of processes,

one climatic and the other tectonic (Loeffler *et al.* 1983). Tectonic uplift lead to the formation of a nearly enclosed basin (Khorat Plateau; Bunopas and Vella 1983) and was probably responsible for the marked incision into the relatively flat weathered land surface of the Mesozoic sediments. This resulted in an undulating bedrock surface that has subsequently been warped by salt dome up-lifting. The infilling of the incised valleys by Quaternary sediments was a function of tectonic movements and rising base level. The character of the sediments infilling the incised valleys are also considered to represent distinct environmental and climatic conditions in the Late Pleistocene and Holocene (Loeffler *et al.* 1983). The significance of Unit 1 is that it provides a bedrock base for the Quaternary infill of the floodplain. Importantly, its modification has resulting in an undulating topography that provides the basic shape of the landscape – the undulating floodplain, including local low rises, and neighbouring valley-side low slope rises – into which people moved during the Holocene.

Palaeogeographical Phase 2: Mid-to-Late Pleistocene

Loeffler *et al.* (1983) reported, for the lower Mun River basin, a period dating from 40,000 to 20,000 years BP characterised by a humid environment, low gradient alluvial plains with central meander belts, and wide marginal back plains supporting alluvial and swamp forests. This phase is characterised by organically-stained sands and is interpreted as a humid phase prior to the last glacial maximum. Overlying these sediments are non-organically stained sands representing considerably drier environmental conditions associated with a braided stream environment and constantly shifting channels and sand bars. Loeffler *et al.* (1983) suggest an age for the latter condition of 18,000-14,000 years BP. Significantly, in the upper floodplain – the area around Noen U-Loke and Non Muang Kao – there are very few such Pleistocene sediments mantling the bedrock surface under the floodplain, suggesting a period of erosion and landscape denudation. Of the two sand units reported by Loeffler *et al.* (1983) only the later non-organic sand is present in the Noen U-Loke area, and only as coarse polycrystalline sandy and gravely sediments (Unit 3) in base of channels at Ban Non Ngui and Non Muang Kao. These sediments date to around 25,000 years BP (McGrath and Boyd 2001), and represent a significant period of inter-fluvial land surface regolith erosion, perhaps leading up to and during the last glacial maximum (18,000 –14,000 years BP). Very similar sediments and depositional conditions are recorded on the other side of the basement divide on the edges of the Bangkok Plain (Boyd *et al*. 1996). In the study area this represents the first phase of infilling of the incised valleys into the bedrock, following significant erosion across the landscape.

Palaeogeographical Phase 3: Late Pleistocene to Early Holocene

There is a temporal and sedimentary gap in the stratigraphic records from the study area from *c*. 14,000 to 8,000 years BP. Regionally, the next sedimentary phase is characterised, elsewhere, by red and yellow loess in the uplands (Chong 1988, Wongsomsak 1987). These sediments reflect a continuation of the trend towards aridity established during the Late Pleistocene. However, the majority of dates from these sediments indicate that their deposition is older than 8,000 years BP (Udomchoke 1989). Loess is absent in the floodplain zone of the study area, but may be present on the interfluves (possibly Unit 2).

Palaeogeographical Phase 4: Early to Mid Holocene

Alluvial sediments directly overlie the Phase 1 bedrock surface and Phase 2 sediments, and date to younger than 8,000 years BP (McGrath and Boyd, 2001). Phase 4 in the study area is represented by Unit 4, and represents humid conditions lasting from *c*. 8,000-3,500 years BP (Udomchoke 1989). These conditions probably included littoral conditions (Kealhofer 1996), a continuation of braided channel riverine conditions, and forested back plains characterised by lakes and swamps (Penny *et al.* 1996). Dating for this phase comes from organic sandy clay and clays interpreted as lake deposits (Udomchoke 1989). Amelioration of climatic conditions is reflected in Phase 4 by the Unit 4 succession from coarse grained (sands and gravels) to fine grained (silty clays) in the study area. Towards the end of this phase deep single-channel rivers, such as those at Ban Non Wat, were present in the landscape (Unit 5), representing rich aquatic habitats and an important resource source for early settlers.

Palaeogeographical Phase 5: Mid-to-Late Holocene

The mid- to late Holocene is characterised by the onset of drier conditions from about 3,500 years BP. In the northern upland catchments, this phase is typified by the deposition of aeolian sands, though they are notably absent on the study area (Table 1:1); while they are absent on the floodplain, they may be entrained into the alluvial sediments. In the study area, the dominant environmental process during Phase 5 is the deposition of fine-grained silty and sandy clays (Unit 5) within topographic depressions on the floodplain. A similar process was noted for the same period in coastal zones of Central Thailand (Boyd *et al.* 1996), where it ultimately resulted in the blanketing of the landscape and reduction of relief in the floodplain to present conditions of a low gradient floodplain land surface. In the Noen U-Loke study area, the effects of this phase are only found on the floodplain, where it blankets ancient river courses (Units 5, 7 and 9) and inter-fingers with archaeological site sediments. This phase represents the last major period of landscape development in the region. There is evidence for three sub-phases of floodplain hydrology in the study area during this time.

- Sub-phase A. This early sub-phase is charac-

terised by the infilling of the deep single-channel rivers between *c.* 3,500 and 2,500 years BP. Human settlement during this time favoured elevated positions close to such channels.

- Sub-phase B. This sub-phase is characterised by the establishment of multiple narrow and shallow channel drainage, with typically silty and sandy bed load (Unit 7); these are equivalent to the anastomosing channels described by Boyd *et al.* (1999a). This sub-phase reflects a reduction in runoff, and the deposition of laminated channel sediments probably heralds the onset of marked seasonal variation, and, probably, the onset of temperature and aridity conditions similar to those at present. Individual channels were relatively short lived, and operated sequentially rather than at the same time (Boyd *et al.* 1999a,b; McGrath and Boyd, 2001). This drainage pattern probably continued until about 2,200 years BP. Human settlement of the floodplain flourished during this time, and included the intense exploitation of rice, fish, shellfish, wild deer, fowl, pig, water buffalo and cattle. Drier floodplain conditions would have facilitated landscape management directed towards agriculture and managed vegetation communities (Boyd and McGrath 2001b).
- Sub-phase C. The final sub-phase is represented by the sandy and clay infill of anthropogenic related channels at the margins of the archaeological sites (the "moats"). These are restricted to the Iron Age occupation at sites on the floodplain, and date largely to *c.* 2,200-1,500 years BP. The channels may have either been modified natural channels or, later, constructed features, and were managed (Boyd *et al.* 1999a,b, McGrath and Boyd 2001). It also is likely that they represent the modification of channels active during Sub-phase B, and were the constructed successors to Sub-phase B channels. This sub-phase is characterised by intensification of the socio-cultural factors and a reliance on rice cultivation and domesticated cattle and pig. The short-lived nature of the channels and infill of this drainage pattern is argued to reflect a decline in regional availability of water and is linked to the subsequent regional changes in settlement pattern (Boyd *et al.* 1999a,b; Habberfield-Short 1999).

Palaeogeographical Phase 6: Late Holocene

This phase is represented by the establishment of channels (Unit 10) that occur on and within the current floodplain land surface. This period of sedimentation represents the late Holocene sedimentary record for the region, and probably post-dates the Khmer occupation in the area. Bishop and Godley (1994) document higher discharge rates at the Yom River in Central Thailand after 1,700 years BP, and it is likely that the onset of wetter conditions in the northeast are related to the onset of climatic conditions similar to the present. Areas that are not drained by channels at the present, but were previously drained by rivers (e.g. the valleys between bedrock interfluves) are now characterised by wide alluvial-style sheet-wash drainage. This drainage feeds the larger channels and main rivers such as the Lam Prasat and Mae Nam Mun. The relationship of this final phase of drainage with former archaeological patterns is unclear. Channel-style drainage patterns ceased to exist at places such as Ban Non Wat since the infilling of former channels and the moats. It is likely that the development of present drainage patterns is a recent historic period phenomenon.

IMPLICATIONS OF THE PALAEOGEOGRAPHICAL MODEL FOR THE ARCHAEOLOGY OF THE NOEN U-LOKE AND NON MUANG KAO AREA

There are three groups of implications arising from this palaeogeographical model: those derived from variability of past environmental conditions; those for the human occupation in the region; and those informing understanding of archaeological site formation.

Implications derived from variability of past environmental conditions

Considerable variation is reflected in past landscapes during the Holocene. Of particular importance for the archaeology are the kinds of landscape that were present at the time of first human settlement, and the ensuing landscape changes throughout the time of occupation in the region. The earliest period of known human occupation in the study area (i.e. the Neolithic occupation at Ban Non Wat) was associated with a well-watered landscape characterised by upland and lowland zones during the late mid-Holocene (Palaeogeographic Phase 4). Regional disturbances in vegetation through firing and widespread decline in regional wooded communities may reflect an intensification of human activity in the Khorat Plateau as far back as 6,400 years BP (Penny *et al.* 1996). However, this Phase represents the availability of a wide range of microenvironments for the early settlers. Aside from relatively high-energy riparian regimes, plains and back swamps, a range of dryland conditions and associated vegetation communities would have been within immediate access to the archaeological sites or within a short distance on the upland interfluves. These conditions would have provided a landscape locality with a considerable range of resources suitable for human occupation supported by, for example, swidden-type agriculture and broad-spectrum hunter gathering.

These conditions appear to have been short lived. By the late Bronze Age (*c.* 3,000-2,500 years BP), the hydrology associated with sites such as Noen U-Loke and Ban Non Wat underwent major changes as lower energy conditions established themselves. Such conditions probably relate to the establishment of open savannah-like grasslands on the floodplain and major anthropogenic-related impacts

on forest vegetation communities (Boyd and McGrath 2001a,b). By the time of Iron Age settlement (*c.* 2,500-1,500 years BP) landscape change was well under way, with the establishment of a managed landscape and increasing aridity (Boyd and McGrath 2001a,b). Settlement by this time is associated with declining resources in the immediate site locality and a reliance on rice cultivation, animal husbandry and some broad-spectrum gathering (McCaw 2000).

Implications for human occupation in the region

The second set of implications concerns a model proposed by Boyd *et al.* (1999a,b), namely, that the Iron Age sites are intimately related to a period of higher runoff characterised by broad belts of multi-string channels. Their observations rely extensively on aerial photograph interpretations of the relationship of the moated sites to former drainage patterns. They relate the high-runoff conditions with the formation of the "moats" at these sites, and support this claim with evidence of the spatial relationship between site location and ancient river patterns. However, there is an issue with the timing of the hydrological patterns, their relationship to the archaeological sites and, hence, their relationship to the formation of the "moats" themselves. One of the implications of the palaeogeographic model presented here is that the landscape the earliest settlers moved into was characterised by higher runoff conditions in comparison to both the Iron Age and present. Importantly, many of the Iron Age moated sites in the floodplain (such as Noen U-Loke, Ban Non Wat, Ban Prasat, and Ban Makham Thae) that Boyd *et al.* describe as being significantly related to past drainage patterns were initially settled in the Bronze Age and possibly earlier. This would suggest that the patterns Boyd *et al.* record are reflections of the palaeogeographical conditions under which the original inhabitants in the region lived some 3,500 years ago. While this still links early human settlement of palaeodrainage conditions, this early (i.e. pre-Iron Age) association between sites and rivers implies that the development of the "moats" during the Iron Age related more to changing hydrological conditions rather than hydrological conditions per se. The development of the "moats" can, therefore, better be explained in terms of human responses to increasingly variable and less reliable water conditions, and perhaps reduced river flows, during the Iron Age. A disruption in the availability of resources, such as a decline in the water supply or reliability in water supply within short distances of the sites, is potentially associated with greater risk and stress for prehistoric communities (Rautman 1993). In the case of the upper Mun River valley and the Noen U-Loke and Non Muang Kao area, this may have stimulated significant cultural responses. It is perhaps to be expected that, against this backdrop of changing and evolving environmental conditions, socio-cultural structures were developed to manage the impact of resource variability: society-wide development of moats, increasing conflict, and exponential changes within domestic, technological and industrial spheres (Chang 2002, Higham 1996a, Higham and Thosarat 1998a, McCaw 2000, McGrath 2001, Talbot 2002).

Implications for site formation

The implications relate to the relationship of the changes of floodplain sedimentation through time to the processes of archaeological site sedimentation. Both Phase 4 and Phase 5 sediments bear stratigraphic and textural relationships with the moated sites at Noen U-Loke, Non Muang Kao and Ban Non Wat; the archaeological sites provide relative dating for the transitions in environmental conditions, because they are composed of sediments derived from sediment deposition during both phases. This supports the conclusions that Phase 4 provides the context for the geological landscape and context into which people moved more than 3,500 years ago, and Phase 5 defines the physical landscape these people abandoned. This is significant because it places, into the timeframe of the sites, a period of fluctuation in sedimentary and physical conditions associated with the Phase 4 to 5 transition. This signifies an important relationship between the sedimentation of the mounds, the formation of the moats and the deposition of young alluvial sediments on the floodplain near sites such as Noen U-Loke and Ban Non Wat. It also downplays the potential role of catastrophic events, such as flooding and their associated implications for the emergence of moated sites (cf. Nutalaya *et al.* 1989; Boyd *et al*. 1999a); such extreme processes need not be invoked to explain site formation. The emergence of the moated sites can instead be considered against a backdrop of relatively normal Holocene environmental processes, and the human need to manage and harness natural resources at times of environmental change and increasing resource stress. This is significant because research in the past has focused on environmental conditions only during the Iron Age and especially on these resources being under optimum conditions (Boyd *et al.* 1999a,b; Boyd and McGrath 2001a,b; McGrath and Boyd 2001). We now have a longer environmental-historical context for the development for sites such as Noen U-Loke that focuses on the effects of changing environmental conditions on the human responses to natural resource use.

II. THE GEOARCHAEOLOGY OF NOEN U-LOKE AND NON MUANG KAO

W.E. BOYD

INTRODUCTION

This report summarises the results of various geoarchaeological studies, now published in the scientific literature, conducted on the encircling earthworks of Noen U-Loke, Non Muang Kao and related nearby sites. While the full published results are based on data gathered at several sites and across the project study area, this report focuses on those data of primary interest to Noen U-Loke and Non Muang Kao. For full details of methods, data and interpretations at other sites, readers are referred to the original publications.

Several types of archaeological site tie the prehistory and early history of the region into the broader sequence of social and cultural development in the past. However, the work reported here focuses on examples of sites originally considered to date predominantly from the Iron Age. These sites typically cluster in the Mun and Chi valleys, the major Thai tributaries of the Mekong River. In particular, they are characterised by distinctive surrounding earthworks, commonly known as "moats" (Williams-Hunt 1950), that form a large component of the geoarchaeological attention. While it has now been demonstrated that these sites date from earlier periods, the encircling earthworks appear to be primarily Iron Age features. Consequently, the geoarchaeological work described here tends to focus on that latter period rather than provide an environmental perspective for the entire period of settlement. Work is still in progress, both at other archaeological sites and off-site, that will provide a longer-term environmental context for Noen U-Loke and Non Muang Kao.

AIM OF THE GEOARCHAEOLOGICAL RESEARCH

Geoarchaeology is defined as the application of geological and geomorphological techniques to address matters of the physical environment and palaeoenvironments associated with archaeological sites and their study. To this end, geoarchaeological research concerns itself largely, although not exclusively, with the sediments and geomorphology of features on or associated with the archaeological site, with a view to determining aspects of the past environments associated with the prehistoric occupation of the site and processes which have been influential upon these environment and the prehistoric occupants. Geoarchaeological research, therefore, largely focuses on the analysis of sediments and their constituent parts, using samples derived from archaeological and non-archaeological contexts, and the analysis of geomorphological features. These analyses yield evidence of the past environmental conditions that affected the study area prior to, during and following the prehistoric occupations that are the interest of the archaeologists. This evidence may provide indications of the nature of these past environments and relationships between people and these environments. Specifically, geoarchaeological research may tell us about: past climates and climatic changes; details of soil-forming processes; sediment deposition and erosion; the creation of geomorphological features; the character and development of vegetation and other ecological conditions; processes of archaeological site formation, destruction and preservation; and possibilities regarding human access and use of natural resources or impacts upon these sites. In summary, geoarchaeological research provides the means to understanding the geographical settings of the archaeological site, providing palaeogeographical descriptions of environmental conditions prior to, during and following prehistoric occupation.

The particular geoarchaeological research questions posed range quite widely, and concern the geomorphological and sedimentological origins of the archaeological sites and, especially, the surrounding earthworks. The relationship between the archaeological sites and the surrounding environment is of particular interest. Several angles have been examined in this regard. What was the landscape like before, during and after the Iron Age occupation? Can we identify environmental processes and conditions that may have constrained or enhanced the Iron Age settlement in the region, influenced the form and organisation of settlement and settlement patterns, and played a role in the late Iron Age changes in settlement pattern? What were the natural resources available to the Iron Age occupants, how were they accessed and utilised, and what impacts did settlement have upon them? In other words, the geoarchaeological research is interested in identifying the environmental parameters pertinent to the Iron Age occupation and use of this landscape, and thus the research aims to establish the palaeogeographical and geological landscape contexts of the archaeological sites being studied and the interpretations derived from the excavation and analysis of data and artefacts collected .

OVERVIEW OF THE WORK COMPLETED TO DATE

Several studies have examined the formation of the

mounds and their surrounding earthworks. Roger McGrath completed his doctoral research on the sedimentary stratigraphy, geomorphology and chronology of the surrounding channels at several sites, including Noen U-Loke and Non Muang Kao, focusing on: (a) establishing the nature of the formation of these channels, with an interest in identifying the relative roles of nature and human processes in their creation; (b) describing and interpreting the sediment infills of the channels, with a focus on identifying the sedimentary and hydrological regimes responsible for these (and thus possibly identifying the climatic and other environmental parameters influencing the history of these channels); and (c) establishing a chronology for channel formation and infilling (McGrath 2001). Jeremy Habberfield-Short has completed his doctoral research on establishing the site-formation history of the mounds at, amongst several sites, Noen U-Loke and Non Muang Kao (Habberfield-Short 1999, submitted). He focused on the physical and chemical characteristics of the sediments making up the mounds, to determine: (a) sources and processes of deposition; (b) inferred environmental conditions during the period of site development; and (c) relationships between human activity and sedimentation.

Other studies allow the sites to be placed into broader geographical contexts, and have emphasised the ways in which the landscape changed through time. The landscape into which the Iron Age people moved was very different to that in which they lived and eventually left. The way in which it changed tells us much about the conditions the prehistoric occupants encountered and had to adapt to, and the ways in which they may have change the environment. First, a substantial study of the aerial photograph coverage of the study area by Boyd provided a detailed description of the Mun valley floor within the study area, highlighting important changes in rivers of the region, and the ways in which former river systems related to the archaeological sites. Importantly, the present river system bears little direct relationship with the archaeological sites, and we need to understand the river regime for the Iron Age in order to understand any relationship between people, their towns and the rivers of this region. Secondly, pollen analyses (by Boyd and McGrath) provide a history of vegetation change for the period of archaeological interest. Finally, we have established a detailed chronology, using, mainly, radiocarbon dating, for the earthworks.

Lastly, while most of the on-site archaeological features are readily explicable, several remains are less readily identified, including fragments of burnt clay recovered from Noen U-Loke. Two Honours students, James Chetwin (University of Otago) and Jeff Parr (Southern Cross University) have examined fragments of this material, with a view to working out their origins.

Publication of the research in this project is well advanced (Boyd 2004), with papers being published under a series title "The geoarchaeology of the prehistoric ditched sites of the Upper Mae Nam Mun valley, Thailand". Commencing with a detailed regional mapping programme, largely based on aerial photograph interpretation (Boyd, Higham and McGrath 1999), Boyd constructed a palaeogeographical model for the study area, demonstrating, in particular, that the fluvial conditions of the floodplain have changed in the past, and that the archaeological sites are intimately and geographically associated with a former river system. This model thus provided a basis for hypotheses regarding the role of environmental, and possibly climatic, change in the history of the Iron Age presence. In particular, the model identified a close relationship between the channels surrounding the sites, and the former fluvial system.

This relationship was further examined using a series of long trenches exposing the sediments of these earthworks. Such work had not been previously undertaken, and despite their prominence, most earlier consideration of the earthworks was based only of their superficial appearance. The trenching, of course, exposed considerable lengths of sediment sequences, and it became immediately apparent that the channels were diverse and complex: surface expression of these was not a good predictor of buried features (Boyd *et al.* 1999b).

Further work has defined the chronology of these features, with the publication of the most comprehensive dating programme for any such features in the region (McGrath and Boyd 2001), an examination of the geochemistry and physical sedimentology of these features (McGrath, Boyd and Bush, in press), and a detailed record of past vegetation change on and around the sites (Boyd and McGrath 2001a, b). The pollen analysis, in particular, provides evidence for a dynamic and partitioned landscape during the Iron Age, and forms the basis for arguments that social behaviour and change were closely related to changes in environmental conditions within this landscape. While work is well advanced on the surrounding earthworks, the on-site research continues, and publication has only recently commenced (Parr and Boyd 2002, 2003; this latter work is summarized below (chapter XXIV).

NOTE ON NOMENCLATURE AND MORPHOLOGICAL ASSUMPTIONS

By 1950, Williams-Hunt had established aerial photography as an archaeological tool for the then unstudied area of Northeast Thailand. He identified the abundant "irregular earthwork" sites (his initial term) of the Mae Nam Mun Valley as important prehistoric archaeological sites. In a cautiously-worded paper (Williams-Hunt 1950), he noted potentially significant site structural regularity and geographic patterning worthy of subsequent archaeological study. Significant though this contribution was, perhaps Williams-Hunt's most important contribution lay in what may have been a subconscious comment. Having care-

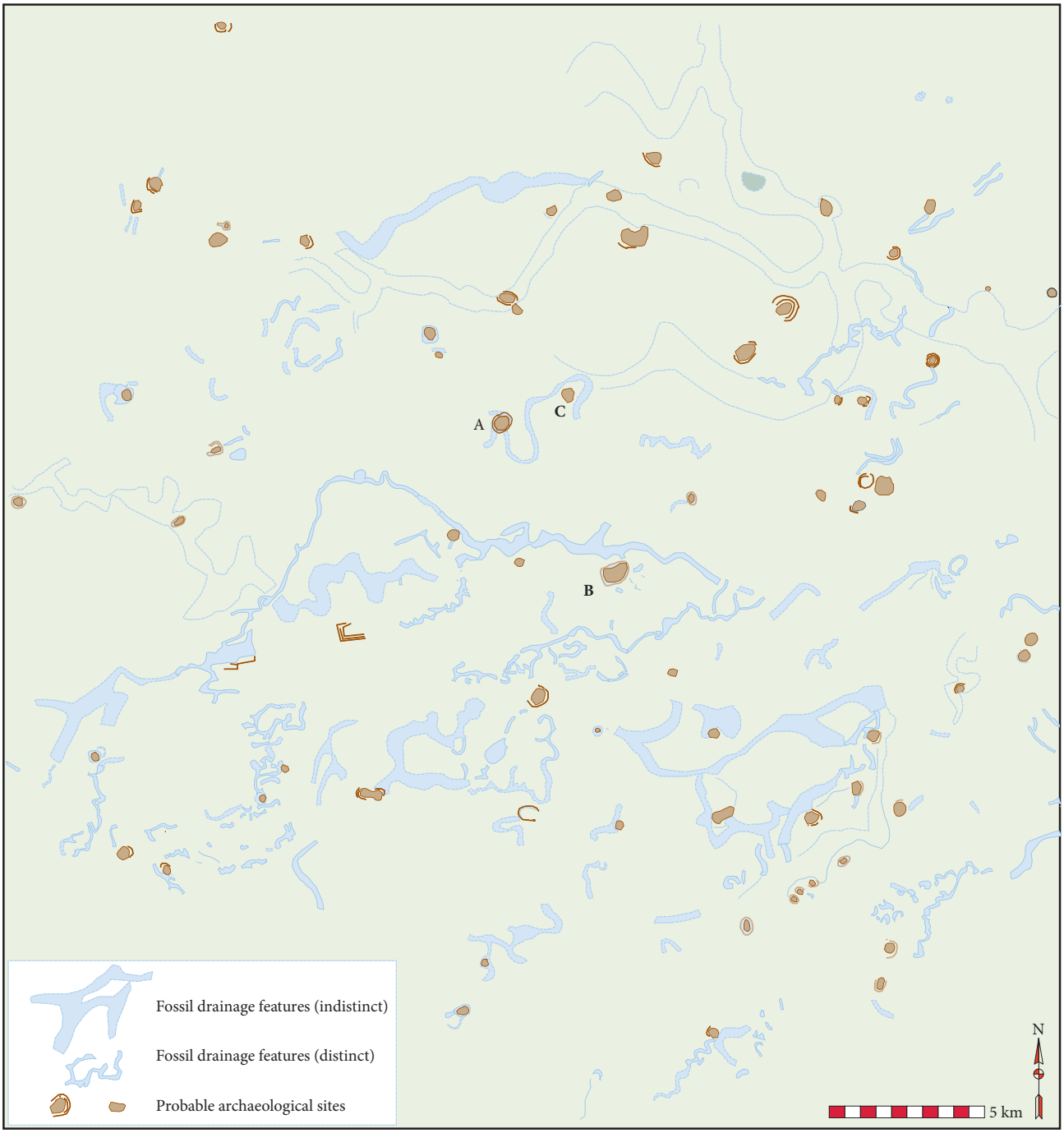


FIG. 2:1 Location of archaeological sites and former river channels, as mapped from the 1:42,000 aerial photography taken in 1954/1955. A. Noen U-Loke, B. Non Muang Kao, C. Ban Non Wat. The drainage pattern indicated around Noen U-Loke is provisional, and is not well supported by the larger-scale aerial photography (Figure 2:2) or fieldwork; patterns elsewhere in the study area were reasonably well supported by later work. The patterning identified for both sites in the 1:16,700 aerial photography (Figs. 2:2 and 2:3) is more reliable

fully described the sites as "earthworks" sites, towards the close his paper he refers to "ramparts" and, importantly, "moats"; the sites have became known as "moated sites", with all the implications that such a structure embodies.

STUDY ONE: PALAEODRAINAGE, SITE-LANDSCAPE RELATIONSHIPS, AND THE ORIGINS OF THE "MOATS"

The publication of geoarchaeological studies at Noen U-Loke and Non Muang Kao commenced with Boyd *et al.*'s (1999a) study of the landscape patterning of the archaeological sites in the study area. This was a study of the aerial photographic record of the study area. The abstract from that paper reads thus:

"The study focuses on the "moated" Iron Age sites of N.E. Thailand, first identified as significant prehistoric settlement sites in the 1940s from aerial photography. Two more recent photograph sets are used to map the surficial geology and prehistoric site distribution for a study area west of Phimai, N.E. Thailand, with a focus on site-landscape relationships and, in particular, relationships between site location and form and patterns of palaeodrainage. The derived record of the surficial geology reflects several phases of palaeodrainage, characterised by differing locations and types of former river channels. Of note is the differentiation between a recent period in which river channels, including those presently active, are single-string meandering channels, and an older period of broad belts of meandering multi-string channels. The prehistoric site distribution correlates closely with the older drainage, and for many, the encircling channels (the "moats") are closely associated with former river channels. These relationships provide a critical and novel model for site distribution; several implications arise, supported by emerging field evidence, and introducing issues for archaeological debate: (i) there is no need, as has been done in the past, to invoke prehistoric artificial forms of drainage associated with the sites; (ii) the definition of the encircling channels as "moats" is seriously called into question; and (iii) the inferred geomorphological evolution of the floodplain implies past changes in environmental parameters such as run-off, climate or bio-physical environments. Since the sites are all located in or beside ancient meander belts, these parameters should now be introduced into archaeological discussions regarding the establishment, history, evolution and abandonment of the Iron Age sites. Methodologically, this paper illustrates the need to be aware of the complexity of aerial photograph interpretation in archaeological survey, showing that careful analysis of aerial photograph information may have a significant impact upon the modelling of prehistoric interpretations. Further stratigraphical studies will be reported subsequently, and will refine the models presented here."

The paper mapped and described in considerable detail the patterning of former rivers in the study area, notably with reference to the locations of many prehistoric sites. The study was based on the examination of two sets of aerial photographs, a 1954/1955 series of thirty-nine small-scale (*c.* 1:42,000) prints, and a 1974 series of twenty-six larger-scale (*c.* 1:16,700) prints. The 1954/1955 photographs provide complete overlapping and stereographic coverage of the study area, while the 1974 photographs provide partial coverage, limited to areas of selected archaeological sites, including Noen U-Loke and Non Muang Kao.

Boyd *et al.* (1999a) indicate that Non Muang Kao (called Site B10 in the paper; 15°13'N 102°17'E) clearly sits on a former channel complex. It is a large site, surrounded by discontinuous multiple ditches, which appear to located in a tight meander that formed the site margin to the north, east and south. The meander belt channels, flowing from the northwest, merge into the moats at several localities (Figs. 2:1 and 2:2).

Boyd *et al.* (1999a) suggested that Noen U-Loke (called Site B7 in the paper; 15°15'N 102°16'E) and two nearby sites (Ban Non Wat, just to the east at 15°16'N 102°17'E ; Ban Kho Hong to the west, 15°15'N 102°23'E) may have been related geographically to one another. The nearby sites of Ban Kok (15°14'N 102°19'E) and Non Muang Kao (15°13'N 102°17'E) lie to the southeast of these sites. The two sets of sites appear to be associated with separate drainage channels. From the aerial photography, it is clear that Noen U-Loke overlies a former meander belt (Figs. 2:1 and 2:3), lying slightly south of a major former channel, to which it may have been connected by one or more meanders entering at the northwest and exiting to the northeast, and flowing anticlockwise around the mound. Ban Non Wat lies downstream form Noen U-Loke, while Ban Kho Hong lies on the same meander belt; if it is contemporaneous with Noen U-Loke (the aerial photograph evidence suggests it may be younger), it would have been upstream from Noen U-Loke.

This evidence suggests that there were three meander belts in the study area, draining the floodplain from west to east. While Noen U-Loke and Ban Non Wat lay on the northernmost, other sites are associated with meander belts to the south; all probably merged not far to the east (only a few kilometers away), providing potential links between the various sites. The small-scale aerial photograph mapping yielded several distributional characteristics. Most importantly, it defined patterns of the present floodplain drainage and infilled channels representing earlier hydrological conditions. Three drainage systems are recognized, a modern drainage system, and two former drainage systems. There is some evidence for a NNW-SSE structural control on the patterning and disruption of the drainage on the floodplain in the past, possibly reflecting regional faulting patterns; more recently, geoarchaeological study of the area has raised the possibility of rising salt-domes within the bedrock providing a stimulus for structural disruption to the surface drainage (Boyd and Habberfield-Short, this volume). These conditions have

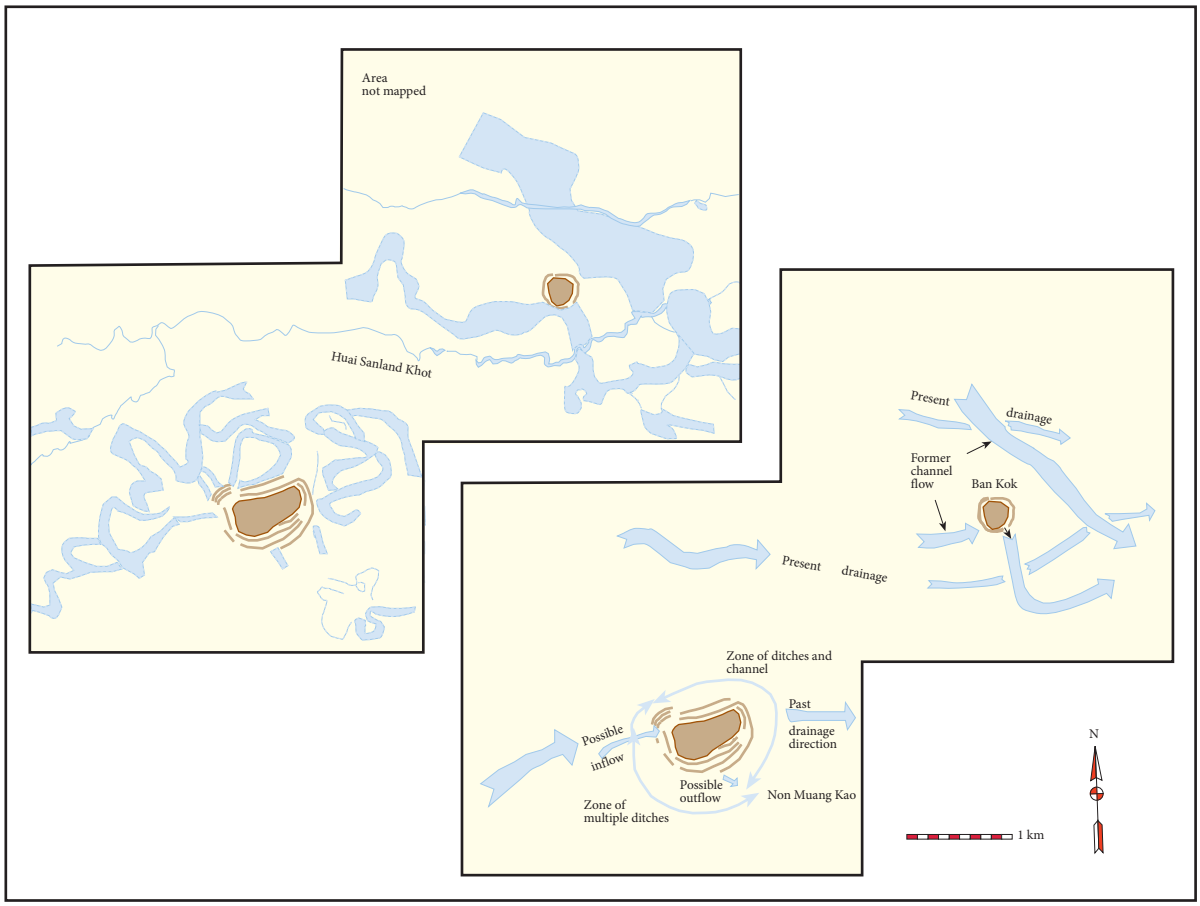


FIG. 2:2 Location of Non Muang Kao relative to evidence for former rivers, as mapped from the 1:16,700 aerial photographs taken in 1974. This interpretation also shows the site Ban Kok: (top) sediment mapping from the aerial photograph interpretation, showing the outlines of former river channels and areas of channels; and (bottom) the interpretation of the sediment mapping

produced a history of inherently unstable channel location, highly susceptible to change induced by fluctuations in factors such as sediment bedload and water flow. If these characteristics are typical of the area's history, the mapped patterns suggest that the northern drainage is long established and stable, whereas the central and southern areas contain relatively young river channels. Importantly, the aerial photograph mapping provided evidence that the prehistoric sites are clustered within the 20% or so of the floodplain characterised by the presence of former rivers. While, at this stage in the study, there was no evidence to indicate contemporaneity of the rivers and the sites, such a spatial patterning is highly suggestive of a real landscape relationship between the sites and the former rivers.

Boyd *et al.*'s description of the hydrological history of the floodplain, at least as could be mapped from aerial photographs, concluded that, of particular importance, is the differentiation between a recent period in which the river channels, including those presently active, are single-string meandering channels, and an older period when drainage comprised broad belts of meandering multi-string or anastomosing channels. The distribution of the prehistoric sites correlates closely with the older period drainage channels, and for many a close link can be demonstrated between the encircling channels (the "moats") and former river channels. It was suggested that these relationships provide a critical model for site distribution, and several implications arise from this model. In particular, there was no need to invoke prehistoric canals and other artificial forms of drainage associated with the sites; such redefinition of implied site function is potentially most important both locally and regionally. The inferred geomorphological evolution of the floodplain implies past changes in environmental parameters such as run-off, climate or bio-physical environments. Since the mapping indicates that the sites are all located in or beside ancient meander belts, these parameters now need to be introduced to discussions regarding the establishment, history, evolution and abandonment of the Iron Age sites. This work then formed a new foundation for subsequent geoarchaeological studies of these sites and their landscapes.

TABLE 2:1 *Stratigraphic units defined in the study of the sections through the encircling earthworks at six sites, including Noen U-Loke and Non Muang Kao in the study area*

Stratigraphic Unit	Summary description	Equivalent regional stratigraphic unit (Boyd and Habberfield-Short, this volume)
Unit 1	Bedrock: fresh and weathered red siltstone	Unit 1. Bedrock
Unit 2	Floodplain alluvium: thin layer of weathered alluvium: mixed bluish or brownish grey sands and clays, with calcareous concretions and pisoliths with depth; thin soil A horizon	Unit 4. Old Alluvium
Unit 3	Channel infill sediments: mainly stiff weakly weathered blue grey clay with occasional fine gravel (in channels close to sites), and gravel, sand or reworked alluvium (in channels further from the sites); channels cut into Units 2 and, in some cases, 1	Unit 9. Sandy and clay channel infill
Unit 4	Archaeological sediments: mixed natural and anthropogenic sediments with artifacts and structural features related to human occupation	Unit 8. Archaeological sediments; also may be modern
Unit 5	Sand: well sorted coarse sand at base of channels on two sites (including Noen U-Loke)	Unit 3. Polycrystalline river sediments
Unit 6	Spoil: disturbed and poorly consolidated sediments located on the mound edge or the moat banks	Unit 8. Archaeological sediments; also may be modern

STUDY TWO: STRATIGRAPHY AND MORPHOLOGICAL SECTIONS OF THE ENCIRCLING EARTHWORKS

Once it had been established that the sites and their encircling earthworks had a distinctive and crucial relationship with former river systems, it became important to understand the nature of the encircling earthworks. This question was addressed by examining sections, cut by mechanical excavator, across examples of the encircling earthworks at selected sites in the study area, including Noen U-Loke and Non Muang Kao. This work was reported by Boyd *et al* (1999b). The abstract of that paper read:

"Iron Age occupation of a large number of sites in the Mun River Valley N.E. Thailand are characterised by distinctive encircling earthworks, these sites being commonly known as "moated sites". The previous focus on the "moat" as an essential structure has tended to obscure the relationship between site and landscape. This paper reports the preliminary results the first excavations of any significance within the moats themselves at six sites – Noen U-Loke, Non Muang Kao, Ban Non Khrua Chut, Ban Non Ngiu, Ban Makham Thae and Ban Non Wat – where the structure of the moats has been examined in section. Lithology, stratigraphy and cross sectional morphology have been recorded, and from these observations several broad conclusions may be reached and are reported

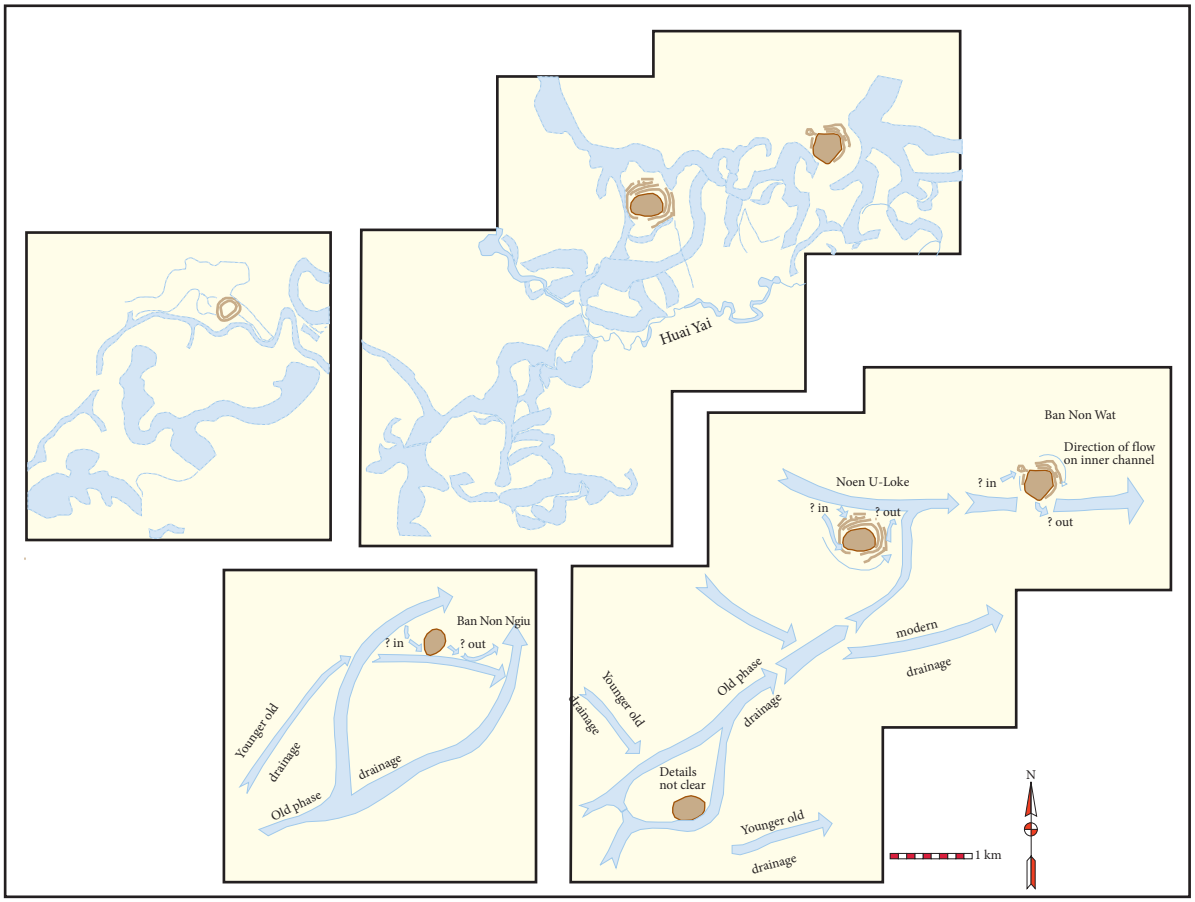


FIG. 2:3 Location of Noen U-Loke relative to evidence for former rivers, as mapped from the 1:16,700 aerial photographs taken in 1974. This interpretation shows the sites of, from west to east, Ban Non Ngiu, Ban Kho Hong, Noen U-Loke and Ban Non Wat: (top) sediment mapping from the aerial photograph interpretation, showing the outlines of former river channels and areas of channels; and (bottom) the interpretation of the sediment mapping

here. Typically, subsurface features comprise infilled river channels and an undulating bedrock and alluvial surface. Significantly the surficial morphology of the moats, and the notable regularity of shape and patterning of the moats in plan, usually does not reflect buried channel morphology. The surficial patterning of the moats may, indeed, be a relatively recent phenomenon, and the buried channel features probably reflect more accurately the landscape of the period of Iron Age occupation of the region."

The work reported by Boyd *et al.* (1999b) was based on examination of the encircling earthworks at six sites including Noen U-Loke and Non Muang Kao. These were examined in section by excavating one or more trenches along lines perpendicular to the trend of the moats across the moat complexes, with a mechanical backhoe. The excavations exposed the buried features of the moats, allowing detailed examination and mapping of the lithology, stratigraphy and cross sectional morphology. Samples were also taken for pollen analysis and detailed sedimentological analysis (reported in later papers; see below). In this paper, the term "channel" was reserved for the subsurface features, whereas the term "moat" referred to the surface expression; this provided a practical resolution to the problem of the term "moat" discussed above. Six stratigraphic units were defined in this study (Table 2:1).

Site-by-site descriptions emphasise that each site's encircling earthworks are individually different.

Non Muang Kao

This site is a large and irregularly-rounded multiple mound, with several ditches discontinuously surrounding the mound . Two trenches were cut through the moats, one to the north and one to the northwest of the mound (Fig. 2:4). The length of the trenches at this site was restricted by land tenure.

- The northern 140-m-long trench crossed two moats, ending on the top of the outermost bank. The innermost moat overlies a concave channel cut through alluvium and bedrock, and is filled with grey clay with interfingering archaeological material at the site edge. The first bank has a spoil cap containing some bedrock, over a core of alluvium. The outer moat is very wide and shallow with two small deeper channels on either side of the moat; it is filled with a reworked alluvium over *in situ* alluvium, and the outer comprises spoil over alluvium.
- The northwestern trench is 74m long but did not

completely cut the outermost moat. There is an inner channel partly underneath the mound edge, filled with grey clay over archaeological sediments and bedrock. Away from the mound edge, the bedrock surface rises before dropping to form a second grey-clay-filled channel.

Noen U-Loke

Three trenches were cut through the moats at Noen U-Loke, one each to the north, south and east of the mound (Fig. 2:5).

• The northern 232m-long trench crossed four moats, ending in surrounding fields. A possible buried channel lies at the side of the mound with a second one cut against the mound side. The inner-most moat is filled with grey clay, with channels on either side cut into the underlying alluvium. The first bank is capped with spoil over alluvium. The next moat has a U-shaped channel cut into the alluvium, while the second bank is all spoil over an alluvium base. The third moat has two channels cut into the alluvium, separated by alluvium rising to the surface. The inner-most is small and filled with grey clay interfingering spoil at the edge, while the outer is larger and filled with reworked alluvium. The third bank is mainly alluvium with some capping spoil. The outermost moat has a reworked-alluvium-filled single channel cut to bedrock in places, and the outermost bank is all alluvium.

• The southern 244m-long trench crossed five moats, ending in surrounding fields. Three channels are buried under mound-edge archaeological sediments: the first is filled with a grey clay, contains pot sherds, and may be large; the others are filled with coarse reddish sand and also contain sherds. The first moat, filled with grey blue clay overlaying bedrock, has a small channel cut into the bedrock. The bank comprises spoil over alluvium. The second moat contains grey clay that continues under the second spoil bank. The third, narrow and shallow, moat has a thin layer of grey clay over alluvium; the third bank is spoil over alluvium. The fourth and fifth moats were filled with grey clay over floodplain alluvium; the fourth bank comprises only floodplain alluvium, while there is spoil over alluvium on the outermost bank. Importantly, this section revealed three channels under the archaeological mound, and only one moat appears to overlie a buried channel noticeably cut into the alluvium or bedrock.

• The eastern trench is 130m long and crossed two moats. The first has two channels separated by alluvium

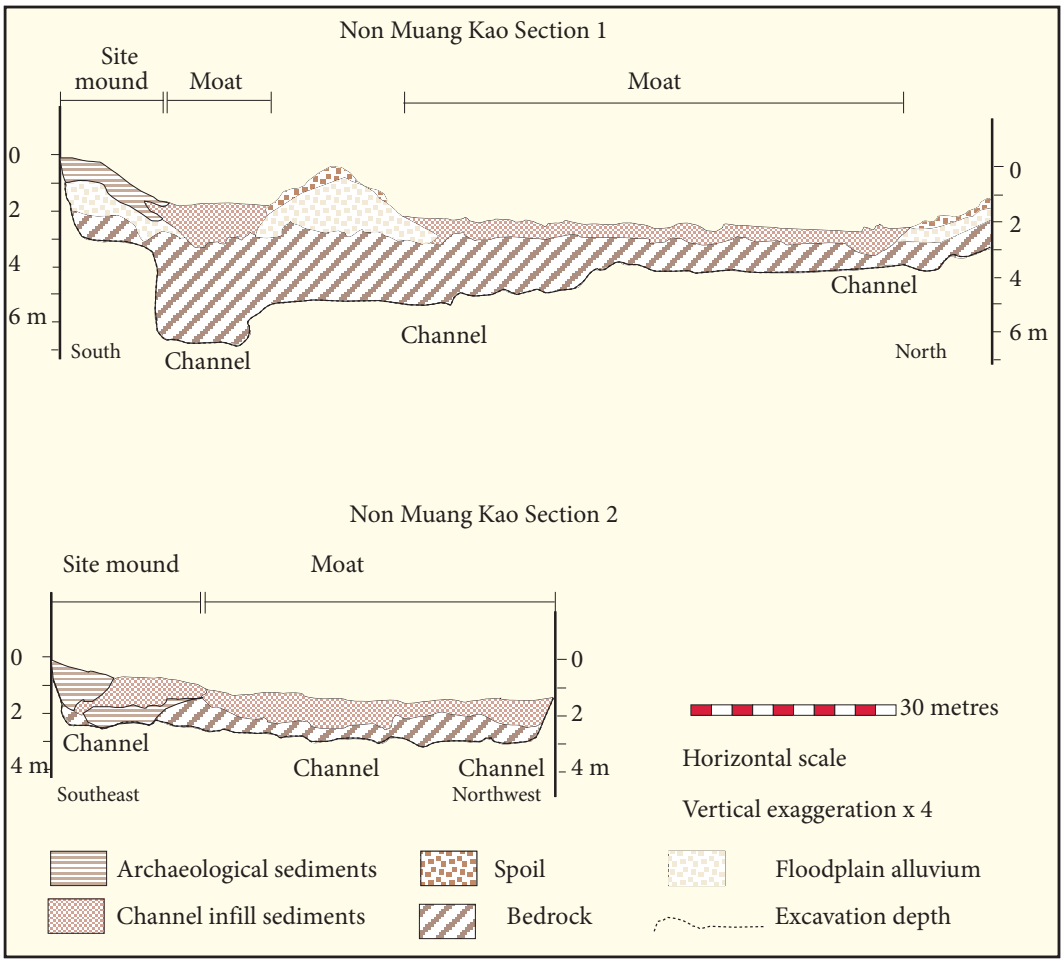


FIG. 2:4 Section through the encircling earthworks at Non Muang Kao. The stratigraphic units are equivalent to the units summarized in table 2:1

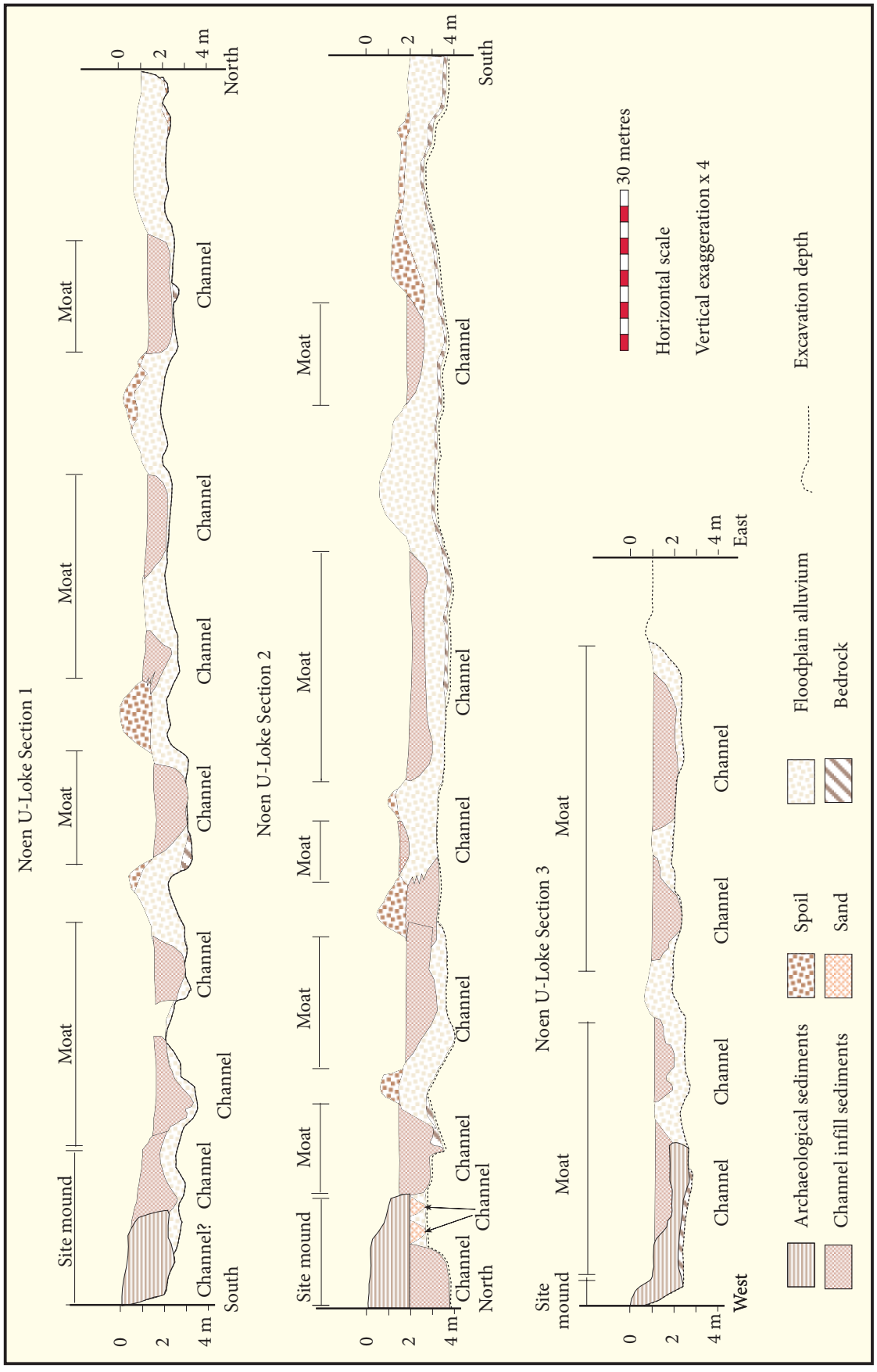


FIG. 2:5 Sections through the encircling earthworks at Noen U-Loke. The stratigraphic units are equivalent to the units summarized in table 2:1

at the surface; both are filled with clay and reworked alluvium, and are cut into alluvium. The first bank consists entirely of alluvium. The second moat also has two channels separated by alluvium, both filled with reworked alluvium; it was difficult to distinguish the basal morphology. The outer bank appeared to be alluvium and modern.

This and the equivalent evidence from other sites confirmed that channels were in existence while the sites were occupied, and that sites expanded over the top of earlier and now-buried channels. The channels appear to be older towards the archaeological mound, and those at the mound edges tend to be late Iron Age at the oldest. Importantly, however, the evidence indicated that moat surface morphology rarely reflected subsurface section morphology. Generally the moats have wide and flat surfaces, whereas the buried morphology reflects an uneven surface with previously unrecorded incised channel features that are not expressed at the surface. These buried features resemble small low-flow channels set in wider flood-flow channels, although the innermost moat at Non Muang Kao in underlain by a channel that strongly resembles a former river channel. Some of the channels extend under the site mound and under present banks. At Noen U-Loke some moats contain two distinct channels; this may be due to modern removal of banks to form larger rice fields. Most of the banks have a core of *in situ* alluvium, have generally been modified or disturbed. The origin of bank spoil is not always clear, although in some cases bedrock indicates possible ancient excavation of the buried channels; some may be modern.

The study at the time concluded that there was little evidence for substantial construction of either the channels or the banks between the moats; this conclusion has been substantially revised subsequently, and there is clear evidence that both are the results of significant engineering of the landscape (McGrath 2001; see below). It was also concluded that the regularity of shape and patterning of the moats in plan is a recent phenomenon, and probably reflects 20th century landscape tidying. The moats that had drawn so much attention to the archaeological sites largely represented modern landscape processes, in which residual geomorphological features from a former alluvial system provided optimal rice-growing conditions and thus attracted the urge to tidy landscape; these places contain the best soils, are the most expensive land, and represent the form of modern field design used to optimise rice production.

STUDY THREE: THE CHRONOLOGY OF THE IRON AGE MOATS OF NORTHEAST THAILAND

With a sense of the spatial distribution of sites and their encircling earthworks providing a model linking the sites and potential palaeolandscapes, and evidence for the morphological details of the encircling earthworks themselves, it is now possible to start to integrate the earthworks into a landscape history. A critical aspect of this is the chronology of the earthworks, which, linked to the on-site chronology provides a fuller picture of the prehistory of these sites. The next study concerned itself with the chronology of the earthworks. The abstract of the publication emerging from that study (McGrath and Boyd 2001) is as follows:

"This paper reports the first chronometric study of the “moats” of the abundant mounded Iron Age sites of northeast Thailand. While previous research has placed the construction and use of the moats within the Iron Age, no sound chronometric data has been available to support this. This study reports 34 AMS C14 dates and 4 TL determinations, which, together, indicate that the moats probably date from a relatively short period during the Mid and, especially, Late Iron Age, and that they infilled relatively rapidly shortly after their creation. The dates also contain preliminary evidence for the chronology of landscape change, a chronology critical to the understanding of the Iron Age occupation of this region."

This study was based predominantly on the AMS radiocarbon (C14) dating of microscopic charcoal collected from sediment samples from the sections across moats and banks described in the previous section, including at Noen U-Loke. Quantities of carbon were very small, hence the use of the AMS radiocarbon dating; dates were reported following established conventions. At Noen U-Loke (and one other site) sand samples were also analysed for thermoluminescence (TL) dating.

Of the thirty-four C14 determinations and four TL dates obtained for this study, four C14 and two TL dates are available for Noen U-Loke (Table 2:2). None were collected for Non Muang Kao (but see Habberfield-Short and Boyd, this volume, regarding later analyses). Two C14 dates (OZD669, OZD670) are from separate buried channels beneath the edge of the mound. These produce similar ages of 81-339 calAD and 87 calBC-114 calAD respectively, which overlap around the first century AD; OZD670, from a channel closer to the edge of the mound, is slightly older. The other two C14 dates (OZD671, Wk6490) were from 1.4m below the first moat, and are from the same spread of carbonised rice grains; there is some overlap of calibrated ages (405-600 calAD and 543-798 calAD). One TL date for Noen U-Loke (W2820) is stratigraphically deeper than the other TL samples, and produced a relatively old age of 69,400±10,800 years before 2000 AD. The second (W2821), from 2m depth, produced a more recent age of 3,333±333 years before 2000 AD; it is from the same buried channel and similar depth as the AMS date OZD670 (87 calBC-114 calAD), *c.* 1000 years younger than the TL date; the stepped plateau exhibited by the samples during TL analysis indicates that the TL clock may not have been fully reset before deposition and burial, resulting in this older age determination.

The significance of these dates can be assessed against

the entire data set, and against the dating of the archaeology in the region. At Noen U-Loke, for example, the early Iron Age is dated to 500-1 BC and the late Iron Age to 1-500 AD (Higham 2000). In comparison, the C14 dating of the channel features provided a range of ages between 2130±50 BP and 1364±63 BP, which calibrates to 357–3 cal-BC at the earliest to 543-798 calAD at the latest. The dates are generally similar across sites; while they lie between 300 BC and 600 AD, most lie between 0 to 600 AD. At Noen U-Loke (and other sites) channels buried below the mounds produced older ages than the moat infill, indicating channels closer to the site are older and have been concealed by the expanding mound. It was not possible, however, to establish if the channels beneath the sites are natural or anthropogenic, although dating of the banks revealed that at least some of the banks, and by implication the channels, were constructed. Individual channels filled in rapidly, with channels closest to the mounds being overtopped by the expanding occupation mounds, in some cases shortly after construction. McGrath and Boyd (2001) argued that the evidence suggested that the channels were constructed with the bank material at each site being excavated and redeposited at a similar time rather than as a slow natural accumulation of over-bank deposits. Although there was no chronometric data available for the banks at Noen U-Loke, in general the evidence across the study area indicated that not only were the banks constructed, but also the construction at each site was confined to short periods.

STUDY FOUR: POLLEN ANALYSIS AND A VEGETATION HISTORY OF THE MOATED SITES

In addition to offering insight into the chronology of the encircling earthworks, the channel infill sediments also provided an opportunity to examine the vegetation surrounding the sites, and the history of that vegetation. This yields a landscape history closely associated with both the environment in which the prehistoric people lived,

TABLE 2:2 *Details of radiocarbon (top) and TL (bottom) dates obtained for samples in the encircling earthworks channels at Noen U-Loke. (Source: McGrath and Boyd 2001)*

Laboratory code material dated and depth (m)	Reported conventional C14 age years BP	Calibrated ages 1 sigma cal BC/AD with relative probability	Calibrated ages 2 sigma cal BC/AD with relative probability	Calibrated minimum and maximum 2 sigma
OZD669 Charcoal 2.25	1817 ± 50	AD 131 – 248 at 96.9% AD 308 – 313 at 3.1%	AD 81 – 263 at 83.4%, AD 274 – 339 at 16.6%	AD 81 – 339
OZD670 Charcoal 2.15	1991 ± 35	BC 38 – 29 at 12.4% BC 22 – 10 at 18.5 % BC 1 – AD 31 at 49.3% AD 38 – 53 at 19.8%	BC 87 - 81 at 1.2% BC 54 – AD 82 at 97.7% AD 108 - 114 at 1.1%	BC 87 – AD 114
OZD 671 Carbonised rice 1.4	1572 ± 46	AD 435 – 533 at 100%	AD 405 – 600 at 100%	AD 405 - 600
Wk 6490 Carbonised rice in clay 1.4	1364 ± 63	AD 619 – 697 at 78.2% AD 698 – 716 at 11% AD 749 – 764 at 10.8%	AD 543 – 553 at 0.8% AD 554 – 780 at 98.9% AD 798 – 798 at 0.3%	AD 543 - 798
Laboratory code and depth in metres	Thermoluminescence age years before 2000 AD	Plateau region	Analysis temperature	
W2821 4.2-4.3	3,333 ± 333	stepped	325 °C	
W2820 2.0	69,400 ± 10,800	325 - 500 °C	375 °C	

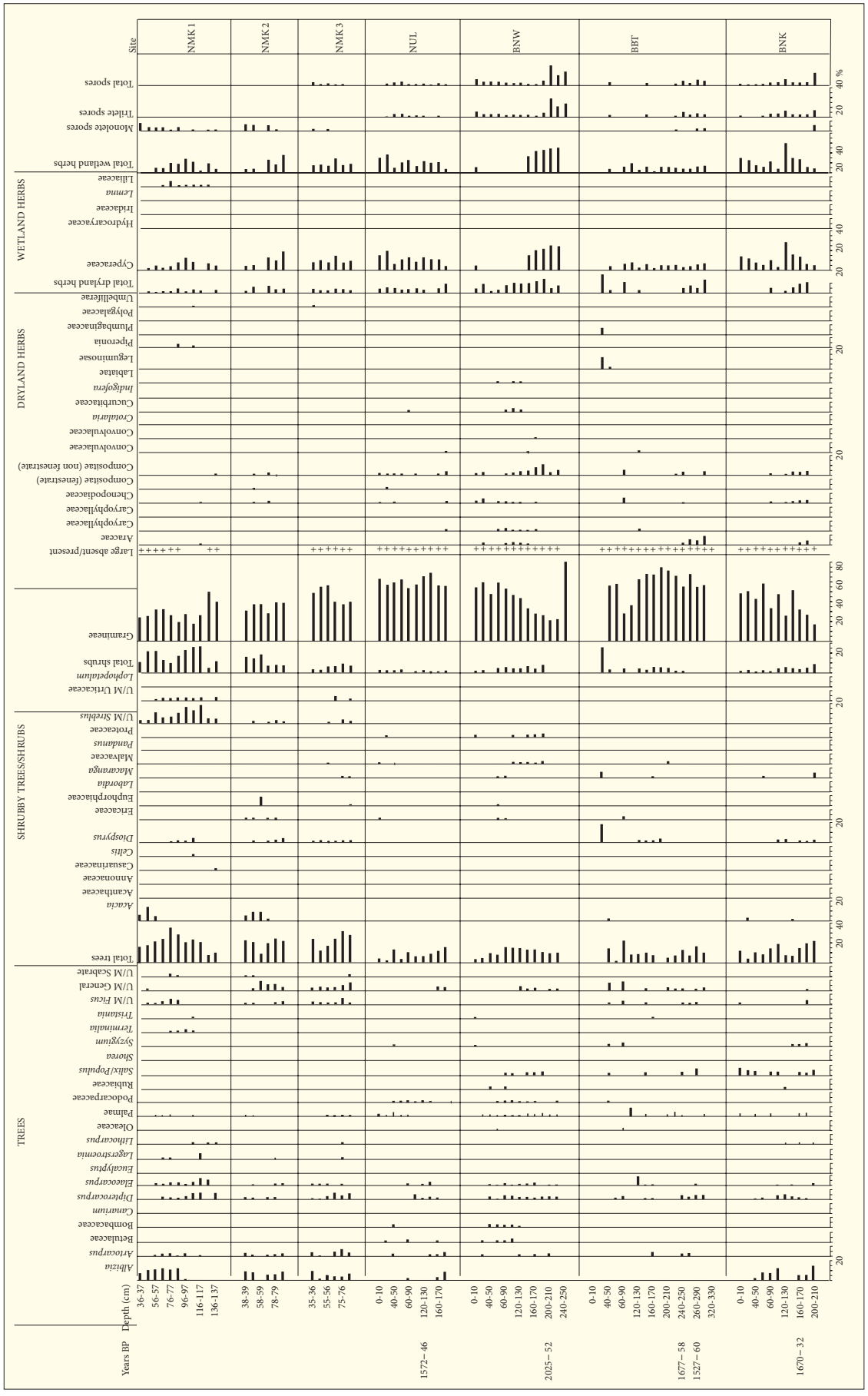


FIG. 2:6 Pollen diagram, showing pollen values expressed as percentages of total pollen spores per sample. The individual sequences are separated by a horizontal line. The site label corresponds to the localities. NMK 1-3 represents the three sequences examined at Non Muang Kao. The other sites are NUL, Noen U-Loke; BNW, Ban Non Wat; BMT, Ban Makham Thae; BNK, Ban Nong Khrua Chut

TABLE 2:3 *Vegetation changes at the archaeological sites of Noen U-Loke, Non Muang Kao and neighbouring Ban Non Wat, Ban Makham Thae and Ban Non Khrua Chut. Horizontal correlation in this table implies approximate chronological correlation, based on parallels in the form and direction of vegetation condition and change, and limited chronological control. This may be a simplification of the situation (See chapter III)*

Upper Mun Valley Vegetation Phase	Noen U-Loke	Non Muang Kao	Ban Non Wat	Ban Makham Thae	Ban Non Khrua Chut	Study area synthesis
VI Late to ?post Iron Age		Increasingly scrubby vegetation; reduction of grassland.			Open lands maintained.	Continuing grasslands and weedy and scrubby; limited woodland regeneration.
V Late Iron Age Period of significant human impact	Grassland, probably with rice; managed forest and/or woodland.	Grassland, probably with rice; managed forest and/or woodland.		Grassland, probably with rice; managed forest and/or woodland.	Grassland, sedgeland and slight woodland presence	Cultivation and arboriculture; forest and woodland decline; maximum vegetation diversity.
IV Period of decline in human impact	Reduction of grassland and rice; forest regeneration.	Reduction of grassland and rice; forest regeneration.	Reduction of woodland; increase in grassland, probably with rice.	Grassland with rice; forest regeneration following forest disturbance.	Grassland with rice; declining forest and/or woodland.	Pioneer forest and woodland established; partial forest and woodland regeneration.
III Period of significant human impact	Grassland, probably with rice; partially managed native forest.	Grassland, probably with rice; forest clearing.	Grassland, probably with rice; managed forest and/or woodland.	Grassland, probably with rice; disturbed native forest.	Grassland, probably with rice; disturbed and partially managed native forest.	Widespread forest clearance; maximum grassland expansion; cultivation with some forest and woodland management.
II Period of increasing human impact		Slightly disturbed native forest; grassland, probably with rice.	Conversion from wet to dry open land; replacement of native forest by managed forest.			Slight forest disturbance; partitioning of landscape commenced.
I Early-mid Iron Age			Grass and sedgeland, probably with rice; partially disturbed native forest.			Mosaic of openland and partially disturbed forest.

and indications of the effects of that settlement. Boyd and McGrath published two papers (Boyd and McGrath 2001a, b) discussing the results of pollen analyses of samples from channel sediments. The first paper (2001a) reported the details of the pollen analysis, and provided an initial biostratigraphy and thus vegetation history. The second paper (2001b), however, provided the opportunity to revise the chronology of the history, in the light of the chronological study then just completed (above); this also provided an opportunity to examine the ecology associated with the immediate surrounds of the sites more closely.

The abstract of the first paper (Boyd and McGrath 2001a) reads as follows:

"The upper Mae Nam (River) Mun valley of northeast Thailand has been occupied at least since the Bronze Age, but is notable for the rapid expansion of intense town-based Iron Age settlement. The area presently forms the seasonally-arid core of mainland southeast Asia, and is presently dominated by increasingly saline soils, low-productivity rice cultivation and regrowth semi-arid scrub. However, the archaeological evidence for this region indicates a highly-productive natural environment within the last two millennia. Pollen sequences from the infill of Iron Age features provide the first palynological evidence for this part of northeast Thailand, detailing late Holocene vegetational change. The area around the sites was initially dominated by forest, which then underwent two phases of the replacement by mosaics of grassland, probable rice cultivation, arboriculture and scrub, prior to a subsequent phase of forest and woodland regeneration. Spatial patterning of the study area's palaeovegetation appears to have been complex. While a general progress of landscape change is evident, local compositional differences are also clear. Although the region's archaeological and, especially, geomorphological evidence suggests significant climatic change during this period, the pollen record, as in studies further north in the region for the same period, appears to have been dominated by human influences. Of note are the effects of intensified human settlement and thus increased land and natural resource use. At present this late Holocene pollen sequence yields no evidence for a direct relationship with climatic change."

The abstract for the follow-up paper (Boyd andMcGrath 2001b) reads thus:

"Here we present a revised interpretation of pollen analyses at Iron Age archaeological sites on the floodplain of the Mun River, northeast Thailand. Following publication of a full chronometric data set for these sites, it has become apparent that the original and admittedly tentative conclusions from the pollen analyses require reassessment. The original account was flawed in two ways: the presumed time span of the record was considerably longer than we believe it to be now; and our correlation between neighbouring sequences was in error. Our new understanding of the evidence allows us to present a vegetation history of the study area that is confined to the details of land use and human impact during the latter half of the Thai Iron Age. Here we also are able to identify ecological groups and landscape partitioning patterns during that period. In particular, we record phases of human impact, with periods of forest clearance and its replacement by grasslands with likely rice cultivation and arboriculture. Two phases are of note. The first is an expansion of rice cultivation and some arboriculture, while the second is more strongly associated with arboriculture. The early phases were followed by forest and woodland regeneration, while the final phase of landscape change represents an increasingly weediness and shrubiness accompanying a reduction of grassland, but no convincing regeneration of forest or woodland. The final stage of this history probably best reflects climatic and/or hydrological change (i.e. regional drying) which probably also influenced the changes in the Iron Age pattern of settlement in the Mun Valley region."

The data discussed by Boyd and McGrath (2001a, b) was derived from sediment samples collected at the sections described above, and prepared using standard Quaternary pollen techniques. Boyd and McGrath (2001a) describe the individual site pollen sequences (Fig. 2:6), including the following at Noen U-Loke and Non Muang Kao.

Non Muang Kao lies in the middle of the present floodplain; the fossil pollen probably largely reflect conditions on the immediate floodplain and archaeological mound. Three sequences were examined (NMK2 and NMK3 were considered to be equivalent to the upper parts of the longer NMK1), and together they reflect the initial sedimentation of an innermost channel and later infilling of the more recent outer channels. The pollen provides evidence for five phases of vegetation change.

- Non Muang Kao Vegetation Phase 1. This earliest period was characterised by a landscape of, possibly as a mosaic, rice cultivation, grassland and native forest including *Dipterocarpus*, *Elaeocarpus* and *Lithocarpus* species.
- Non Muang Kao Vegetation Phase 2. Forest was cleared, and replaced by pioneering shrubs and small trees (e.g. *Diospyros*, *Macaranga*, *Casuarina*, *Celtis* and *Streblus* species). Rice cultivation, however, probably continued.
- Non Muang Kao Vegetation Phase 3. Rice cultivation either ceased or at least became less common around the site. During this phase, forest and woodland became re-established.
- Non Muang Kao Vegetation Phase 4. The forest and woodland re-establishment was cut short with a second phase of cultivation, this time characterised by the reappearance of rice and introduction of a number of trees typical of arboriculture (the pollen taxa *Artocarpus*, *Canarium*, Palmae, *Terminalia* and *Ficus* all represent genera and families with significant arboricultural members).

• Non Muang Kao Vegetation Phase 5. Towards the sequence top, the forest appears was becoming increasingly open and weedy, with both forest and some of the grassland (possibly) being replaced by a woodland or forest dominated by *Albizia* (probably a shrubby species is represented); the *Albizia* expansion may, however, simply represents a shrubby colonisation of the abandoned mound.

Noen U-Loke was noted to lie close to the edge of the extensive floodplain, about 1km from a slight rise of weathered bedrock. While some of the pollen may have come, therefore, from the drier environments of this nearby topographic rise, most was expected to represent the floodplain and the mound of the archaeological site. The Noen U-Loke sequence generally represents a more open landscape than does the fossil pollen evidence at the nearby site of Non Muang Kao (which is further out into the floodplain). Rice was probably present throughout the period represented at Noen U-Loke. Fluctuations in trees, shrubs and herbs, however, suggest a three-phase sequence of vegetational change, all during the Iron Age.

• Noen U-Loke Vegetation Phase 1. At the earliest period, the landscape was probably largely open, with grasses and some herbs present, and with trees dominated by *Artocarpus*, species within the Moraceae/Urticaceae group, and possibly *Albizia*. This suggests a managed landscape of rice cultivation and some modified woodland or forest.

• Noen U-Loke Vegetation Phase 2. Although rice seems to remain after this phase, there is evidence, especially in the increase of forest trees (notably *Dipterocarpus*, *Elaeocarpus* and Podocarpaceae) and the woodland pioneer *Macaranga*, that suggests the re-establishment of forest and/or woodland. Openland herbs (especially in the Compositae and Chenopodiaceae families) also decline in abundance.

• Noen U-Loke Vegetation Phase 3. The final phase was a decline and loss of the tall trees, and their replacement with trees more likely to have been used for their natural products (such as species within the genera *Artocarpus* and *Syzygium*, and the families Bombacaceae and possibly Palmae). This suggests further management of the arboreal components of the area's vegetation.

The overall vegetation sequence for Noen U-Loke, Non Muang Kao and neighbouring sites is presented in table 2:3 (Boyd and McGrath 2001b). The pollen sequences largely reflect local palaeovegetation conditions, as may be expected for sediments intimately associated with archaeological sites and representing localized small depositional catchments. In this case, the sequences are associated with the Iron Age.

Of note is that this region is now marginal for human settlement—the soils are poor, largely salinated, and yield only one poor rice crop per year, and the climate is seasonally arid—and thus supports a small population of dispersed marginal farming communities. In contrast, Iron Age environmental conditions were substantially different. The rich record of Iron Age settlement suggests that the immediate site catchments must have been able to supply all necessary immediate needs of, for example, timber, food and mineral resources. Whether the resource catchments were the immediate surrounding landscapes of each site, or were some more complex patterning of shared and partitioned landscape, the implication is that spatial partitioning of the landscape under such dense settlement could be expected. This is observed in the pollen data. At all sites, the pollen evidence supports the idea of a landscape of changing and mosaiced grasslands, sedgelands, rice cultivation, arboriculture, and forest and woodland. Importantly, site-specific details differ, reflecting local variations of parameters such as vegetation, landscape partitioning, human land management practice, and environmental constraints, and implies a local scale of spatial patterning. All the pollen data yield evidence for human vegetation management (see appended notes to this chapter on pollen identification and interpretation).

Most of the vegetational changes identified represent the progressive shifts in the balance between natural and managed vegetation, shifts related to the expansion and contraction of grassland, sedgelands, cultivated land, natural forest and woodland, and cultivated or managed forest and woodland. There is clear evidence for the decline of natural forest and its replacement with shrubby woodlands and managed forest, on the one hand, and grasslands, on the other hand, which probably included the cultivation of rice. There is, however, little evidence for extensive burning or firing of the landscape, and thus forest and woodland clearance was probably either by the physical removal of woody plants, or replacement of plants as the spread of openland management affected both the biology and hydrology of the region.

The six vegetation phases identified in table 2:3 are as follows. It should be noted that the term "Upper Mun Valley Vegetation Phase" is introduced here, and did not appear in previous publications; this is used to differentiate the palaeovegetation phasing from other sequencing of environmental history (especially cf. Boyd and Habberfield-Short, this volume).

• Upper Mun Valley Vegetation Phase I. This is only present at Ban Non Wat, where it probably represents the early to mid Iron Age. Dominated by Cyperaceae, and probably reflecting periodic flooding or waterlogging, the pollen provides evidence for conditions that were both open (both wet swampy and dry grassy) and partially disturbed native forest.

• Upper Mun Valley Vegetation Phase II. This phase is represented at Nong Muang Kao and Ban Non Wat, and is characterised by evidence for slightly disturbed native forest and grassland, probably with rice being grown in places. With the partial forest disturbance, landscape partitioning was already in progress. This is Non Muang Kao

Vegetation Phase 1.

• Upper Mun Valley Vegetation Phase III. Represented at all sites, including Noen U-Loke, this phase provides widespread evidence for forest clearing and cultivation throughout the study area, with some evidence of forest and woodland management. The pollen indicates a managed, if diverse, landscape of grasses and rice cultivation everywhere, and some modified woodland or forest, with the forest fully or partially cleared or disturbed, and possibly managed. The base of the Noen U-Loke sequence, reflects an already-open grass (and rice) and herb landscape with trees dominated by *Artocarpus*, species within the Moraceae/Urticaceae group, and possibly *Albizia*. This phase corresponds with maximum grass values, and reflecting maximum grassland expansion accompanied by forest disturbance and opportunity for pioneer and disturbance regeneration on the forest floor. This is Noen U-Loke Vegetation Phase 1.

• Upper Mun Valley Vegetation Phase IV. Following the phase of landscape opening, the extent of open land contracted during Phase IV, and forest regenerated. There is, however, some evidence for continued cultivation. Rice remained at Noen U-Loke and possibly Non Muang Kao, despite the increase of forest trees (notably *Dipterocarpus*, *Elaeocarpus* and Podocarpaceae) and the woodland pioneer *Macaranga*, suggesting a re-establishment of forest and/or woodland around the site; open land herbs also declined in abundance. This is Non Muang Kao Vegetation Phase 3 and Noen U-Loke Vegetation Phase 2.

• Upper Mun Valley Vegetation Phase V. Forest or woodland re-establishment was cut short by another phase of cultivation, grassland expansion and the probable reappearance of rice at some sites. At Noen U-Loke, trees typical of arboriculture (*Artocarpus*, *Syzygium*, *Canarium*, *Terminalia*, *Ficus* and possibly members of the families Bombacaceae and Palmae) mark the decline and loss of the tall trees and their replacement by trees more likely to be used for their natural products. There is stronger evidence for a period of arboriculture being an important part of the managed landscape. Dating suggests that this phase dates to the late Iron Age. This is Non Muang Kao Vegetation Phase 4 and Noen U-Loke Vegetation Phase 3.

• Upper Mun Valley Vegetation Phase VI. The phase of mixed vegetation management finally gave way to conditions of grassland, with forest and woodland in decline, grasses increasing. This latest phase appears to represent a landscape of declining managed vegetation, but in which forest or woodland are unable to recover. At some sites, such as Non Muang Kao, shrubby vegetation colonises the mound and/or the floodplain. The evidence for forest regeneration failure following the decline in cultivation and arboriculture reflects either climatic drying or the long-term cumulative effects of human use of the landscape. This phase is dated to either the late Iron Age or post Iron Age times. This is Non Muang Kao Vegetation Phase 5.

In conclusion, the pollen provides a short-term vegetation history dating to the latter half of the Thai Iron Age. Local vegetation conditions during this time in part reflected the mosaic of soil and hydrological conditions on and around the sites, especially on the floodplain, but also to a lesser extent on the immediately neighbouring rises. However, the periodic modification of the vegetation better reflects the type and degree of localised human intervention and environmental management. While individual sites have their own vegetation history, overriding local variants is a study-area-wide and cross-site history of vegetation change marked by native forest woodland and open land habitats being periodically impacted and replaced by managed communities. An earlier phase of human impact probably pre-dated these records; given our understanding of the Bronze Age and Neolithic presence in the study area, this is unsurprising. For the later Iron Age, however, two impact phases are notable: the earlier was characterised by the expansion of rice cultivation and some arboriculture, while the later, also associated with rice cultivation, was more strongly associated with arboriculture. The result was continuing landscape partitioning, with grasslands and other open environments, rice cultivation, and mixed managed and disturbed forests and woodlands.

CONCLUSIONS

The four studies outlined here have been published in detail. The purpose of this report is to synthesis them, especially from the perspectives of Noen U-Loke and Non Muang Kao. It is clear now, for example, that Noen U-Loke and Non Muang Kao formerly sat on the banks of rivers that no longer flow through the landscape. Indeed the entire hydrology of the floodplain has changed significantly (Boyd 2004, McGrath, Boyd and Bush in press). In the early geoarchaeological publications arising from this study it was suggested that this was a feature unique to the Iron Age, and furthermore, it was suggested that the Iron Age sites were specific responses to a specific set of environmental conditions – increased climatic wetness and consequential increased river flow – whose start and finish marked the opening and closing of the Iron Age.

It now seems more likely, however, that the encircling earthworks, rather than being features developed to optimise already good environmental resource conditions, were built to ensure continuing supply of water at a time when previously-reliable supplies of water were under threat (see, especially, Boyd and Habberfield-Short, this volume). It seems that conditions of the floodplain hydrology and vegetation were well established by the early to mid Iron Age (McGrath, Boyd and Bush, in press), and that the development of the moats was a later engineering response to changing conditions. Indeed, the vegetation history may also reflect this change in natural resource availability, with the increasing interest in arboriculture

later in the sequence, an agricultural change that would have reduced the reliance on rice.

The encircling earthworks, therefore, are important indicators of such changes. They are now, despite earlier views published from the geoarchaeological studies that they were essential natural, viewed as engineered adaptations to natural conditions. McGrath, especially in his PhD thesis (2001), argues that they represented engineering solutions to ensuring a ready supply of water. In his conclusions, he describes a relatively simple method for building new channels, using the hydrological force of running water to excavate wide channels during flood time; this removes the need for substantial workforces, and would allow for relatively small communities to have the capacity to manage their water resources. Boyd and Habberfield-Short (this volume) extend that argument, by placing the sites and their encircling earthworks into the context of the floodplain geology. In particular, they note that the geological evidence suggests an increasingly fragile water supply to the floodplain during the Iron Age. While there is evidence for previous river channels running close to the sites (and indeed the sites expanding to fill them in and overtop them), the evidence we have is for relatively late construction or modification of the channels and banks. This accords with the geological evidence that water supply was becoming less reliable. We suggest, therefore, that the modification and management of the channels and banks were reactions to this declining water supply during the middle of the Iron Age, a response that largely worked, although each channel was relatively short-lived as it filled in with sediments and was, in some cases, over-topped by the expanding sites.

The final stages of management of the water supply is reflected in the outer-most moats. These appear to be completely constructed rather than being modified natural channels, and were probably built using McGrath's proposed method of digging small deep channels (commonly done extensively and by hand at present throughout the landscape), and using them as focal points for flood run-off. These new modified channels were the least successful, and filled in rapidly with local floodplain alluvium. By this stage, water supply to the floodplain was diminishing, reflected in the reduction of sediment supply; the grey clays that typify channel infilled earlier were not now available, and the evidence for local floodplain sediments infilling the latest channels suggests that water flow through the landscape was diminishing also.

This environmental change is also reflected in the final stage of the vegetation history. Environmental resources appear to been have been managed successfully for many centuries, although the exact form fluctuated throughout the Iron Age, reflecting shifts in the balance in rice cultivation, wetland and woodland management, and arboriculture. It is likely that the Iron Age management of vegetation was a continuation of earlier practices, although this is still to be tested. That these conditions survived for many centuries represents the successful management of the floodplain, enhanced, as the geological record indicates, by a reliable or reliably-managed water supply. Eventually, however, this became unsustainable, and the vegetation, in parallel with the water supply, could not maintain its previous reliability. During previous periods in which agriculture seems to have declined, the natural forest or woodland was able to regenerate and recolonise the landscape. In this final period, however, that was not possible. Either climatic conditions were unsuited to this (there is some evidence for a climatic shift at the end of the Iron Age, work is continuing to determine whether this is a real possibility), or the landscape was responding to the cumulative effects of repeated and widespread human impacts on the landscape. While the result may be due to a combination of both, it is likely that the effects of a managed and agricultural landscape had extended to the point where the plant refuges and seed banks needed for successful forest and woodland regeneration were simply insufficient. This reduction of both a reliable water supply and lack of agricultural capacity would have seen the end of the viability of Iron Age settlement such as at Noen U-Loke and Non Muang Kao.

APPENDIX TO CHAPTER II. FOSSIL POLLEN IN THE STUDIES OF VEGETATION HISTORY AT NOEN U-LOKE AND NEIGHBOURING ARCHAEOLOGICAL SITES

In two papers, Boyd and McGrath reported the results of pollen analyses of sediment samples collected from the infills of several channels associated with the encircling earthworks at sites such as Noen U-Loke (Boyd and McGrath 2001a, b). These analyses were based on identification of fossil pollen types, and the subsequent interpretations were based on ecological understandings of the pollen taxa identified. This note records the details of pollen identification used during this study, and thus of the pollen taxa reported in the published pollen diagrams and ecological information regarding the taxa, especially as used by Boyd and McGrath (2001b).

METHODOLOGICAL BACKGROUND

The pollen analysis described here is based on standard Quaternary palynological methods of sample preparation, microscope identification and data presentation (e.g. Berglund 1986). Identification of pollen is based on various keys and pollen floras (Selling 1947; Knox 1950; Pike 1956; Nair 1965; Erdtman 1966; Huang 1972, 1981; Moore and Webb 1978; Bonnefille and Roillet 1980; Hooghiemstra 1984; Punt 1984; Gupta and Sharma 1986; Faegri and Iversen 1989; Maloney 1991; Tissot *et al.* 1994), and on an unpublished key by Boyd partly based on Maloney's (1991) pollen type listing. The list presented in this paper summarises the pollen types identified in this study, and includes supplementary notes (based largely on Willis 1973; Smitinand 1980; Bunyavejchewin 1983, 1986; Wongsamsak 1986, McMakin 1993) regarding aspects of ecology and human use of members of the plant groups most likely to be represented by the pollen types.

POLLEN IDENTIFICATIONS

The following notes contain summarised information regarding the identification of the pollen types, and their possible or probable plant sources. The literature on ecological association of specific plants and on modern and recent resource use of some of the plants is patchy for the region, so the comments should be regarded as indicative, especially given the degree of taxonomic uncertainty in linking pollen types with plant species.

Acacia. This pollen type comprises polyads, occasionally with four grains, but more commonly with 8; individual grains are psilate with tiny pores, and are arranged in a loose regular arrangement typical of pollen of the genus *Acacia*. *Acacia* spp. are shrubby trees are typically found on the semi-evergreen rainforest to dry deciduous forest ecotone in the region (Bunyavejchewin 1986), and typical of drier parts of south Asia. Many species, including the native forest medium tree *A. catechu*, provide valuable products, including gum, tan bark and timber (Willis 1973:3-4; McMakin 1993:51).

Acanthaceae. This family is represented by two types. A *Barleria* type is typical within the family, being more or less spherical with a distinctive open reticulum of wrinkled or meandering muri. It best resembles pollen of the genus *Barleria* (Bonnefille and Roillet 1980, plates 5-7:31). *B. siamensis* and *B. prionitis* are, respectively, forest shrubs and herbs native to Thailand (McMakin 1993:1 and 42). The identification of a *Justicia* type is based on a large (*c.* 40*μm*) fragment of a square-ended large prolate pollen grain, with a very thick, strongly reticulate of variable thickness. No apertures are present on the fragment. The fragment corresponds best with pollen in the shrubby genus *Justicia* (Bonnefille and Roillet 1980, plate 12). At least one species, *J. gendarrusa*, is native and often used as a hedge shrub (McMakin 1993:2).

Albizia. This pollen type occurs mainly as individual grains, although occasional clusters of three or four grains are present (Nair 1965:21-2, records polyads with up to 16 grains). The individual grains have several slightly rectangular-shaped pores, although these are not always clear on the fossil material. Maloney (1991) describes 5-7 pores with granular margins and more or less rectangular outline; Nair (1965:21-2) mentions six pores, and Selling (1947, plate 23) indicates a range of aperture arrangements within this genus. In the region, *Albizia procera* is a common tree in tall dry dipterocarp forest on immature or denuded land surfaces (Wongsomsak 1986); other species of *Albizia* in northeast Thailand are trees (Smitinand 1980:13-14). These are fast growing, some providing good timber (Willis 1973:38).

Annoniaceae. This is a large smooth elongate grain with possibly one long colpus: the grain viewed is unclear, but best resembles pollen of the shrubby genus *Gonianthualamus* (Tissot *et al.* 1994:16). The family contains native shrubs and small forest trees (McMakin 1993:6 and 43).

Araceae. This small (15-20*μm* diameter), spherical, inaperturate pollen type, has a thin and psilate exine with faint undulations or faint reticulae. The grain is difficult to ascribe to genus level, and resembles pollen in various genera (*Arisaema*, *Anadendron*, *Gonotanthus*, *Pothos*, *Smilax*: Maloney 1991; Ertdman 1966; Huang 1972). The best fit is with pollen of terrestrial herbs in the Araceae, a family containing native perennial and tuberous herbs and vines typically growing in mixed forest or open places (McMakin 1993:44 and 88).

Artocarpus. This is a very small (*c.* 12-15 *μm*) spherical tri- or tetraporate grain with a thick psilate exine, and distinctive, moderately large, annulate and round to slightly elongate pores. The pollen represents a genus containing several cultivated species in the Moraceae family, including *Artocarpus altilis*, the breadfruit tree, which provides a valuable starchy food. Some species provide good timber (Willis 1973:96-7), and several are found in semi-evergreen rainforest in the region (Bunyavejchewin 1986).

Betulaceae. This triporate, oblate-spheroidal grain (*c.* 23-24 *μm*) with a psilate exine resembles the pollen of the tree *Carpinus rankanensis* (Huang 1972).

Bombacaceae. This is a large (*c.* 50 *μm*) colporate subangular grain with distinctive club-shaped apertures and a scabrate exine. It resembles the pollen of *Bombax malabari* (Huang 1972:69); *B. ceiba* is a Thai cotton or kapok tree, and the family also contains the edible fruit tree, durian (*Durio zibethinus*) (McMakin 1993:105).

Canarium. This is a small (10-15 *μm* long axis), prolate and tricolporate grain, with equatorially-constructed colpi, and a thick, psilate exine, which resembles the pollen of *Canarium* (Tissot *et al.* 1994: cf. plate 9). *Canarium* is a tree used for its edible seeds throughout southeast Asia; some species are sources of resin (Willis 1973:196).

Caryphyllaceae. This pantoporate (*c.* 30 pores) spheroidal grain (*c.* 25*μm*) with a psilate exine, strongly resembles pollen of *Cucubalus baccifer* (Huang 1972:77).

Casuarinaceae. This is a triporate and finely stippled psilate grain strongly resembling the pollen of *Casuarina* spp. (small to medium sized shrubby trees). Several species are native to central and, mostly, coastal Thailand (Smitinand 1980:73), and now grow throughout the country. The pollen here may be modern, although the relatively poor preservation state of the few grains noted suggests these are fossils. The wood of some *Casuarina* species is valued for its hardness, and the green shoots are used as emergency animal fodder (Willis 1973:213).

Celtis. This is a round psilate grain with four slightly thickened pores taking up some 20-25% of the surface. Celtis is a shrubby tree typically found on the semi-evergreen rainforest to dry deciduous forest ecotone in the region (Bunyavejchewin 1986). Some species provide edible fruit, and the wood is useful for turning; the tree provides animal fodder in India (Willis 1973:219).

Chenopodiaceae. This pantoporate pollen is the typical Chenopodiaceae-Amaranthaceae type, here with *c.* 60 pores. This pollen is largely inseparable at sub-family level (Boyd 1992). The pollen represents many predominantly halophytic, coastal and arid land terrestrial herbs, shrubby herbs and low shrubs; many are edible.

Compositae. Two types are the characteristic fenestrate and non-fenestrate pollen types found within the family Compositae (e.g. Moore and Webb 1978; Faegri and Iversen 1989; Boyd 1992). The fenestrate type is spherical with an open network of slightly echinate ridges and fenestrae forming the exine. The non-fenestrate type contains various echinate, tricolpate types. Both represent one or more of many terrestrial herb or shrubby herb species mostly found in open places or forest margins (McMakin 1993:46, 89-90).

Convolvulaceae. This pollen is a typical Convolvulaceae type: a large, spherical, polyporate pollen grain with slight spiney ornamentation. It is typical of the pollen of the genus *Ipomea*, of which several native species are vines common in open environments (McMakin 1993:91).

Crotalaria. This is a small, prolate to spheroidal and finely reticulate tricolporate (the colpi have transversely elliptical ora) pollen grain, which strongly resembles pollen in the Papilionaceae family and, specifically, the genus *Crotalaria* (Huang 1972:144; Bonnefille and Roillet 1980:82, plate 68). This genus contains herbs and small shrubs, including two native highland forest species, and *C. mucronata*, which grows in open places (McMakin 1993:68 and 96).

Cucurbitaceae. This is a large (*c.* 60*μm*) oblate to spheroidal grain with three pores and a slightly scabrate exine, which best resembles pollen of *Trichosanthes cucumberoides* (Huang 1972:103). Several Thai species of this family are edible (McMakin 1993:91-92).

Cyperaceae. This family is represented by two types. The first is the common tetraporate elongate and longitudinally non-symmetrical Cyperaceae pollen type, with the pores being three equatorial and one polar weak exine areas (e.g. Moore and Webb 1978; Faegri and Iversen 1989; Boyd 1992). The second type is also a typical Cyperaceae grain which differs from the most in being rounder, lacking or less strongly exhibiting the typical asymmetry. This type is more robust than the first. Both represent one or more of many sedges in the various genera of the family, which typically grow in terrestrial wetlands. Wongsomsak (1986) notes that *Scirpus mucronatus* and *S. grossus* are common herbs on the Mae Nam Mun floodplain. At least plants of this genus are possibly represented here.

Diospyros. This thin-walled tricolporate pollen grain often has a "washed-out" appearance. The pore is unclear, although for several species the pore is recorded elsewhere as indistinct, a large ora, or a colpal constriction (e.g. Selling 1947:260-1; Bonnefille and Roillet 1980, plate 37; Gupta and Sharma 1986:66). Two species of the shrubby

dry evergreen tree *Diospyros*, *D. rhodocalyx* and *D. mollis*, are common in this region, especially on denudation plains and in semi-evergreen rainforest (Bunyavejchewin 1986; Wongsomsak 1986).

Dipterocarpus. This group contains two types. The first is a medium sized (*c.* 25*μm*) tricolpate and psilate type with thick exine and more or less granulate colpi resembling some Dipterocarpaceae types, notably the relatively large pollen of the genus *Dipterocarpus* (Erdtman 1966). The second type is a small, reticulate to very finely reticulate, tricolpate grain, with the reticulum fining towards the colpus. The colpus is very short, open and in some cases is granulate, and the exine thin. This also probably represents species of the genus *Dipterocarpus*. Dipterocarp trees are often dominant in evergreen mixed lowland tropical forest and mixed dipterocarp forests, and grow abundantly in areas with a marked dry season and poor soils (Willis 1973:375). Regionally, *D. obtusifolius*, *D. tuberculatus* and *D. alatus* are common or dominant in tall dry dipterocarp forest, semi-evergreen rainforest, and on the semi-evergreen rainforest to dry deciduous forest ecotone, in various environments both on and beyond the floodplain (Wongsomsak 1986; Bunyavejchewin 1986). Many species provide economic materials, notably wood oil, garjun balsam used as a varnish, and timber (Willis 1973:376).

Elaeocarpus. This small to very small (*c.* 10-15 *μm*), tricolpate, psilate and more or less oblate pollen grain has a fragile exine, and a thin, medium length colpus. It strongly resembles the pollen of the genus *Eleaocarpus* (Tissot *et al.* 1994, plate 24), a genus of large trees. The Thai species, *E. floribundis*, grows in mixed forests (McMakin 1993:49).

Ericaceae. This type comprises moderately square, quite small tetrads of slightly scabrate to scabrate grains. In some cases the tetrads contains deflated grains, a characteristic common to some groups in this family (cf. Boyd 1992). This type strongly resembles pollen in the Ericaceae family of shrubs and shrubby trees. Several *Rhododendron* and *Vaccinium* species grow in Thailand, although not within the immediate region (Smitinand 1980:288, 341; McMakin 1993:48). *Vaccinium* provides edible fruits, while, curiously, genera in the Rhododenroideae are noted to produce toxic pollen (Willis 1973:426-7).

Eucalyptus. This is a parasyncolpate grain with narrow colpi, large apocolpium, polar islands, rounded amb, and variable (coarsely scabrate in parts) exine pattern. Only a single grain of this typical *Eucalyptus* pollen type is recorded, and may be a modern contaminant.

Euphorbiaceae. Two types are included here. The *Agrostistachys* type is a prolate tricolporate grain with strongly reticulate and thick exine. It strongly resembles grains of the shrubby genus *Agrostistachys* (Tissot *et al.* 1994, plates 25 and 31). The *Croton* type is the typical spherical pollen grain of the family, exhibiting the distinctive *Croton* exine structure and patterning found only in pollen of this family (Erdtman 1966; Boyd 1992).

Gramineae. There are two size classes of the cosmopolitan type, small (*c.* 20-30*μm*) and large (40-60 *μm).* The pollen is sub-spherical and monoporate, with an annular pore and a slightly stippled exine. Many grass species provide a source for this pollen; Wongsomsak (1986) indicates that *Arundo donax* is common herb on the Mae Nam Mun floodplain, and some of the pollen may be from this species. The large type is also of the typical Gramineae form, and often with a well-defined and large pore. Many grains are crumpled, making exact size determination and confident separation of large and small grains difficult. Due to these difficulties this type is only recorded here as common or present, forming a minor if persistent component of the count. Given the size range and its cereal-like characteristics, and recognising that complete separation of the pollen types of rice and other grasses is difficult (Köhler and Lange 1979; Maloney *et al.* 1989; D. Penny, pers. comm.), this relatively uncommon type probably represents rice pollen.

Hydrocaryaceae. This is a large (*c.* 70 *μm*) tricolpate grain with very long colpi and a thin psilate exine. The grain best resembles pollen of the aquatic herb *Trapa natans* (Huang 1972:124.).

Indigofera. This is a prolate and more or less psilate or faintly stippled tricolporate pollen grain most closely resembling pollen of the herb genus *Indigofera* (Bonnefille and Roillet 1980: plates 68-71).

Iridaceae. This is a small slightly symmetrical monocolpate grain. The colpus runs almost to the grain ends, and the exine is thin and psilate. It resembles pollen in the family Iridaceae (Erdtman 1966), a family of predominantly lily-like aquatic or wetland herbs.

Labiatae. This is a *c.* 20-25 *μm* diameter spheroidal grain with six colpi and a scabrate exine reducing towards the apertures, and slightly thickening towards the poles. This most closely resembles pollen of *Acrocephalus indicus* (Huang 1972:127).

Labordia. This tetraporate grain with possibly annulate pores is slightly rectangular in polar view with the pores at each corner. It most strongly resembles pollen in the family Loganiaceae, specifically in the shrubby genus of *Labordia* (Selling 1947, plate 41; Erdtman 1966:248-9, Fig. 145).

Lagerstroemia. This pollen type is apparently inaperturate, being a small (<20*μm*) grain. The grain is more or less spherical, with one slightly flattened side, and occurs in some cases as complete or broken tetrads. Its exine is notably thick and distinctly scabrate, with the processes resembling low and broad blunt echinae. It resembles pollen from the Lythraceae genus *Lagerstroemia* (Erdtman 1966). Species are found in the region's dry deciduous forest and semi-evergreen rainforest (Bunyavejchewin 1983 1986), and *L. cuspidata* is a tall dry dipterocarp tree common on immature erosional land surfaces (Wongsomsak 1986). Some species provide good timber (Willis 1973:630) and are now common ornamental garden trees (McMakin 1993:25).

Leguminosae. This is a large (*c.* 50*μm*) suboblate and triporate grain with a verrucate exine, which best resembles pollen of *Phaseolus calcaratus* (Huang 1972:153).

Lemna. This is typical of the aquatic herb *Lemna* (e.g. Moore and Webb 1978; Faegri and Iversen 1989).

Liliaceae. Three types are recognised. The *Dracaena* type is a large (*c.* 80-100*μm* long axis), elongate and asymmetrical oval-shaped grain, of a shape typical of many Liliaceae types (e.g. Erdtman 1966). The surface pattern is strongly or weakly striate-rugulate, and the grain resembles pollen of *Dracaena aurea* described by Selling (1947, plate 56). The genus *Dracaena* contains a number of wetland herbs including *D. lourieri*, a large native herb (McMakin 1993:69). General and small (to *c.* 30-40*μm* long) types are pollen types comprising several, usually broken or otherwise damaged grains, which do not contain sufficient detail or clarity of detail for subfamily identification, but strongly resemble pollen from the Liliaceae family (e.g. Erdtman 1966), the characteristic asymmetrical oval shape, and exine textures from smooth to scabrate. They represent one or more wetland and aquatic herbs.

Lithocarpus. This finely scabrate tricolpate grain resembles the pollen of *Quercus* or *Lithocarpus* within the family Fagaceae, although being more finely scabrate than *Quercus* pollen (cf. Moore and Webb 1978). In this region, it probably represents species of *Lithocarpus*, a tree common or present in medium-tall dry dipterocarp forest, on erosional land surfaces, hills and river terraces (Wongsomsak 1986).

Macaranga. This is a distinctive small (<20*μm*) tricolporate grain with a thick and psilate exine. The long colpus has a small, neat and circular pore. It represents the Euphorbiaceae genus *Macaranga*, a vigourous shrubby pioneer tree, common throughout and beyond southeast Asia.

Malvaceae. This distinctive and typical pollen grain of this family of shrubs and shrubby trees is very large, spherical and ornamented by large spines (cf. Erdtman 1966). While many species now grown as ornamental plants are not native to Thailand, native species typically grow in open environments (McMakin 1993, pp.98-99).

Monolete spores. This group comprises typical bean-shaped fern spore shapes, with a monolete mark in the concave surface, and with or without a perine of various textures. Six types are recognised; no taxonomic identification is attempted, largely due to the poor preservation state. Psilate type: perine absent or very closely attached; psilate surface; *c.* 35-45*μm* long. Loose perine type: small (25-30*μm* long) spore with a thick wall and broad loose and convoluted perine (maximum size >60 *μm*). Fine scabrate type: medium-sized spore with finely scabrate or coarsely-stippled, loose-fitting exine. Coarse scabrate type: medium-sized spore with coarsely-scabrate loose-fitting exine; scabrae may be perine folds. Very coarse scabrate type: medium-sized to large with very coarsely-scabrate loose-fitting exine; scabrae may be perine folds. Striate-rugulate type: several whole and fragmented grains, with some or all of a loose rugulate or coarsely-striate perine attached. All these types represent ferns.

Oleaceae. This grain is tricolporate, suboblate (c. 40 *μm*), with a circular-lobate amb and clavate exine. It closely resembles pollen of the shrubby tree *Ligustrum pricei* (Huang 1972:176).

Palmae. Two types resemble pollen of the family Palmae, and are grouped together in the pollen diagram. The first is a small to medium sized (*c.* 15 - 25 *μm* length), monocolpate asymmetrically-oval grain with slightly square ends, and with a thin, slightly stippled, spotty or apparently reticulate exine. The second is a large, monocolpate and asymmetrically-oval pollen grain, with a scabrate exine. These probably represent several species of palm trees; palms are present especially in the region's semi-evergreen rain forest (Bunyavejchewin 1986), and several are native to Thailand. Relevant to this study area are the apparently native forest palms, *Caryota mitis* and *Licuala spinosa* (medium-sized and small palms respectively) and about a dozen species of rataan climbing palms (*Calamus* spp.) (McMakin 1993:32 and 58).

Pandanus. This is a small, more or less spherical and finely spinuliferous grain with a single unclear ulcerate pore, which resembles the pollen of *Pandanus* (Erdtman 1966:307-8, plate 179; Selling 1947:340-341, plate 54). The genus contains shrubby trees often associated with dry savannah-like conditions. Some provide edible fruits,

and are widely used for thatching and weaving materials (Willis 1973:848).

Peperonia. This is a very small (10-15*μm*) spheroidal grain which takes a strong stain and has a solid appearance. It is strongly scabrate, and has one large (*c.* 25% of grain diameter) and obscure pore with sharp edges, which sits in a broad shallow hollow, giving the grain a slightly bean-shaped appearance. This resembles pollen in the family Piperaceae, probably in the genus *Piperonia* (synonym *Peperomia*) (Erdtman 1966:321-2), which contains several epiphytic and succulent dryland herbs (Willis 1973:871), including the succulent native herb *P. pellucida* growing in damp areas of shady forests (McMakin 1993:58).

Plumbaginaceae. A subprolate tricolpate grain of *c.* 55-65*μm* maximum length, this has a circular-lobate amb and a granulate exine. It best resembles pollen of *Plumbago zeylendica* (Huang 1972:181).

Podocarpaceae. This type is represented by large detached conifer bladders, and by one complete large (*c.* 80 *μm*) grain. The bladders are large (*c.* 35-40*μm* diameter) and have a typical pattern of irregular folds or loose reticulum. The grain body is more or less rectangular, ornamented with a strong spotting. Both the individual bladders and the full grain best resemble the pollen of tree species within the Podocarpaceae family.

Polygalaceae. This is a polycolpate grain with a distinctive equatorial ring or thickening. It is typical of the pollen of this group of dryland herbs within the family Polygalaceae, which includes the apparently native *Salomonia ciliata*, a small annual herb found in dry grassy places (McMakin 1933:100).

Proteaceae. This medium sized (*c.* 30*μm*) grain is triporate, with a thin psilate exine which slightly thickens a the pore margins, and resembles Hooghiemstra's type 34b (1984, plate 4).

Rubiaceae. This is a small (*c.* 15*μm*), spherical grain with a strongly rugulate or scabrate-rugulate exine. The apertures are unclear, and may be tricolporate or polycolporate with possible very short colpi. The type is reminiscent of pollen of *Ulmus*, although pollen within the family Rubiaceae provide the best correlates (Selling 1947, plates 45-7; Erdtman 1966, fig. 224; Maloney 1991). The Rubiaceae contains many herb, shrub and tree genera and species, many with economic importance, including, for example, those providing quinine and various alkaloids (e.g. coffee and ipecacuanha) (Willis 1973). Native species tend to be forest plants (McMakin 1993:59-60), including the tree genus *Anthocephalus*, a medium-tall tree present in the dry dipterocarp forest of the river terraces of the region (Wongsomsak 1986).

Salix/*Populus.* This a small prolate tricolpate and reticulate grain which strongly resembles pollen typical of *Salix* or *Populus* spp. (Moore and Webb 1978).

Shorea. This is a tricolpate and more or less reticulate oblate grain, circular in polar view, with long colpi whose ragged margins can be unclear. The exine is thin. This type represents one or more of several tree species of *Shorea* (McMakin indicates about 20 species in Thai forests; 1993:48). *S. obtusa*, *S. thorellii* and *S. siamensis* are all common in dry tall dipterocarp forest in several environments in this region (Wongsomsak 1986), as well as in semi-evergreen rainforest (Bunyavejchewin 1986). Many species provide useful timber, and some yield edible fats in their nuts, and resin used for varnish (Willis 1973:1064).

Syzygium. This small trisyncolpate psilate grain with a polar island resembles grains of *Syzygium* and *Eugenia* (synonym for *Syzygium*) (Tissot *et al.* 1994:53; Pike 1956). It probably represents trees in the genus *Syzygium*/*Eugenia* which are found in semi-evergreen rainforest in this region (Bunyavejchewin 1986). Several species provide edible fruits (McMakin 1993:107), while the dried flower buds of *S. aromaticum* form the spice cloves (Willis 1973:1126).

Terminalia. This distinctive small (10-15 *μm*) pollen grain with six colpi, some containing a small round and distinct pore. The grain is lobed in polar view, and has a thin exine with no clear pattern. It resembles pollen of the tree genus *Terminalia* in the family Combretaceae (in which case the six colpi are three true colpi and three intervening pseudocolpi: Erdtman 1966:17; Bonnefille and Roillet 1980:31). One species, *T. alata*, is common in tall dry dipterocarp forest and dry deciduous forest in the region, and may be found in semi-evergreen rain forest (Wongsomsak 1986; Bunyavejchewin 1983 1986). The fruit of some species is used for medicine and dyes, while the bark is used for lime and tan; the timber is noted to be good (Willis 1973:1136).

Trilete spores. Five trilete spore types are recognised, all with the distinctive bipolar asymmetry of spores of ferns and some fern allies, and triangular or rounded triangular polar view. One face contains a trilete mark, often not clearly delineated, and the two polar faces often have slightly or distinctly different textures. Psilate type: small (*c.* 15*μm*) spore with more or less round amb and thick outer edge; psilate surface, and a fine trilete mark on one face resembling that on *Pteridium* spores. Faintly scabrate: generally corroded, making the outer surface pattern unclear (the scabrate pattern may be due to corrosion); equatorial diameter *c.* 30*μm*; thin wall. Reticulate type:

medium-size, with a distinctly reticulate surface pattern. cf. *Lycopodium*: small spore strongly resembling those of the fern ally *Lycopdium* (Moore and Webb 1978). cf. *Ophioglossum*: large and strongly scabrate spore strongly resembling that of *Ophioglossum* (e.g. Moore and Webb 1978).

Tristania. This is a very small trisyncolpate and psilate grain, with colpi meeting at the pole, and a rounded triangular amb which is, in some cases, slightly concave. It strongly resembles pollen of the tree genus *Tristania* (Pike 1956). Smitinand (1980:355) indicates that while there are three Thai species, none are presently in the immediate region.

Umbelliferae. This has the distinctive shape of pollen within the family (cf. Punt 1984). It is tricolporate; one colpus has a possible pore towards one end of the grain, and the other pores are equatorial. The grain is prolate and of slight dumbbell shape, its thick exine having a faint stippling which fining towards the colpi. This family comprises a large number of large terrestrial herbs, many of which have a culinary use.

Urticaceae/Moraceae. This group contains five types, abbreviated in the pollen diagram to U/M types. The *Ficus* type is small and psilate, with a small pore at either end of a slightly elongate grain typical of the *Ficus* genus of trees. Many native Thai *Ficus* species, including *F. benjamina*, an epiphytic strangler tree, *F. hirta*, a small shrub, and *F. racemosa*, a large tree, grow in mixed forest (McMakin 1993:55-6). Bunyavejchewin (1986) indicates that *Ficus* is typically present in semi-evergreen rainforest in the region, and various species of *Ficus* provide edible fruits, rubber and timber (Willis 1973:458-9), as well as providing spiritual shade. General and scabrate types comprise pollen with the typical small, polyporate (>4 small pores) and more or less spherical grains, but for which no further differentiation may be made, largely due to lack of well-preserved detail. The types are differentiated by exine patterns: the general type typically has a psilate or very finely stippled exine surface, whereas the scabrate type has a finely scabrate exine. The Urticaceae family contains many herbs and shrubby trees, whereas the Moraceae comprises shrubby and larger trees. Given this range of plant types, these types may be assigned to various species, including those covered within the *Ficus* type, as well as the native *Broussonetia papyrilera* (the paper mulberry tree) (McMakin 1993:55). The *Streblus* type is a typical small, spherical and psilate type, with four small unclear and more or less obscure pores. The grain resembles pollen of *Streblus* spp. (cf. Selling 1947, plate 13; Erdtman 1966:274); *S. asper* is an evergreen shrubby tree common in dry forest on denudation plains in the region (Wongsomsak 1986). *Streblis* is a source of paper in Thailand (Willis 1973:1109). The Urticaceae type is a typical small, round and psilate grain, slightly larger than the *Streblus* type, with a very finely stippled exine. It is polyporate, with more than 12 very small pores, and best resembles pollen in the Urticaeae family (Selling 1947: plates 12 and 13), a family mostly comprising herbs and shrubs, some of which are used as sources of fibres (Willis 1973:1198).

REPRESENTATION OF SPECIFIC PLANTS IN THE POLLEN RECORD, AND THE ECOLOGICAL IMPLICATIONS

In the tropics, it is in some cases difficult to identify pollen to a low taxonomic level. Even at the generic level, the flora of a region may contain a great diversity of species, representing a wide range of growth forms and ecological preferences and constraints. Interpretation of palaeoecology and other environmental conditions, therefore, can be risky. However, certain pollen types may be more representative of certain groups and conditions, and where a cluster of these is present in an analysed sample, interpretation of particular conditions may be made with some confidence. In the pollen analytical studies at Noen U-Loke and neighbouring sites, several broad groups of plants are represented, as described below. The uncertainty expressed throughout the discussion of pollen results reflects the inability to absolutely identify specific plants and their ecological conditions.

Forest

The first group contains pollen types representing plant groups typically containing forest trees (*Dipterocarpus*, *Elaeocarpus*, *Lithocarpus* and Podocarpaceae). Dipterocarp trees are often dominant in evergreen mixed lowland tropical forest and mixed dipterocarp forests of the region, and grow abundantly in areas with a marked dry season and poor soils (Willis 1973:375). Regionally, *D. obtusifolius*, *D. tuberculatus* and *D. alatus* are common or dominant in tall dry dipterocarp forest, semi-evergreen rainforest, and on the semi-evergreen rainforest to dry deciduous forest ecotone, in various environments both on and beyond the floodplain (Wongsomsak 1986; Bunyavejchewin 1986). Likewise, *Elaeocarpus* is a genus of large trees; the Thai species, *E. floribundis*, grows in mixed forests (McMakin 1993:49). Finally, in this region, the *Lithocarpus* pollen probably represents species of *Lithocarpus*, a tree common or present in medium-tall dry dipterocarp forest, on erosional land surfaces, hills and river terraces (Wongsomsak 1986). The Podocarpaceae pollen type, while not being specific, clearly represents one of the tree species within the family. Finally, it should be noted that while these pollen types are best interpreted as representing native forest communities, especially in the company of the other forest genera, it is of note that many species of *Dipterocarpus*

provide economic materials, notably wood oil, garjun balsam used as a varnish, and timber (Willis 1973:376).

Pioneer, regeneration and/or disturbance habitats

The second group contains pollen types typical of pioneer, regeneration and/or disturbance species. Notable amongst these are the pollen types *Diospyros*, *Macaranga*, *Casuarina*, *Celtis*, *Streblus*, Malvaceae and Euphorbiaceae. Two species of the shrubby dry evergreen tree *Diospyros*, *D. rhodocalyx* and *D. mollis*, are common in this region, especially on denudation plains and in semi-evergreen rainforest (Bunyavejchewin 1986; Wongsomsak 1986). The *Macaranga* pollen represents the Euphorbiaceae genus, *Macaranga*, a vigorous shrubby pioneer tree, common throughout and beyond southeast Asia. The distinctive and typical pollen grain of the Malvaceae family of shrubs and shrubby trees may represent many species now grown as ornamental plants. However, these are not native to Thailand, and native species typically grow in open environments (McMakin 1993:98-9). Some of the represented plants may be from ecotonal communities or open forest: *Celtis* is a shrubby tree typically found on the semi-evergreen rainforest to dry deciduous forest ecotone in the region (Bunyavejchewin 1986); *Streblus asper* is an evergreen shrubby tree common in dry forest on denudation plains in the region (Wongsomsak 1986). Casuarina is discussed below.

Arboriculture

A third group contains pollen types of genera and families with significant arboricultural members. Notable in this group are the pollen types *Artocarpus*, *Canarium*, *Syzygium*, *Terminalia*, *Ficus*, and the families Bombacaceae and Palmae. The *Artocarpus* pollen represents a genus containing several cultivated species in the Moraceae family, including *Artocarpus altilis*, the breadfruit tree, and *A. heterophylla*, the jackfruit, both of which provide a valuable starchy food. Some species provide good timber (Willis 1973:96-7), and several are found in semi-evergreen rainforest in the region (Bunyavejchewin 1986). *Canarium* is a tree used for its edible seeds throughout Southeast Asia; some species are sources of resin (Willis 1973:196). Small pollen grains resembling the pollen of *Syzygium* and *Eugenia* (synonym for *Syzygium*) probably represent trees in the genus *Syzygium*. These are found in semi-evergreen rainforest in this region (Bunyavejchewin 1986), but, importantly, several species provide edible fruits (McMakin 1993:107), while the dried flower buds of *S. aromaticum* form the spice cloves (Willis 1973:1126). One species of *Terminalia*, *T. alata*, is common in tall dry dipterocarp forest and dry deciduous forest in the region, and may be found in semi-evergreen rain forest (Wongsomsak 1986; Bunyavejchewin 1983, 1986); of note is the fact that the fruit of some species is used for medicine and dyes, while the bark is used for lime and tan; the timber is noted to be good (Willis 1973:1136). The distinctive and large Bombacaceae pollen type resembles the pollen of *Bombax malabari* (Huang 1972:69); *B. ceiba* is a Thai cotton or kapok tree (and the family, incidentally, also contains the edible fruit tree, durian [*Durio zibethinus*] found closer to the equator) (McMakin 1993:105). *Ficus* and the Palmae are discussed below. Finally, while *Celtis* is discussed above within the second group, it should be noted that some *Celtis* species provide edible fruit, and the wood is useful for turning; the tree provides animal fodder in India, and is a source of paper in Thailand (Willis 1973:219, 1109).

Non-specific indicators

There is a fourth group of predominantly trees that presents some difficulties in ascribing a likely or possible ecological niche. This includes the pollen types *Albizia*, Palmae, *Casuarina* and *Ficus*. The genus *Albizia* contains both shrubby trees and tall forest trees, and thus its pollen is difficult to place: *Albizia procera* is a common tree in tall dry dipterocarp forest on immature or denuded land surfaces (Wongsomsak 1986), and other species of *Albizia* in northeast Thailand are fast growing trees providing good timber (Willis 1973:38; Smitinand 1980:13-14), which thus might better be interpreted as economic trees. However, given its domination of pollen assemblages here, it is probably a shrubby species that is represented. The Palmae pollen, of course, presents some interpretational difficulty, given the many species and genera within the family. Two predominant pollen types are grouped together in the pollen diagram, and these probably represent several species of palm trees. Palms are present especially in the region's semi-evergreen rain forest (Bunyavejchewin 1986), and several are native to Thailand. Relevant to this study area are the apparently native forest palms, *Caryota mitis* and *Licuala spinosa* (medium-sized and small palms respectively) and about a dozen species of rataan climbing palms (*Calamus* spp.) (McMakin 1993:32 and 58). In ecological term, the *Casuarina* pollen may also be ambiguous. Several *Casuarina* species are native to central and, mostly, coastal Thailand (Smitinand 1980:73), and are now present throughout the country; it is likely that the pollen recorded here may be modern, although the relatively poor preservation state of the few grains noted suggests these are fossils. Finally, the fig group is particularly difficult to interpret; the Moraceae comprises shrubby and larger trees growing in many contexts. Many native Thai *Ficus* species, including *F. benjamina*, an epiphytic strangler tree, *F. hirta*, a small shrub, and *F. racemosa*, a large tree, grow in mixed forest (McMakin 1993:55-56), while Bunyavejchewin (1986) indicates that *Ficus* is typically present in semi-evergreen rainforest in the region. However, various species of *Ficus* are important economic species, and provide edible fruits, rubber and timber (Willis 1973:458-9), as well as providing spiritual shade.

Openland habitats

A fifth group includes likely openland plants. While it is difficult to assign genus or species to the Gramineae pollen, as many grass species could provide a source for pollen, Wongsomsak (1986) does indicate that *Arundo donax* is a common graminid on the Mae Nam Mun floodplain; some of the pollen may be from this species. Significantly, however, there is also a distinctively large grass pollen type (40-60*μm*), often with a well-defined and large pore. Many grains are crumpled, making exact size determination and confident separation of large and small grains difficult. Due to these difficulties this type is only recorded here as common or present, forming a minor if persistent component of the count. Given the size range and its cereal-like characteristics, and recognising that complete separation of the pollen types of rice and other grasses is difficult (Köhler and Lange 1979; Maloney *et al.* 1989; D. Penny, pers. comm.), this relatively uncommon type probably represents rice pollen. Of the other significant dryland herbs, the Chenopodiaceae pollen recorded here is largely inseparable at sub-family level (Boyd 1992); it represents many predominantly halophytic and arid terrestrial herbs, shrubby herbs and low shrubs, and many are edible. Likewise the two Compositae types – characteristic fenestrate and non-fenestrate types (e.g. Moore and Webb 1978; Faegri and Iversen 1989; Boyd 1992) – probably both represent one or more of many terrestrial herb or shrubby herb species mostly found in open places or forest margins (McMakin 1993:46, 89-90). Finally, the wetland type, Cyperaceae, is represented by a family level pollen type which is of little help; two pollen types recorded here both represent one or more of many sedges in the various genera of the family, which typically grow in terrestrial wetlands. Wongsomsak (1986) notes that *Scirpus mucronatus* and *S. grossus* are common herbs on the Mae Nam Mun floodplain, and thus at least plants of this genus may be represented here.

III. THE GEOARCHAEOLOGICAL DEVELOPMENT OF NOEN U-LOKE AND NON MUANG KAO

J. HABBERFIELD-SHORT AND W.E. BOYD

INTRODUCTION

The site of Noen U-Loke, including the encircling earthworks (the "moats"), covers *c.* 36 ha; the mound, 450 m (E-W) by 250 m in area, rises 5 m above the floodplain. Non Muang Kao, including the moats, covers *c.* 27 ha; the mound is 700 m (E-W) by 300 m (N-S), and is *c.* 7 m high. The mounds comprise thick beds of floodplain-derived sediments, typically containing lateritic iron nodules (pisoliths), fragments of baked clay and pottery, shell and animal bone. They are surrounded by channels and banks that mask complexes of buried channels and banks often not reflected in the surface geomorphology of the moats (Boyd *et al.* 1999b). Noen U-Loke is ringed by up to five channels and banks, and Non Muang Kao has up to three channels. The banks comprise *in situ* floodplain alluvium and archaeological spoil, while the buried channels are cut into the alluvium and, in some cases, the bedrock. The bedrock is weathered red silt and clay mudstone, and the channel infill is predominantly fine sandy clay (see full details of the region's sediments and of the encircling earthworks in Boyd and Habberfield-Short, and Boyd, this volume). This chapter presents detailed descriptions of the lithology, derived from observations and sampling of sections exposed during the archaeological excavations at Noen U-Loke and Non Muang Kao. It provides descriptions of the lithology (both the physical and geochemical composition) and the geochronology of the site sediments. In doing so, these analyses identify the natural sources of the sediments, the processes by which these sediments have accumulated, and the timing and phasing of sedimentation. These provide a basis for understanding the history of human use of natural resources associated with the occupation and development of the sites.

METHODS

Archaeological excavations between 1996 and 1998 through the highest part of the mound at Noen U-Loke exposed 60 m of sections over a 220m² area to a depth of 5.2 m; excavations at Non Muang Kao exposed 20m of sections over a 25m² area to a depth of 3.7 m (O'Reilly 1999). We also examined a floodplain section in a trench (dug by Boyd and McGrath in 1999) from slightly northwest of the mound at Noen U-Loke. A single representative sequence was examined from each of these locations for this study: Profile 1 at Noen U-Loke; Profile 2 at Non Muang Kao; and Profile 3 at the floodplain section site. Each sequence is introduced by Boyd and Habberfield-Short (this volume); they are, respectively, Locations 21, 22 and 7 (Fig. 3:1). Samples for the chronometric component of this study were collected from various places at the Noen U-Loke and Non Muang Kao archaeological excavations, depending on availability of suitable (organic) material for radiocarbon dating.

Waters (1996) identifies three stages in analysing site sedimentation processes: defining the sediments and soils that comprise the site layers; describing the contacts between sediment layers; and establishing the time each layer represents. Here we initially use particle size analysis and sediment geochemistry to quantitatively describe the archaeological mound sediments and layer contacts. Particle size analysis quantitatively expresses the distribution of size ranges, and assists in inferring the energy of a transport medium and, thus, the environment within which sediments are deposited (Folk and Ward 1957, Friedman 1961, Visher 1969, Folk 1974, Shackley 1975, Stein 1987, Lewis and McConchie 1994). Acid extraction of metals, salt and trace elements is a standard approach used to investigate sedimentary composition and, thus, inferred depositional processes and pedogenesis (Lewis and McConchie 1994). Radiocarbon dating provides the chronological control on sedimentation processes.

THE PHYSICAL AND GEOCHEMICAL RESULTS FOR PROFILE 1 (NOEN U-LOKE), PROFILE 2 (NON MUANG KAO) AND PROFILE 3 (THE FLOODPLAIN SEQUENCE)

The physical and geochemical analyses for the profiles at Noen U-Loke and Non Muang Kao are summarised in figures 3:2 to 3:7, and are discussed in the same order as they appear in the figures. The horizontal dotted lines indicate stratigraphic boundaries, and all depths are relative to the present ground surface at each profile. Figures 3:2 and 3:3 present the particle size analysis results graphed as a percentage according to the distribution of sediment across four broad categories: gravel (>1 mm), sand (1 mm-62.5 μm), silt (62.5 μm-4 μm) and clay (<4 μm). All acid-digested metals, trace metals and salts data are expressed as mg/lt in figures 3:4 to 3:7.

Particle size analysis

Particle size trends for Noen U-Loke (Profile 1) generally correlate well with the archaeological layers identified during archaeological excavation (Fig. 3:2) and lithological field observations described by Boyd and Habberfield-Short (this volume). There are clear textural boundaries

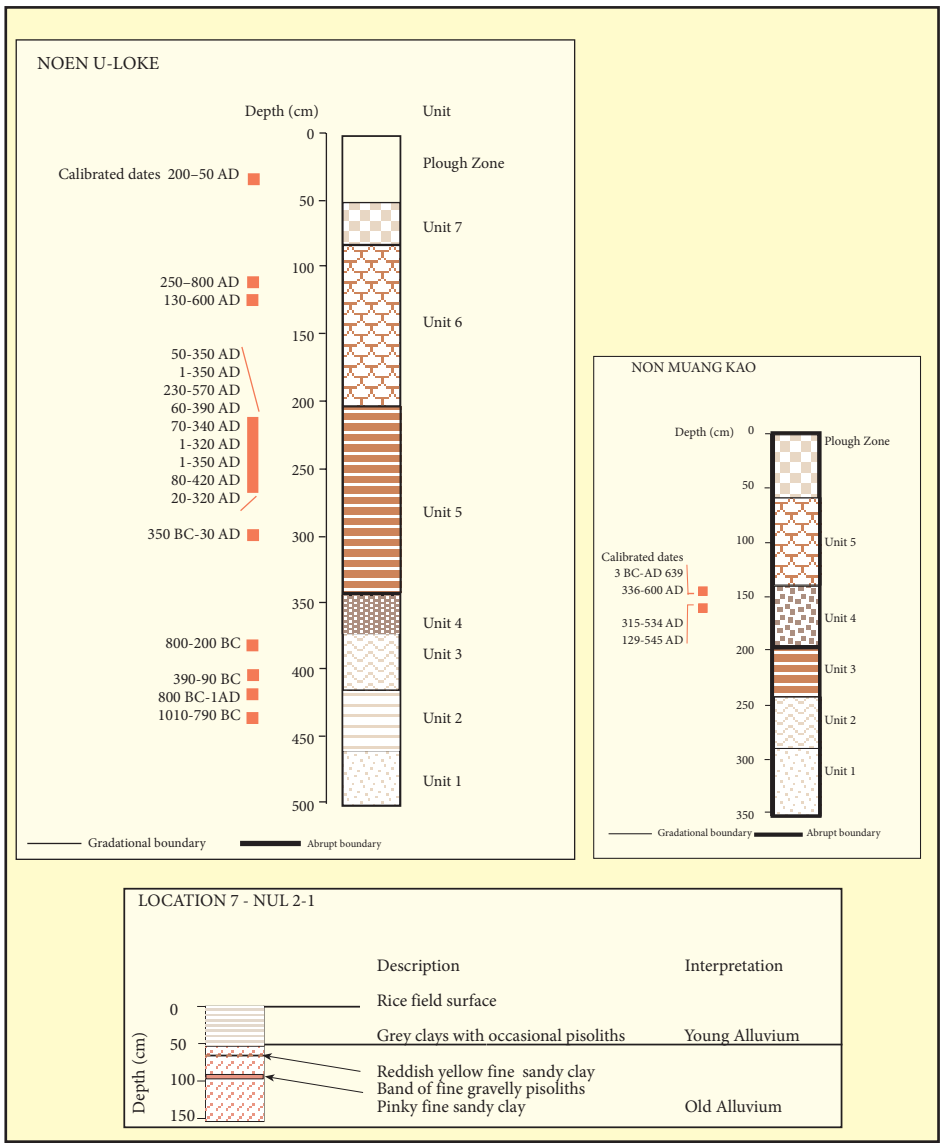


FIG. 3:1 Sedimentary summary for mound and floodplain profiles at Noen U-Loke and Non Muang Kao (Location 21 is the archaeological section at Noen U-Loke (Profile 1); Location 22 is the archaeological section at Non Muang Kao (Profile 2); and Location 7 is the trench section northwest of Noen U-Loke (Profile 3)

between the archaeological layers, and the basal channel infill and alluvial substrate. The alluvial substrate has distinctly different particle size distribution from the channel infill sediments and the overlying archaeological sediments (Layers 2 to 6). The alluvial sediments predominantly comprise sandy silt-clays with small iron nodules, whereas the channel infill sediments are predominantly sandy with occasional clay enrichment. The channel sediments become increasingly sandy towards their upper surface, and are distinct from the alluvial substrate and later archaeological sediments. An absence of gravels suggests some similarity with overlying Layer 5 and 6 sediments. Layers 4, 3 and 2 are gravel rich. In the case of Layer 4, the gravels are almost exclusively baked clay, whereas the Layers 3 and 2 gravel comprises exclusively iron nodules. Layer 4 contains three peaks of baked clay fragments, at the upper and lower boundary and near the middle section. Layer 3 and 2 contain fluctuating levels of iron nodules. The archaeological layers show an up-profile increase in the proportion of silt and clay to sand, although these sediments fluctuate markedly in Layers 3 and 2. Overall gravel increases in the upper two layers and sand lessens in proportion.

Individual particle size trends fall into four broad categories: gravels and coarse sands (500-8,000 μm), medium to very fine sands (62.5-250 μm), silt and clay (Fig. 3:3). Medium to fine sands appear to remain constant throughout the sequence, except in the lower channel infill. The sediments within Layer 4 appear to be homogenous in their textural composition, whereas sediments in higher and lower layers show considerable variation.

The particle size analysis of the sediments at Non

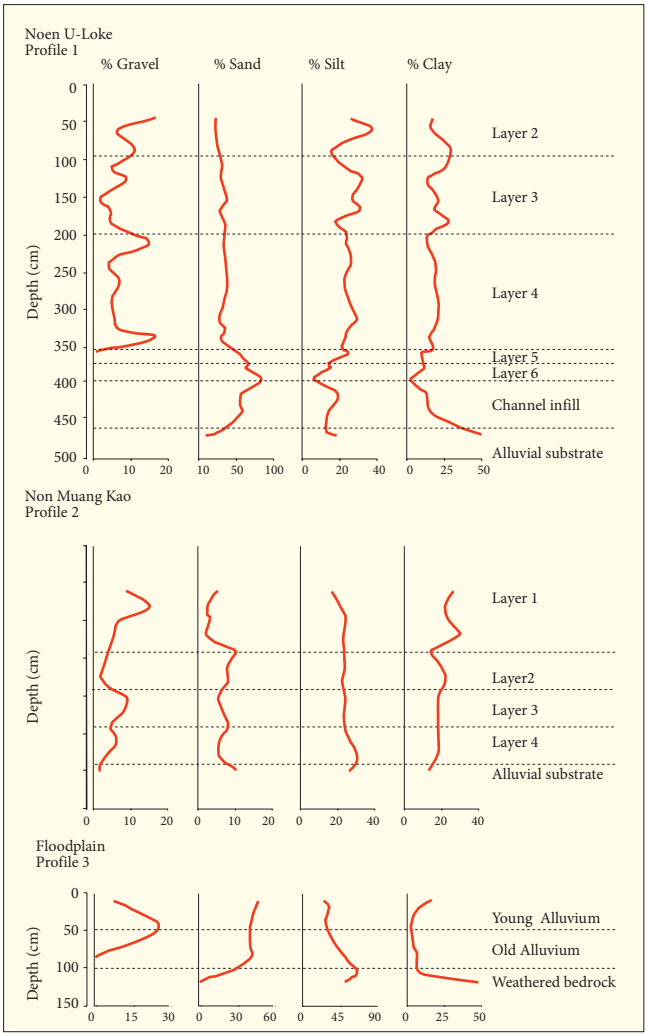


FIG. 3:2 Percentages for gravel:sand:silt:clay fractions for the archaeological sediment sequences at Noen U-Loke (Profile 1), Non Muang Kao (Profile 2) and the floodplain sequence near Noen U-Loke (Profile 3). The layers listed at the side are the archaeological layers identified during excavation

Muang Kao (Profile 2) support the identification of the archaeological layers defined during excavation (Fig. 3:2). In comparison to Noen U-Loke, the Non Muang Kao sediments have more coarse sand and fine gravels, and show a marked increase in clays in the upper layer. There are distinct textural boundaries between the archaeological layers and basal alluvium. The alluvium is clay-silt sand. Layer 4 shows an upward increase in gravels and sand, with an associated decrease in silt. Likewise, Layer 3 shows an upward increase in gravels and an associated decrease in sand. This cyclic trend is repeated in Layers 2 and 1, with the exception of sands, which decrease markedly in proportion to the clays at the lower boundary of Layer 1. Layer 1 also shows larger proportions of gravel-sized sediments near the surface of the layer. The gravel is mostly composed of large and small irregular-shaped iron nodules and angular polycrystalline sediments, but the latter lessen in proportion upwards. Individual particle size trends show that medium sand to very fine silt category (62.5-250 *μm*) forms the modal sediment size in the lower layers (including the alluvium). In the upper layers, the mode becomes increasingly finer towards the surface.

The floodplain profile (Profile 3) is characterised by a significant up-profile increase in gravel associated with peaks of iron laterite nodules at the boundary between the Young and Old Alluvium (see Boyd and Habberfield-Short, this volume, for definitions of Old and Young Alluvium). The weathered bedrock contains very little sand, but the higher proportions of clay and silt content mark this stratigraphic unit. Sand tends to maintain a 45-50% presence in the alluvium. Clay shows an up-profile increase near the surface, while silt shows an up-profile decline. The individual particle size trends show that the iron nodules are considerably finer (4,000-500 *μm*) than those in the mound profiles. The floodplain sediments generally show a coarsening upwards trend in gravels associated with greater concentrations of iron nodules than in the mound profiles. The 500 *μm* trend reflects the distribution of small iron nodules, with peaks at the surface, within laterite sediments, and at the alluvium-bedrock boundary. The distribution of the sand fraction (30-500 *μm*) and coarse silt mirrors closely the iron nodules. The fine to very fine sand forms the modal size in the lower and upper alluvium, sandy gravel in the lateritic sediments and clays in the weathered bedrock material.

Acid extractable Al, Fe, Mn and magnetic susceptibility

The magnetic susceptibility curve at Noen U-Loke (Profile 1) inversely mirrors trends of Al, Fe and Mn in the upper layers, but only Al in Layer 4 (Fig. 3:4). Fe and, to a lesser extent, Al and Mn, are highly concentrated in the upper layers. The peaks of Fe and Mn in the upper layers are associated with peaks in the >1 mm coarse fraction (iron nodules), and in Layer 4 these are associated with Al and the >1 mm coarse fraction (baked clay). It is likely that these are the materials generating the high magnetic susceptibility values. Mn, Fe and Al values in Layers 6 and 5 are similar to the alluvium substrate. The latter is characterised by similar trends in metals to the upper two layers, but here the peaks in metals are associated with the >1 mm fraction (iron nodules).

The sequence at Non Muang Kao (Profile 2), on the other hand, shows a slight relationship between levels of magnetic susceptibility and the other metals (Fig. 3:4), although magnetic susceptibility values are high in the alluvial substrate. Mn shows higher concentrations towards the surface of Layers 3 and 1. Fe levels are similarly distributed, but are highly concentrated in the archaeological sediments compared to the alluvial substrate. As a whole, Mn and Fe values and, to a lesser extent, Al values are associated with the >2 mm coarse fraction (iron nodules

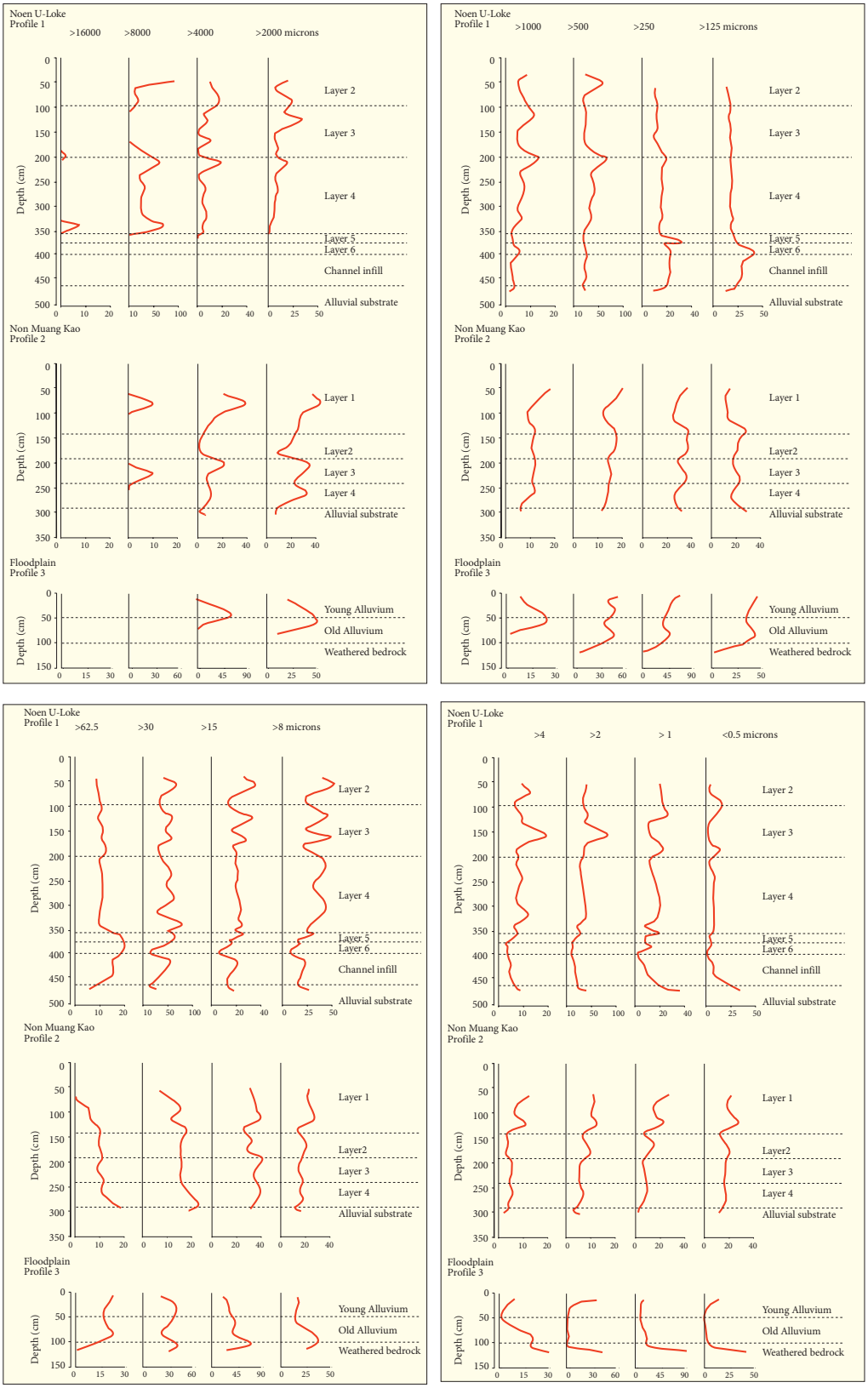


FIG. 3:3 Individual (%) particle size analysis results for Noen U-Loke (Profile 1), Non Muang Kao (Profile 2) and the floodplain (Profile 3): Figures from top to bottom showing the details of specific sediment grain size ranges: 16 mm - 2000 *μm*; 1000 - 125 *μm*; <62.5 - >8 *μm*; >4 - >0.5 *μm*

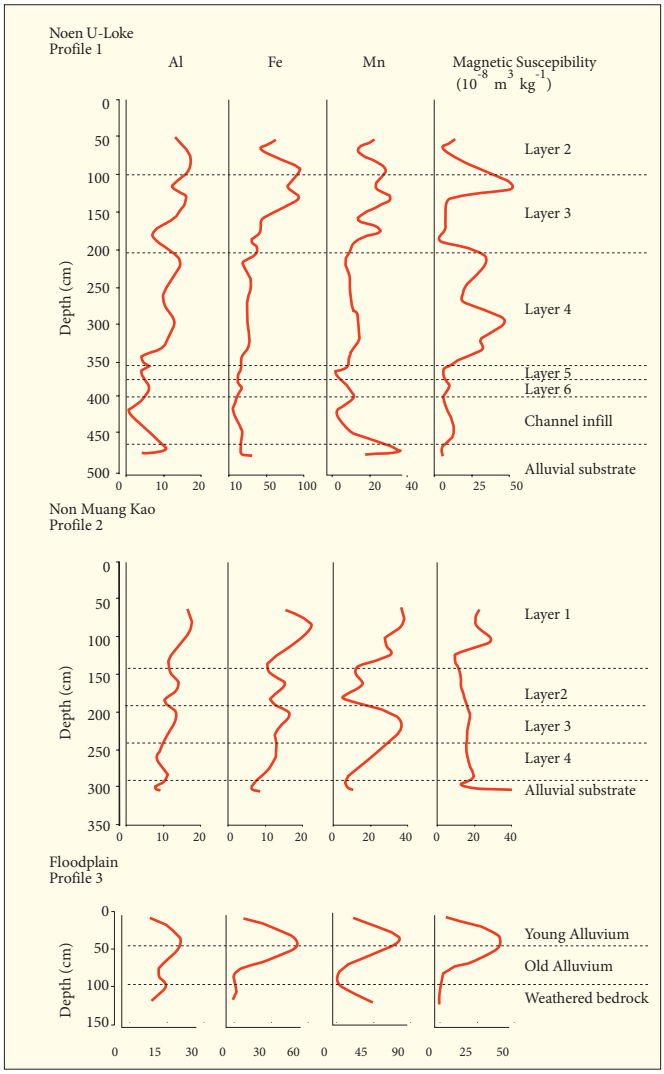


FIG. 3:4 Acid extractable metals (aluminium, iron and manganese) analysis (ppm) and magnetic susceptibility values for Noen U-Loke (Profile 1), Non Muang Kao (Profile 2) and the Floodplain (Profile 3).

and polycrystalline sediments) in all layers.

Al, Fe, and Mn are also strongly correlated with the coarse particle size fraction (iron nodules) in the floodplain sequence (Profile 3) (Fig. 3:4). The iron nodules are mostly concentrated in the alluvial sediments. However, they are also found overlying the weathered bedrock, though in lesser amounts, and this is reflected in the geochemistry. Only Al and Mn appear to be strongly associated with the laterite found overlying the bedrock. The high magnetic susceptibility values are also strongly associated with the distribution of the iron nodules in the alluvium. The marked reduction in the concentration of metals and magnetic susceptibility of the weathered bedrock probably reflect the weathered nature of the substrate.

Acid extractable trace metals

Fluctuations in the trace metals Ba, Ce, Co, Cr, Mo, Ni, Pb, Th, Ti, U, V and Zr are correlated with each other in the Noen U-Loke (Profile 1) (Fig. 3:5), reflecting the presence of iron nodules in the coarse particle size fraction; the trace metal values are closely associated with Mn and Fe values. Sediments that contain baked clays in Layer 4, and have high Al and magnetic susceptibility values, also indicate relatively high concentrations of Ba, Cu, Sn, Ti and Zn and, to a lesser extent, Mo, Ni, Pb and U; they have low concentrations of Ce, Co, Cr, Th, V and Zr. Cu and Sn, in particular, are closely matched with the presence of baked clays. Trace elements in the channel infill sediments reflect the distribution of finer sediments (silts and clays), but also show close affinity with Al, Fe and Mn. The background concentrations of Ce, Co, Cr, V and Zr in the channel infill, and Layers 6, 5 and 4 suggest a similar source for these sediments.

The close association between the presence of iron nodules, Al, Fe, Mn and trace metals, is also observed at Non Muang Kao (Profile 2), and the cyclic sequence noted in the metals is also inherent in the trace metals (Fig. 3:5). Notable transitions in Ba, Co, Ce, Mo, Ni, Pb, Ti, U, V and Zn relate to the boundaries between Layers 1 and 2, and Layers 2 and 3, and these correlated with similar trends in Fe, Mn, Al and gravels. Apart from Ba, Ni and Zr, the basal alluvium shows a relative paucity of all trace elements.

All peaks in trace metals, except Ba, Sn, Ti and, to a lesser extent, Th, correlate with the presence of iron nodules, metals and magnetic susceptibility in the floodplain profile (Profile 3) (Fig. 3:5). Th, in addition to showing a similar distribution to the trace metals above and metals associated with iron nodules, also shows a marked increase at the base of the profile. Mn, Sn, Ti and Zn appear to correlate with the presence of finer iron nodules in the profile.

Acid extractable salts, pH, organic matter carbonates and electrical conductivity

The sediment pH at Noen U-Loke (Profile 1) is alkaline, but with an upwards trend towards neutrality (Fig. 3:6). Fluctuating levels of organic matter, carbonates and salts are found at the contacts between layers (Figs. 3:6 and 3:7). Organic matter concentration is low, but there are peaks within the alluvial sediments and upper Layer 4 sediments. Carbonate values are also low, and have an inverse relationship with organic matter and electrical conductivity values; the carbonate values correlate with those of Ca, K, Mg and Na. The mirrored peaks in carbonates and Ca suggest that calcium is in the form of calcium carbonate in the basal contacts of Layers 3 and 4. Carbonate and Ca values closely match Mn, Fe and trace metals associated with iron nodules in Layers 3 and 2. K, Mg and Na are largely concentrated in Layer 4. The distribution of salts in Layers 6 and 5 and the channel infill sediments generally correlate with finer particle sizes. Layers 3 and 2 show a gradual up-profile decline in K and Na concentration. The enrichment of K, Mg and Na in Layer 4 is associated with high electrical conductivity. These sediments are more

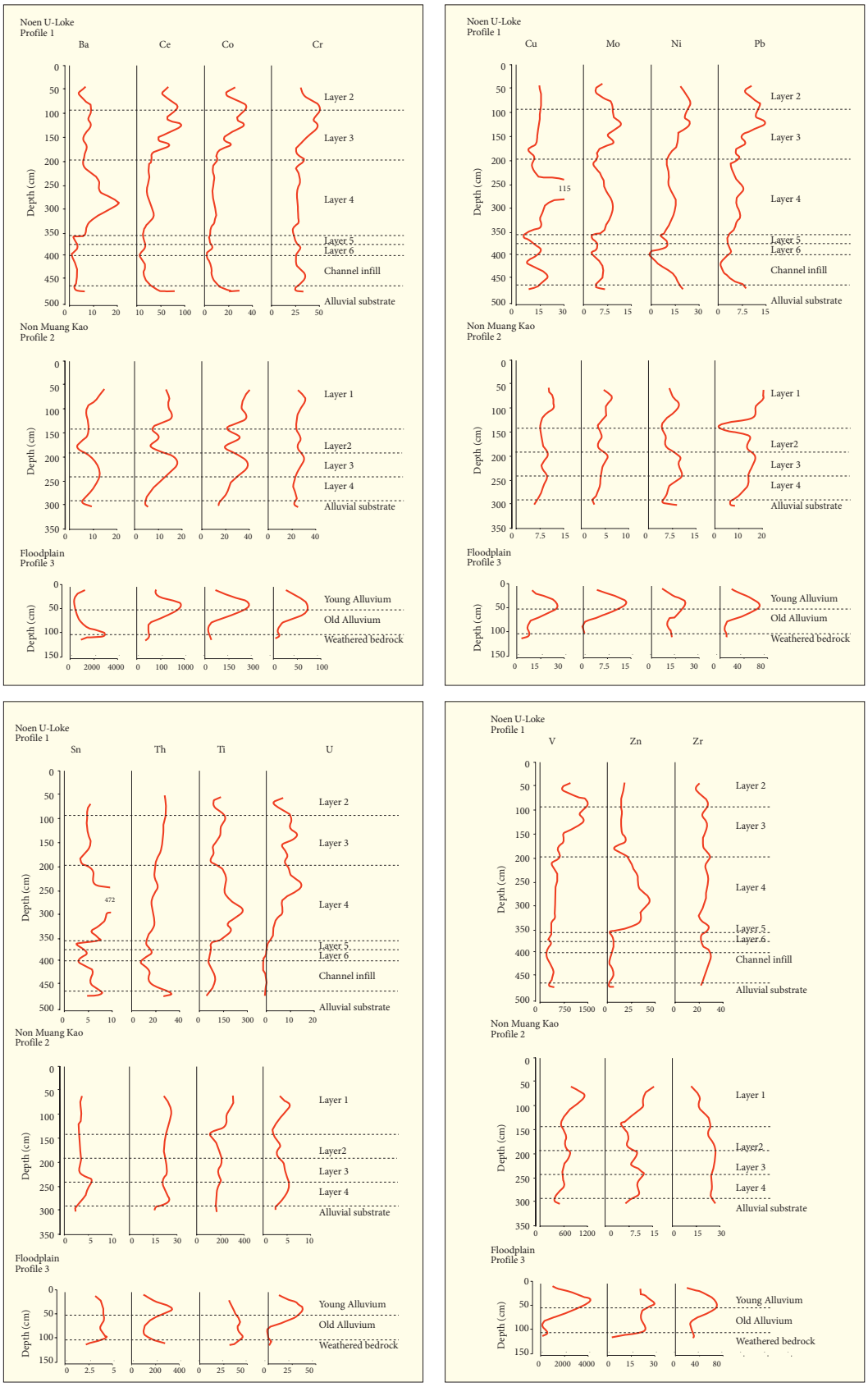


FIG. 3:5 Acid extractable trace metals 1: Barium, Cerium, Cobalt and Chromium; 2: Copper, Molybdenum, Nickel and Lead; 3: Tin, Thorium, Titanium and Uranium; 4: Vanadium, Zinc and Zirconium (shown in ppm) for Noen U-Loke (Profile 1), Non Muang Kao (Profile 2) and the Floodplain (Profile 3)

sodic than both the alluvial and later archaeological sediments. The association of Na with high EC levels indicates that the sodium is probably in the form of salt (NaCl) in these sediments.

The profile at Non Muang Kao (Profile 2) is mostly alkaline, although pH oscillates slightly within each layer. Organic matter values correlate slightly with carbonate values, and increase slightly in upper Layer 1. Carbonates are inversely associated with Mg throughout the sequence, and increases slightly in concentration in the upper layer. Small variations are found at the contact between each layer. Ca is significantly concentrated in upper Layer 1 and associated with enrichment in Mg, possibly in the form of magnesium-chlorides. The pH, C and Ca and Mg concentrations reflect the distribution of iron nodules and associated concentrations of Al, Mn, and Fe and Cr, Mo, Pb, Ti, U, and V. K, Na and electrical conductivity show a mid-profile peak, and are likely associated with the uptake of sodic sediments. In this regard Layer 4 and 3 sediments show closer affinity to the basal alluvium than to the Layer 2 and 1 sediments.

The floodplain profile pH (Profile 3) declines towards the top, and is mostly alkaline to neutral. Organic matter values mirror the distribution of carbonates and Ca, but is slightly enriched in the basal alluvial sediments. Carbonate values show a slight increase in the pisolith-richer sediments, but along with Ca, they are mostly concentrated in the weathered bedrock sediments and associated with the presence of calcium carbonate nodules. The salts – K, Mg and Na – are concentrated near the weathered bedrock and alluvial boundary. K values show a slight increase near the surface of the profile. Electrical conductivity values mirror those of the salts and, to a lesser degree, the iron nodules. Importantly, these data show that enrichment of salts in this profile is near the bedrock-alluvium boundary, and indicates that saline ground water is the likely source for much of the salts in this section.

The geochronology of archaeological sites of Noen U-Loke and Non Muang Kao

Evidence for the geochronology of the sites at Noen U-Loke and Non Muang Kao comprises fifty radiocarbon age determinations collected from both archaeological and geoarchaeological sections at both sites. These radiometric determinations were collated to address issues of the sedimentation and formation processes of the mounds themselves, and were obtained using Atomic Mass Spectrometry (AMS) radiocarbon dating of materials recovered from mound sediments and moat infill (Lawson *et al.* 2000). Archaeological samples from Non Muang Kao and Noen U-Loke comprised a few rice grain samples and, mostly, charcoal from hearths, daub remains, furnaces, ash spreads and floors. Dates reported by McGrath and Boyd (2001) comprised charcoal, shell and carbonised rice from trenches excavated through the surrounding earthworks at Noen U-Loke. Additional samples were also collected from the channel infill in the trenches excavated at Non Muang Kao; these are published here for the first time. The mound sediment dating strategy was designed to build on the chronology arising from these samples and to amplify the resolution of on-site dating. Samples of charcoal, rice grains and shell were collected at 5 cm intervals from archaeological sections at Noen U-Loke and Non Muang Kao. The measurement results were calibrated to 2 σ using the Calib software, Calculation Method B: Probability distribution at 95.4% (2 σ) confidence intervals (Stuiver *et al.* 1998).

The data set (Tables 3:1 and 3:2) consists of twenty-five previously published dates (Higham 2000, McGrath and Boyd 2001, O'Reilly 1999), and twenty-five previously unpublished dates from samples collected by Habberfield-Short and Boyd.

The use of the archaeological dates in establishing a chronology for site formation is limited because they are not necessarily from spatially and vertically contiguous contexts. They do assist, however, in relating the geochronology to the archaeological sequence. The off-mound dates are used here to establish a geochronological

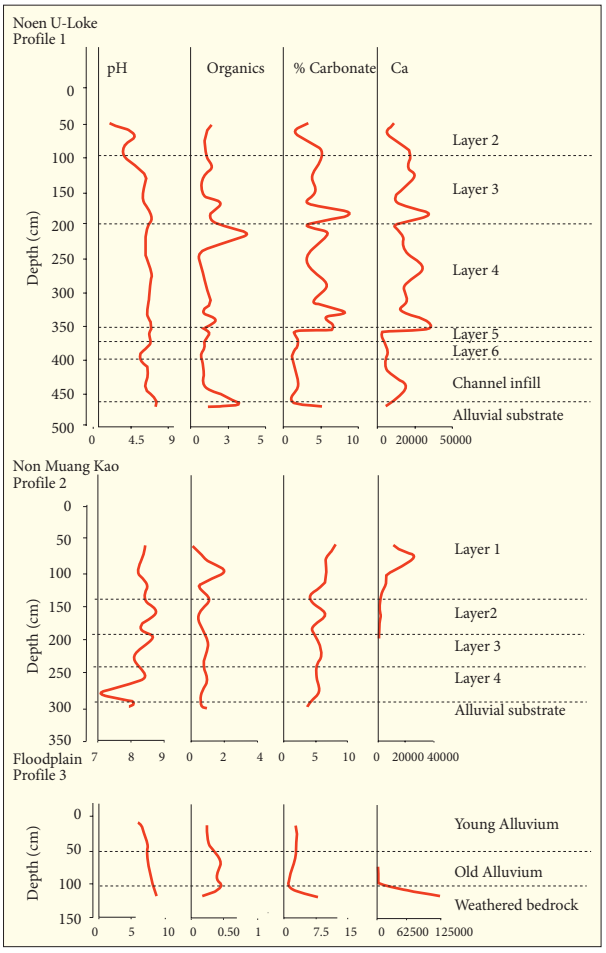


FIG. 3:6 pH, Organic matter (%), carbonate (%) and acid extractable calcium (ppm) for Noen U-Loke (Profile 1), Non Muang Kao (Profile 2) and the floodplain (Profile 3)

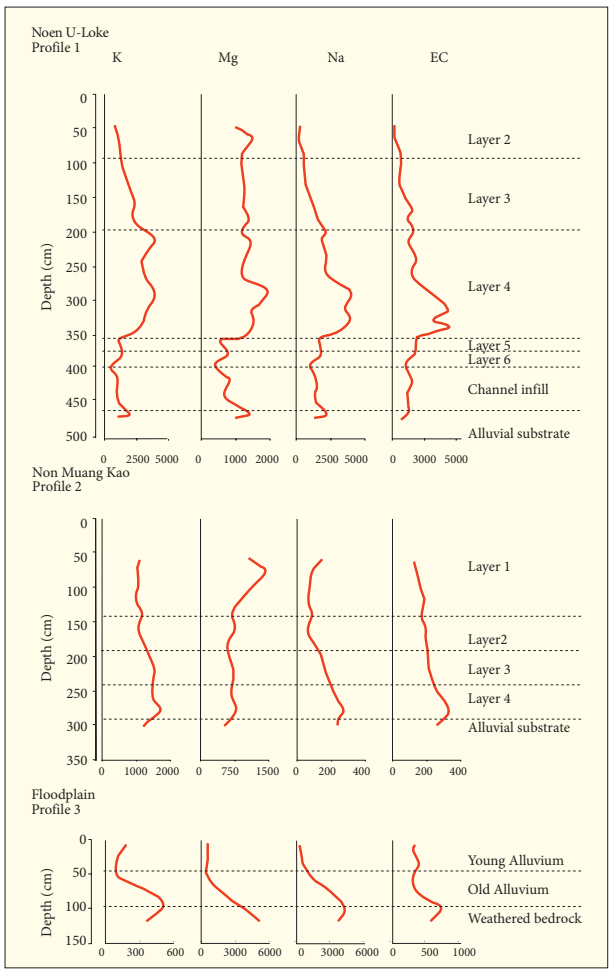


FIG. 3:7 Acid extractable salts (potassium, magnesium and sodium) (ppm) and electrical conductivity (µs) for Noen U-Loke (Profile 1), Non Muang Kao (Profile 2) and the floodplain (Profile 3).

relationship between the establishment of the encircling earthworks, and their subsequent infilling, and the formation and use of the mounds. Analysis of this data set is continuing, and the full description and analysis will be published elsewhere (Habberfield-Short and Boyd, in prep.). The following is a review of the salient points emerging form the data set.

The geochronology of Noen U-Loke

Seventeen AMS radiocarbon determinations have been obtained from three archaeological layers (Higham 2000) (Table 3:1, Fig. 3:8). Along with associated archaeological evidence, these determinations provide evidence that settlement occurred at this site from the late Bronze Age and continued throughout the Iron Age. The chronological study of the moats associated with Noen U-Loke by McGrath and Boyd (2001) yielded four AMS dates, which give a range of acceptable ages from 405 AD at the earliest to 798 AD at the latest. The two dates from the buried channels provided older dates than the moat infill, supporting McGrath and Boyd's (2001) argument that channels closer to the mounds are older and have been concealed by the expanding mound. McGrath and Boyd further suggested that the timing of the construction of the moats at Noen U-Loke and other similar sites in the area occurred between 0–600 AD while the infilling and over-topping of the channels buried by the mounds dates to around 0-250 AD.

At Noen U-Loke ten new dates were obtained from the mound sediments (Table 3:2). Nine are from the archaeological sediments (OZE-941, OZE-942, OZF-185 to 188, OZF-336, OZF-333, OZE-878), and these form three clusters of dates.

- Layers 5 and 6 (base of sequence). Dates OZF-333, OZF-187 and OZF-188 overlap around 600 calBC, with OZE-878 being slightly older and OZF-187 slightly younger. This group provides a maximum age range from the 11th to 3rd C BC; excluding the outliers, these determinations indicate a 7th to 6th C BC timeframe.
- Layer 4. Dates OZF-185, OZF-336 and OZF186 come from Layer 4, yielding very similar ages that indicate a *c.* 1st C AD age for Layer 4.
- Layers 2 and 3. Dates OZE-941 and OZE-942 come from Layer 2 and 3, and have the same age, and indicate a *c.* 6th C AD age.

The geochronology of Non Muang Kao

Four published dates from Layer 2 indicate a calibrated age of 300-500 AD for its associated occupation (Table 3:1, Fig. 3:9). Combined with ceramic data, the entire archaeological sequence is interpreted to represent continuously occupation for a period of 400-500 years during the Late Iron Age.

Fifteen new dates are available from Non Muang Kao (Table 3:2), seven from the archaeological excavation, six from trenches within the moats (Fig. 3:12), and two from a trench through the middle of the site (Location 18, Boyd and Habberfield-Short, this volume). At the latter location, dates OZC-911 and OZC-912 indicate a 3rd century BC to 1st century AD age for the onset of anthropogenic sedimentation. The dates from the archaeological site cluster according to the archaeological layers, with a notable inversion for the uppermost layer.

- Underlying alluvium. The oldest date (OZF-184) provides an age of 2nd-3rd C BC for the alluvium underlying the archaeological sediments at the base of the mound.
- Layer 4. Two dates (OZF-183, OZF-342) indicate a 1st-2nd C BC age for the deposition of these sediments.
- Layer 3. Only one date (OZF-182) is available for this layer, and provides an indication of a 1st-2nd C BC age.
- Layer 2. Only one date (OZF-181) is available for Layer 2, and indicates a 4th C AD age for this layer.
- Layer 1. Dates OZF-180 and OZF-339 yield ages

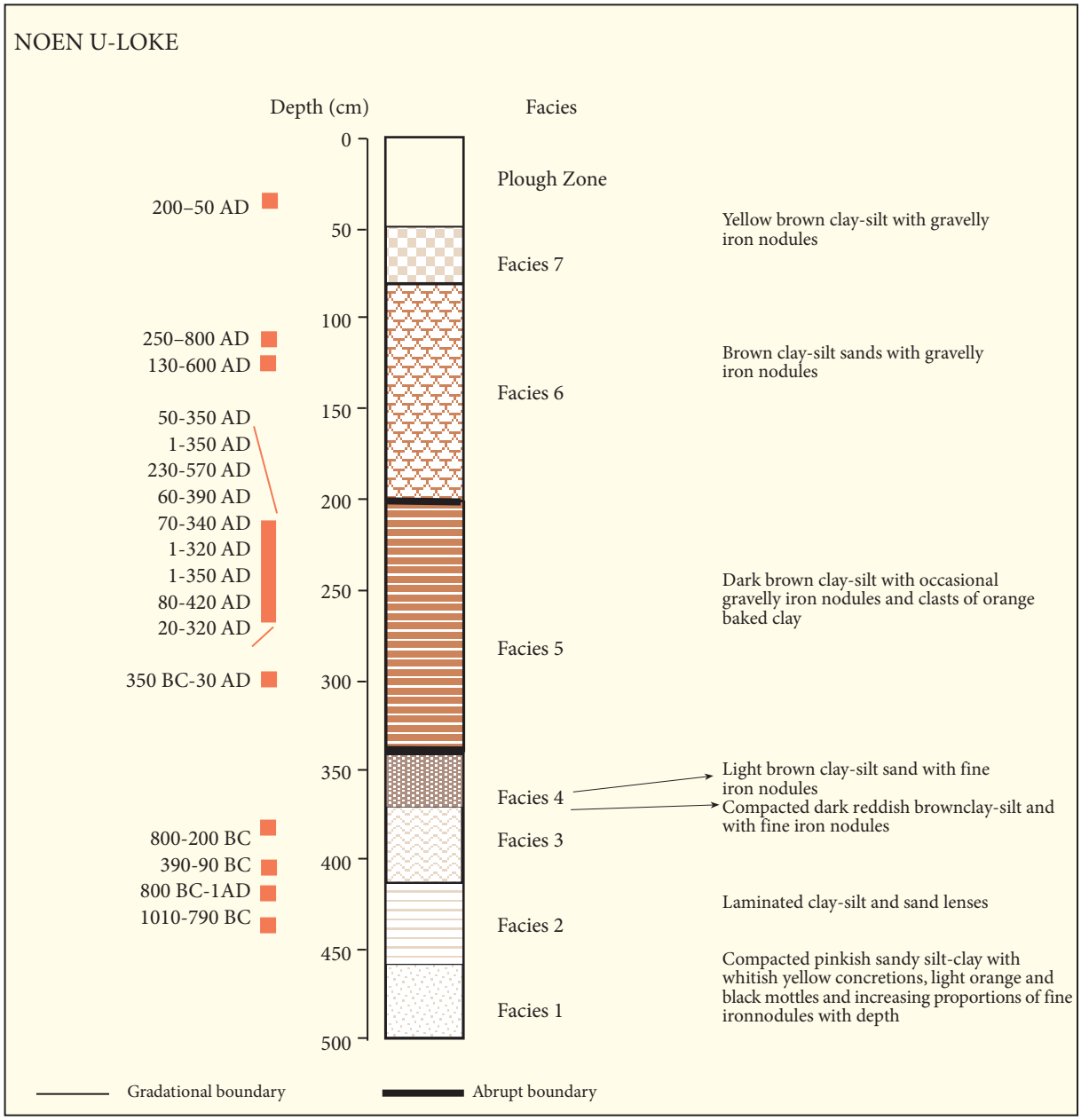


FIG. 3:8 Summary of the archaeological dating, stratigraphy and sediment descriptions for Noen U-Loke. The calibrated C14 dates are those of Higham (2000) and are documented in Table 3:1

that indicate a 1st C AD time span for the sedimentation of Layer 1.

The moat dates provide indications for the encircling channels as follows.

- Channel 1 (innermost; closest to the mound edge). OZF-306 provides a young age of for the middle of the channel infill in Section 1, while OZF-341 indicates a 9th century AD age for sedimentation.
- Channel 2. Dates OZF-304 and OZF-305 899-1253 cal AD provide young and inverted ages for the infill of this channel.
- Channel 3 (outermost). Date OZF-340 returns a modern age near the top of the fill, while date OZF-309 dates the fill base at around the 2nd century AD age.

Discussion (i) Stratigraphic contacts between mound strata

The physical and geochemical data presented here support interpretations based on the field observations of site stratigraphy. Where abrupt stratigraphic boundaries had been previously identified (Figs. 3:1 and 3:2), these are characterised by significant change in particle size and/or geochemical data. At Noen U-Loke, for example, such changes occur at the boundaries between Layers 4 and 5 and Layers 3 and 4. At Non Muang Kao there is similar evidence at the Layer 2-3 boundary. In some cases, on

TABLE 3:1 *List of previously published Atomic Mass Spectrometry (AMS) radiocarbon age determinations from the sites of Noen U-Loke (NUL) and Non Muang Kao (NMK). L2, L3 and L4 = Archaeological Layers 2, 3 and 4 respectively; these were determined during the excavation of the sites. The sample depths are below the present land surface at sample locations*

Collector and published source	Site, context and depth (m)	Lab Ref No.	Conventional Radiocarbon Age years B.P.	δC13	Calibrated Age	Calibrated Age minimum & maximum (2σ)
Higham (2000)	NUL L1 <0.5m	WK-6147	200±50	N.A	N.A	N.A
Higham (2000)	NUL L3 1.05m	WK-5353	1470±120	-28.3	250 AD-800 AD	250-800 AD
Higham (2000)	NUL L3 1.15m	WK-5352	1680±90	-28.1	130 AD-600 AD	130-600 AD
Higham (2000)	NUL L4 2.0m	WK-5359	1840±60	-27.4	50 AD-350 AD	50-350 AD
Higham (2000)	NUL L4 2.05m	WK-5354	1850±70	-25.6	1 AD-350 AD	AD-350 AD
Higham (2000)	NUL L4 2.25m	WK-5358	1830±50	-25.0	70 AD-340 AD	70-340 AD
Higham (2000)	NUL L4 2.2m	WK-5362	1650±70	-24.5	230 AD-570 AD	230-570 AD
Higham (2000)	NUL L4 2.35m	WK-5360	1770±60	-26.3	80 AD-100 AD (1%) 120 AD-420 AD (99%)	80-420 AD
Higham (2000)	NUL L4 2.2m	WK-5351	1820±60	-26.7	60 AD-390 AD	60-390 AD
Higham (2000)	NUL L4 2.3m	WK-5355	1850±70	-27.3	1 AD-350 AD	1 AD-350 AD
Higham (2000)	NUL L4 2.45m	WK-5357	1870±50	-25.4	20 AD-260 AD (98%) 300 AD-320 AD (2%)	20-320 AD
Higham (2000)	NUL L4 2.25m	WK-5361	1880±60	-25.3	1 AD-260 AD (98%) 300 AD-320 AD (2%)	1 AD-320 AD
Higham (2000)	NUL L4 3.15m	WK-5356	2090±50	-14.4	350–310 BC(4%) 210 BC-30 AD (96%)	350 BC-30 AD
Higham (2000)	NUL L6 3.75m	WK-5363	2360±60	-26.4	800–350 1 BC (97%) 300–200 BC (3%)	800-200 BC
Higham (2000)	NUL L6 4.0m	WK-6148	2180±45	-25.7	390-90 BC	390-90 BC
Higham (2000)	NUL L6 4.1m	WK-5364	2280±130	-25.0	800 BC-1 AD	800 BC-1 AD
Higham (2000)	NUL L6 4.2m	WK-5365	2720±60	-26.0	1010-790 BC	1010-790 BC
McGrath & Boyd (2001)	NUL Buried Channel (1) 2.25m	OZD-669	1817±50	-25.0	AD 81–263 (97%) AD 274– 339 (3%)	81-339 AD
McGrath & Boyd (2001)	NUL Buried channel (1a) 2.15m	OZD-670	1991±35	-25.0	BC 87 – 81 (1%) BC 54 – AD 82 (98%) AD 108-114 (1 %)	87 BC-114 AD
McGrath & Boyd (2001)	NUL Inner moat (2) 1.4m	OZD-671	1572±46	-25.0	AD 405 – 600 (100%)	405-600 AD
McGrath & Boyd (2001)	NUL Inner moat (2) 1.4m	WK-6490	1364±63	-25.0	AD 543 – 553 (0.8%) AD 554 – 780 (99%)	543-798 AD
O'Reilly (1999)	NMK L2 1.44m	WK-4512	1750±160	-26.9	N.A	3 BC-639 AD
O'Reilly (1999)	NMK L2 1.45m	WK-4515	1610±60	-26.2	N.A	336-600 AD
O'Reilly (1999)	NMK L2 1.53m	WK-4514	1700±90	-25.3	N.A	129-545 AD
O'Reilly (1999)	NMK L2 1.54m	WK-4513	1640±70	-24.0	N.A	315-584 AD

TABLE 3:2 *Sedimentary Atomic Mass Spectrometry (AMS) radiocarbon age determinations from the mounds and moats at Noen U-Loke (NUL) and Non Muang Kao (NMK). L2, L3, L4 and L5 = Archaeological Layers 2, 3, 4 and 5 respectively; Moat Section 1.1 = inner channel in Section 1; Moat section 2.1 = inner channel in Section 2; Moat Section 2.2 = middle channel in Section 2; Moat Section 2.3 = outer channel in Section 2. The sample depths are below the present land surface at sample locations*

Site, context and depth (m)	Lab Ref No.	Conventional C14 Age years B.P.	δC13	Calibrated Age	Calibrated Age minimum & maximum (2σ)
NUL L2 0.75m	OZE-941	1490±40	-7.0	439-452 AD (3%) 463-504 AD (7%) 506-649 AD (90%)	439-649 AD
NUL L2 1.6m	OZE-942	1490±40	-25.0	439-452 AD (3%) 463-504 AD (7%) 506-649 AD (90%)	439-649 AD
NUL L3 2.0m	OZF-185	1944±56	-25.0	50 BC-218 AD	50 BC-218 AD
NUL L3 2.65m	OZF-336	1946±40	-25.0	40 BC-132 AD	40 BC-132 AD
NUL L3 3.15	OZF-186	1944±47	-25.0	46 BC-140 AD (96%) 151-176 AD (2.1%) 193-212 AD (2%)	46 BC-212 AD
NUL L5 3.6m	OZF-333	2310±40	-7.0	834-756 BC (81.1%) 686-662 BC (0.5%) 639-549 BC (13.2%)	834-549 BC
NUL L5 3.7m	OZF-187	2020±40	-7.0	478-349 BC (65%) 319-227 BC (32.2%) 226-206 BC (2.8%)	478-206 BC
NUL L6 3.75m	OZF-188	2240±40	-7.0	801-515 BC (99.3%) 432-431 BC (0.7%)	801-431 BC
NUL L6 4.5m	OZE-878	2840±40	-25.0	1187-1182 BC (1%) 1128-898 BC (99%)	1187-898 BC
NUL Alluvium 4.7m	OZF-189	2570±45	-25.0	825-749 BC (46.1%) 724-532 BC (53.9)	825-532 BC
NMK L1 0.55m	OZF-180	1760±40	-7.0	166 AD-25 AD	166 BC-25AD
NMK L1 0.85m	OZF-339	1640±40	-7.0	37-12 BC (2.7%) 3 BC-141 AD (91.2%) 153-209 AD (6.1%)	37 BC-209 AD
NMK L2 1.5m	OZF-181	1662±38	-25.0	256-302 AD (12.2%) 318-447 AD (83.2%) 450-529 AD (4.6%)	256-529 AD
NMK L3 1.95m	OZF-182	2070±130	-25.0	392BC-AD136 (98.6%) 160-170 AD (0.5%) 196-208 AD (0.9%)	392 BC-208 AD
NMK L4 2.4m	OZF-183	1960±40	-25.0	40 BC-93 AD (89.1%) 96-125 AD (10.9%)	40 BC-125 AD
NMK L4 2.8m	OZF-342	2190±94	-25.0	403 BC-1 AD	403 BC-1 AD
NMK Alluvium 2.95m	OZF-184	2150±40	-25.0	355-289 BC (26.1%) 253-87 BC (70.4%) 76-60 BC (3.4%)	355-60 BC

TABLE 3:2 (Cont).

Site, context and depth (m)	Lab Ref No.	Conventional C14 Age years B.P.	dC13	Calibrated Age	Calibrated Age minimum & maximum (2σ)
NMK Moat Section 1.1 0.75-0.83m	OZF-306	279±33	-25.0	1496-1600AD (57.3%) 1614-1666 AD (41%) 1787-1791 AD (1.6%)	1496-1791 AD
NMK Moat Section 2.1 0.60-0.65m	OZF-341	1110±54	-25.0	785-794 AD (2.2%) 808-1019 AD (97.8)	785-1019 AD
NMK Moat Section 2.2 0.46-0.56m	OZF-304	959±84	-25.0	899-919 AD (2.1%) 956-1253 AD (97.9%)	899-1253 AD
NMK Moat Section 2.2 0.69-0.79m	OZF-305	Modern			
NMK Moat Section 2.3 0.35m	OZF-340	Modern			

the other hand, where stratigraphic interpretations indicated gradational contacts between layers, the data presented here show diffuse physical and chemical trends; examples include the Layer 2-3, Layer 5-6 and channel-alluvium boundaries at Noen U-Loke, and the Layer 1-2 and 3-4 boundaries at Non Muang Kao. However, stratigraphic boundaries between layers at Non Muang Kao may be more pronounced than is visually apparent. This is especially the case for the contact between Layers 1 and 2, where changes in particle size and geochemical data indicate an unconformity, and a possible shift in sedimentary processes and conditions, although an abrupt contact was not apparent in the field observations.

Discussion: (ii) The lithology of the mounds

The alluvium at Noen U-Loke (Profile 1) is well-weathered silty clay, and, compared to the channel infill and overlying layers, its fine texture indicates that it has been deposited under low energy conditions. The channel infill and overlying layers are notably coarser than the alluvial substrate; the channel infill is exclusively composed of well-sorted clay-silt sands, indicating higher-energy flow conditions in comparison to the alluvium. Although the clay-sand laminations observed in the field are not reflected in the results (due to the coarse sampling strategy), laminated banding of clays and sands in the channel sediments implies fluctuations in the energy of depositional conditions. The coarsening-upwards nature of this layer probably reflects a coarse local sediment source associated with the infilling of the channel. The sediments at Noen U-Loke (Layers 5 and 6) immediately overlying the channel infill are inferred to represent a reduction in energy conditions, and are perhaps associated with avulsion or alluvial processes. The presence of cultural materials indicates that these sediments are also partly anthropogenic in origin. The geochemistry of these sediments reflects the distribution of 1-2 mm iron nodules.

Particle size analysis and geochemistry clearly distinguish between these preceding layers. The sediments in Layers 4 to 2, however, show a gradual decline in sandiness and become siltier upwards, notably so in the uppermost layers. Whereas the alluvial and channel infill sediments are characterised by either clay or sand, these sediments are gravely clay-silt sand. Layers 2 and 3 are enriched in iron laterite nodules. In particular, the iron nodules are gravel sized, and are found in higher proportions in Layer 2. Clay and silt display an inverse relationship to the concentrations of the gravels and associated geochemistry. Peaks in metals (Fe, Mn), salts (Mg) and trace metals are associated with the lateritic sediments. The geochemistry is notably different in Layer 4 but likewise reflects the coarser fraction. Here Al, Ba, Ca, Cu, K, Na, Sn, Pb, Ti, U and Zn are associated with the distribution of baked clays, and to a lesser extent, iron nodules. Layer 4 is relatively homogenous, with consistent amounts of the sand, silt and clay. As a whole, the deposition of gravel-sized particles indicates a change in the processes of mound formation at this time. The deposition of Layers 2 and 3 occurred under rhythmical sedimentation. It is

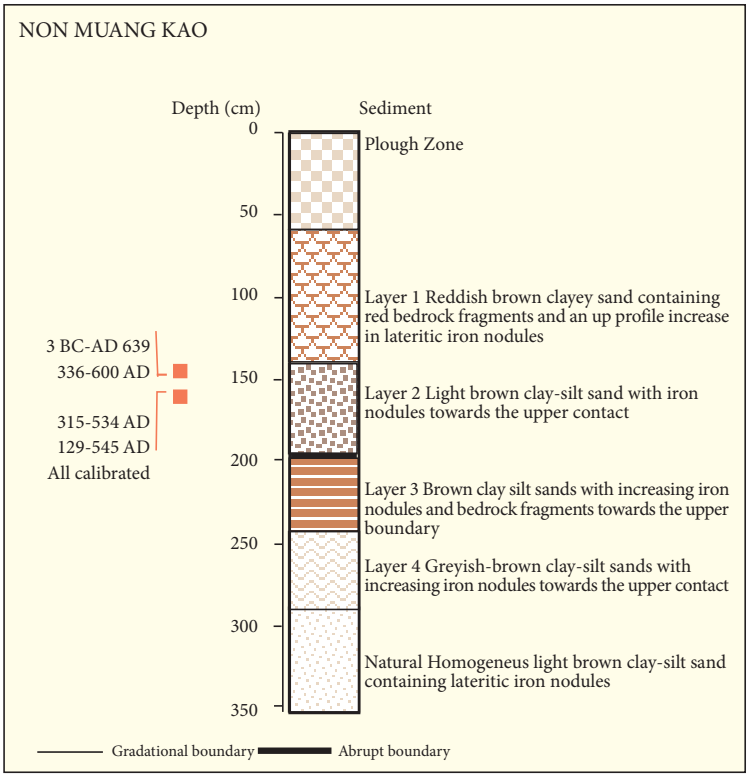


FIG. 3:9 Summary of the archaeological dating, stratigraphy and sediment descriptions of Non Muang Kao. The AMS dates are those collected by O'Reilly (1999) and are documented in table 3:1

possible that the regularity and scale of these sediments reflects a succession of small-scale and repeated depositional processes and conditions that are repeated in the same order.

A similar conclusion can be drawn from the particle size data for the sequence at Non Muang Kao (Profile 2). The lithology here displays a rhythmic sedimentation that is best exemplified by the gravel sediments. The basal alluvium is slightly sandier than the overlying sediments and characterised by lower concentrations of metals and trace metals. The distribution of the gravels in the other layers is mirrored by the distribution of iron nodules and polycrystalline sediments, and, in turn, by peaks in specific metals and trace metals. These sediments are enriched in Al, Fe, Mn, Ba, Co, Ce, Mo, Ni, Pb, Ti, U, V and Zn. The unconformity noted between Layers 1 and 2 is characterised by a succession from sandy to clayey sediments. The relative paucity of metals and trace metals suggest that the basal alluvium is well weathered; it contains little in the way of lateritic gravel, and is sandier than the archaeological sediments. The sand within the archaeological sediments has a medium to fine mode; there is an overall up-profile reduction in the proportion of sand within these two modes and an associated increase in the proportion of gravels, silts and clays. Of note is the decrease in sand between Layers 2 and 1. This may reflect the incorporation of clay-rich bedrock sediment into the archaeological layers at this point, a suggestion supported by the presence of bedrock fragments and reddish brown sediments in Layer 1. As a whole, however, the cyclicity of sediment geochemistry and particle size data is notable. This cyclicity reflects the distribution of iron nodules, while other constituents such as polycrystalline gravels and bedrock fragments appear to contribute little in the way of metals and traces elements to the complexity of this data. The geochemistry of the lateritic sediments is comparable with lateritic sediments at Noen U-Loke. The issue of source is discussed further below.

Discussion: (iii) The source of the archaeological sediments at Noen U-Loke

The upper mound sediments (Layers 2 and 3) at Noen U-Loke match the weathered alluvium in the floodplain profile, in particular the banding of laterite nodules. The archaeological sediments as a whole are more clayey but have similar amounts of sand and silt. The laterite nodules within the alluvium and archaeological sediments are also associated with elevated levels of magnetic susceptibility, metals and trace metals (McGrath [2001] recorded similar results). However, McGrath's (2001) analysis of a mound profile at Ban Non Wat found that the mound sediments are very similar in both particle size and geochemistry to floodplain alluvium as a whole, except that the mound sediments contained more sand.

The iron nodules in floodplain and mound contexts at Ban Non Wat form by the precipitation of iron and in particular, the mineral, maghemite (McGrath 2001:148; McGrath, Boyd and Bush, in press). Magnetic minerals such as maghemite are derived from iron nodules and probably form under dynamic redox conditions associated with seasonal water table fluctuations. De Olivera *et al.* (2000) also identify a significant association between magnetization and trace elements in soils. These may help explain the elevated concentrations of Ce, Co, Cr, Mo, Ni, Pb, Th, Ti, U, V and Zr in the sediments associated with iron nodules (McGrath 2001:145). At Ban Non Wat, McGrath located the largest amount of these iron nodules at the boundary between the floodplain and bedrock material. Since it is, therefore, unlikely that such nodule forming processes would have occurred within the raised mound, McGrath (2001:149) argued that the distribution of iron nodules within the sediments of the mound was best explained by their being deposited on the mound rather than being formed *in situ*. This idea helps to explain the presence of iron nodules within the mound materials at Noen U-Loke. Importantly, deposition as opposed to *in situ* formation implies a distinctive set of processes were associated with later mound formation at Noen U-Loke. McGrath argues that this process at Ban Non Wat was

largely unintentional, possibly linked to iron smelting.

Sourcing the salts in the profile from Noen U-Loke is problematic. The concentration of salts in Layer 4, especially, is most comparable in concentration to the saline sediments in the lower floodplain sequence. However, in the case of the latter, not only are saline sediments located at the bedrock alluvium boundary, but their accumulation can best be explained by the presence of Ca2+, Na+, Mg2+ and K+ in highly saline ground waters (Birkeland 1984:139-144). The precipitation of salts in the mound profile due to saline ground waters cannot be argued at Noen U-Loke due to the height of the mound above the bedrock sediments. We could argue that the salts are best explained by their being manually deposited on the mound, in a similar process to the later deposition of the iron nodules, although the possibility of capillary rise or an atmospheric origin for the salts cannot be ruled out. Capillary rise is a possible source of salts at Noen U-Loke.

The origins of sedimentary salts are critically linked to local environmental conditions (Birkeland 1984:139-144); in areas of relatively high evapotranspiration, under the influence of a high or fluctuating water table, salts can concentrate at some depth in a profile depending on the depth of the water table and height of capillary rise. Bluish-black manganese compounds and bright yellow and red oxidised iron compounds are produced in sediments characterised by a fluctuating water table. The position of the mottles helps indicate the presence of the water table. Weathering conditions can lead to the formation of hard iron and manganese concretions and represent an extreme form of mottling in tropical regions. Both mottling and small black concretions were recorded in the alluvial substrate beneath Noen U-Loke; these sediments, likewise, have a significant concentration of manganese. This indicates that the water table fluctuates close to the archaeological sediments, and thus it is a possibility that the salts were precipitated in Layer 4 by capillary rise rather than derived from *in-situ* parent materials. However, under seasonal aridity or in areas of aridity, salts more soluble than carbonate (e.g. NaCl) accumulate at depth in well-drained soils above the influence of water tables (Birkeland 1984:144). Under such conditions the salts derive from an atmospheric origin, either as solid matter or dissolved in precipitation, and can form gypsic or salic horizons at a depth reached by soil water. An external source, such as dust fall, is hence also a possible origin of the salts in the profile at Noen U-Loke.

Importantly, the environment round Noen U-Loke is typically saline, and these various sources can all be accounted for in this environment. The salts in the mound profile at Noen U-Loke are, nevertheless, less likely to derive from parent materials inundated by saline groundwater or from the deposition of these materials on the mound. Rather, they are best explained by a mixture of precipitation and capillary rise, under high water table conditions, and aeolian deposition and accumulation at depth by rainwater percolation. Similarly, Birkeland (1984:144) notes that an atmospheric origin for pedogenic carbonates is favoured in semiarid to arid regions; a locally important source of the Ca2+ in carbonate is atmospheric gypsum, which, on dissolution, forms Ca2+. There are some zones in the profile from Noen U-Loke in which the salts appear to be reprecipitated pedogenic carbonate. In these zones (e.g. lower Layers 3 and 4), carbonate and Ca strongly correlate and are likely to be present in the form of $CaCO_3$. Calcium carbonate in a carbonate horizon may come from several sources. First, precipitation of a CaCo3 horizon forms in part due to a progressive increase with depth of Ca2+ and HCO_3- ions in the soil solutions as water percolates downwards and is lost by evapotranspiration. If Ca is derived from this weathering then it should have a close relationship with the CaCo3 content of the parent materials (in this case the archaeological sediments), the amount of weathering in the upper part of the soil sequence to release the Ca2+, and the amount of CaCo3 in the carbonate horizon. In dry environments, Ca can increase at depth if $CaCO_3$ has been accumulated. The presence of carbonate-enriched horizons in these conditions is suggestive of a buried soil if it is outside of ground water contexts (Birkeland, 1984:32). This rules out an anthropogenic source for the salts in the profile at Noen U-Loke. Importantly, it also eliminates an anthropogenic source for the salts in Layer 4, and allows us to assess the origin of the remaining sediments.

Isolated peaks in the values of Al, Cu, Mo, Pb, Sn, Ti, U, Zn and magnetic susceptibility characterise the sediments of Layer 4, and these appear to be associated with the occurrence of baked clay. The baked clay fragments are similar in texture, colour and chemistry to baked clay daub structures that are mostly limited to Layer 4. Parr and Boyd (2002) (see also Boyd and Parr, this volume) have shown that baked clay daub samples from this zone have high magnetic susceptibility values, are enriched in As, Fe, and Sn and contain higher values of As, Cr, Cu, Fe, Mn, Ni, Pb, Se, Sn and Zn than floodplain samples. They suggest the accumulation of the elements has formed under normal weathering conditions and volatilization accumulation associated with the addition of materials such as iron ore during industrial activity. The latter is suggested as the likely reason for the enrichment of these elements in the baked clay (Parr and Boyd 2002). The presence of clay daub as a local parent material is a reasonable source of the concentrations of metals, trace metals and magnetic susceptibility in Layer 4.

Discussion: (iv) The source of the archaeological sediments at Non Muang Kao

The sequence at Non Muang Kao (Profile 2) is distinctive because it is composed of a mixture of natural sediments, including bedrock fragments, laterite nodules, polycrystalline sediments and clays. Whereas the sequence at Noen

U-Loke suggests that mound layers are sourced from specific sediments on the floodplain, the sequence at Non Muang Kao indicates that the layers within the mound each represent a mixture of sources. A key stratigraphic and diagnostic marker is the lateritic sediments that are abundant throughout the site. The same argument that has been applied to the deposition of lateritic sediments at Noen U-Loke is relevant when considering their source, i.e. that laterite nodules were deposited on the mound rather than forming *in-situ*. The distribution of the salts K and Na is also inferred to be post-depositional and thus not related to the parent materials within the mound sediments. The polycrystalline sediments and laterite are also important diagnostic markers. The polycrystalline sediments appear to show little influence on the geochemical data. However, their association with laterite nodules in weathered floodplain alluvium (Boyd and Habberfield-Short, this volume) in the vicinity of Non Muang Kao is a likely source for both materials.

In the upper-most layer at Non Muang Kao, the same sediments are present together with bedrock fragments (Unit 1). It is worth noting the difficulty of differentiating between the geochemistry of the iron nodules, polycrystalline sediments and bedrock sediments in this sequence, as the geochemistry of the iron nodules tends mask that of the other two. Studies of polycrystalline sands elsewhere show low concentrations of metals and trace elements in the polycrystalline sands, but enrichment in Na and Ca and other salts (McGrath 2001). The floodplain profile (Profile 3) from near Noen U-Loke shows that the bedrock is equally well weathered but significantly concentrated in Ca and Mg. McGrath (2001) found an association between bedrock fragments and Ca and Mg concentrations in moat bank spoil at Ban Non Wat (McGrath, Boyd and Bush, in press). The same situation is apparent at Non Muang Kao, where there are high concentration levels of Ca and Mg in the upper layer. Of the salts, Mg is a good indication of weathering as it is an essential component of weathering products (i.e. Mg-chlorite; Birkeland 1984). Groundwater, capillary rise and atmospheric origin all seem likely for the Ca in the profile. However, the strong association of Ca and Mg with the other metals and trace metals suggest that Layer 1 is derived from bedrock and weathered alluvium. The absence of the other salts (K and Na) associated with bedrock sediments in this layer can easily be explained by their down-profile percolation and accumulation in lower Layer 4.

Discussion: (v) The geochronological dating of Non Muang Kao and Noen U-Loke

The previously-published chronology from Noen U-Loke and, to a lesser extent, Non Muang Kao, gives an impression that such mounds accumulated rapidly. However, three things remain ambiguous: (i) the actual rate at which each layer accumulated; (ii) the exact timing and continuity of the deposition of each layer within the archaeological site; and (iii) the relationship between the formation and use of the mound and moats. Despite previous impressions (e.g. Chantaratiyakarn 1984a; Bayard *et al.* 1986; Welch and McNeill 1990, 1991; O'Reilly 1999) that such sites in the Mun and Chi valleys sites were occupied continuously during the Iron Age, stratigraphic boundaries between distinct archaeological layers at both Noen U-Loke and Non Muang Kao indicate discontinuous sedimentation.

The enlarged group of dates from Noen U-Loke ages, while signaling a lengthy period of sediment accumulation, importantly indicates that accumulation was discontinuous (Fig. 3:10). The pattern of dates suggests three reasonably discrete age spans, with groups of calibrated ages associated with specific archaeological layers. At least two hundred years separate both the first and third period from the second, suggesting that each group of layers represents temporally-confined periods of sedimentation, separated by lengthy periods of, at least, minimal sedimentation.

A different picture, however, emerges from the enlarged group of dates from the mound at Non Muang Kao (Fig. 3:11). Three groups of dates are also indicated, loosely paralleling the trends at Noen U-Loke, and supporting lithological observations of a discontinuity between Layers 2 and 3 described above. The chronological inversion towards the top of the sequence, however, complicates matters. The date inversion in Layer 1, importantly, reflects the presence of older and possibly recycled sediments, deposited in the area at the time of first settlement (including weathered alluvium and bedrock) and used as a resource in later mound formation. O'Reilly (1997) observes parallel patterns in the deposition of ceramics.

The phases of dating at Noen U-Loke and Non Muang Kao are as follow.

- Noen U-Loke. Layer 5, 6, channel infill and alluvial substrate 12th to 2nd C BC; midpoint at around the 6th to 7th C BC.
- Noen U-Loke. Layer 4 1st C BC to 2nd C AD; midpoint is *c*. 1st C AD.
- Noen U-Loke. Layer 2 and 3 5th to 7th C AD, with a midpoint at *c*. 6th C AD.

- Non Muang Kao. Layers 3 and 4 and the surface of the alluvial substrate 4th C BC to 2nd C AD, with a midpoint at *c*. 2nd C BC to 1st C AD. These dates accord well with dates from the central trench, implying a 2nd C BC onset of mound accumulation.
- Non Muang Kao. Layer 2 3rd to 6th C AD; with the archaeological dates, a midpoint of the late 3rd C to early 4th C AD is indicated.
- Non Muang Kao. Layer 1 2nd C AD to the 1st C BC; only two dates, overlapping in the 1st C BC-AD.

Little is known of the chronological and sedimentary association between the use of the moats and formation of the mounds, despite much previous research (Chantaratiyakarn 1984b; Vallibhotama 1984; Welch 1985; Moore 1988, 1992; Welch and McNeill 1990, 1991; Parry 1992; Higham 1996a,b; McNeill 1997; Boyd *et al.* 1999a,b; McGrath 2001; McGrath and Boyd 2001;). Boyd, McGrath and Higham (1999b) suggested that two types of channel exist at Noen U-Loke: (i) a buried channel, dating to *c.*100 cal BC-300 cal AD lies at the site margin; and (ii) a channel within the inner moat infill dates to *c.* 400-800 cal AD. The former is contemporaneous with Layer 4, while the latter is contemporaneous with Layers 2 and 3. At Non Muang Kao, on the other hand, moats appear had to have infilled as early as the first phase of mound accumulation, although the data are slight; dates from near the infill surface indicate floodplain sedimentation continuing into the last millennium.

CONCLUSIONS: THE GEOCHRONOLOGY OF SEDIMENT DEPOSITION AND SOURCING, AND THE HUMAN OCCUPATION AND ABANDONMENT OF THE SITES OF NON MUANG KAO AND NOEN U-LOKE

The physical and geochemical analyses of the respective sedimentary profiles support stratigraphic and lithological field observations at the sites. The data indicate that sharp stratigraphic boundaries within the mound sediments are associated with changes in sedimentary processes and conditions. At Noen U-Loke, the sequence can be divided into five sedimentation phases (Table 3:3).

- Noen U-Loke Sedimentation Phase 1 is associated with the deposition of the alluvial substrate, and represents floodplain sedimentation during the Holocene. It is equivalent to the Old Alluvium (Unit 4: Boyd and

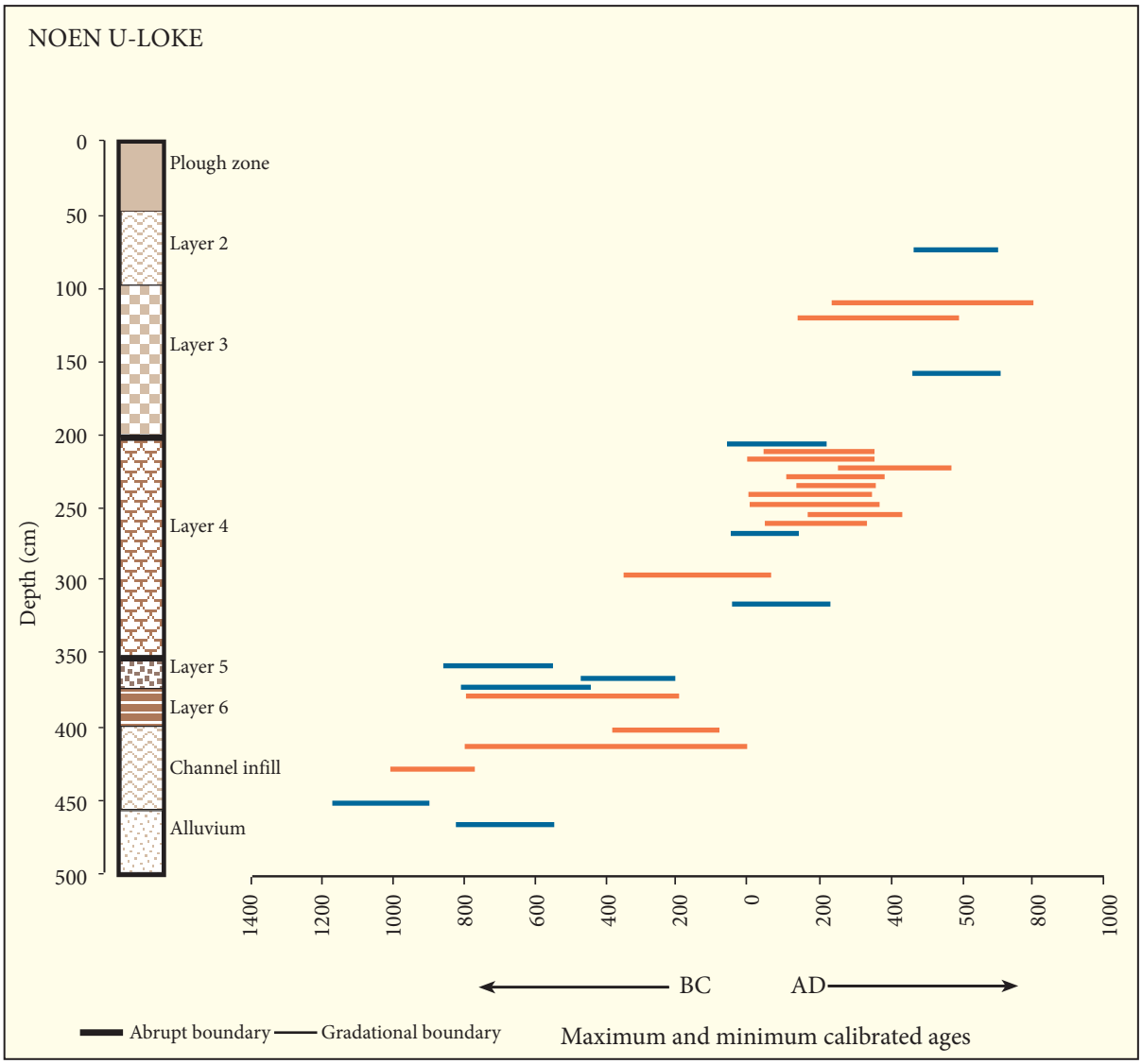


FIG. 3:10 Age-depth relationships for the mound at Noen U-Loke. Previously published dates (Table 3:1) are are shown in red and new dates (Table 3:2) are shown in blue

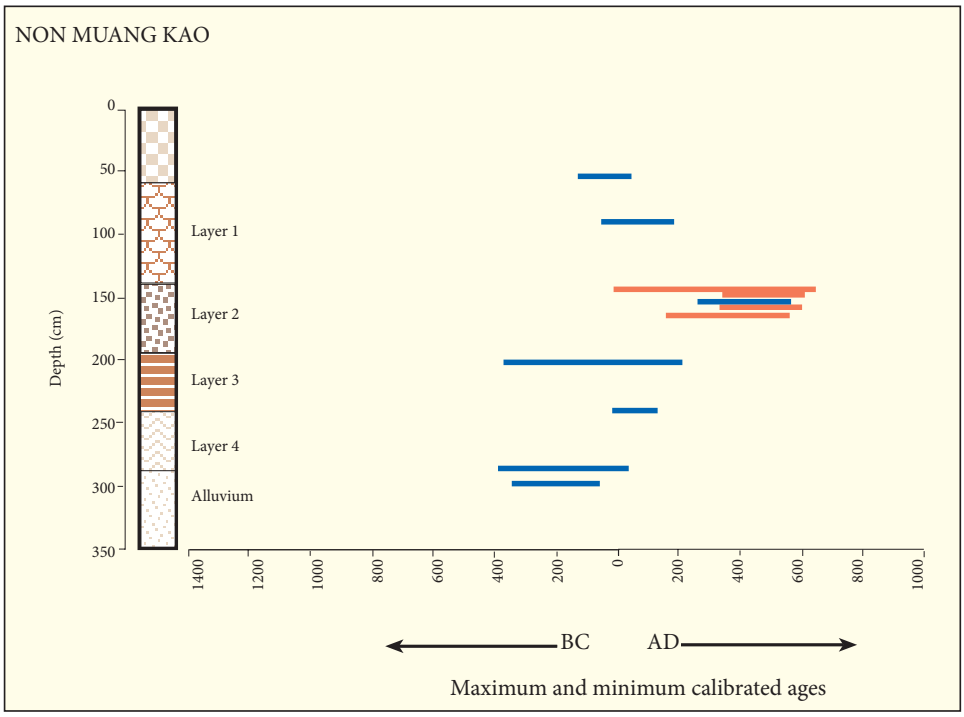


FIG. 3:11 Age-depth relationships for the mound at Non Muang Kao. Previously published dates (Table 3:1) are shown in red, while new dates (Table 3:2) are shown in blue

Habberfield-Short, this volume).

- Noen U-Loke Sedimentation Phase 2 is associated with the deposition of the laminated channel infill, and is equivalent to the sub-site channel infill (Unit 7) recorded by Boyd and Habberfield-Short (this volume).
- Noen U-Loke Sedimentation Phase 3 represents sedimentation on the floodplain, associated with the first period of human occupation at the site, and refers to the deposition of Archaeological Layers 6 and 5.
- Noen U-Loke Sedimentation Phase 4 is associated with the deposition of Archaeological Layer 4, and is dominated by processes associated with the human occupation of the site.
- Noen U-Loke Sedimentation Phase 5 is associated with the deposition of Archaeological Layers 3 and 2, and is also associated with human occupation of the site.

At Non Muang Kao four sedimentary phases are indicated strongly by cycles in the physical and geochemical data.

- Non Muang Kao Sedimentation Phase 1 represents the deposition of the alluvial substrate prior to human settlement, and as at Noen U-Loke, represents the Old Alluvium (Unit 4) defined by Boyd and Habberfield-Short (this volume).
- Non Muang Kao Sedimentation Phase 2 comprises the deposition of Archaeological Layers 4 and 3, and shows the first influences by human settlement.
- Non Muang Kao Sedimentation Phase 3 represents the deposition of Archaeological Layer 2.
- Non Muang Kao Sedimentation Phase 4 represents the deposition of Archaeological Layer 1.

At both sites, the lowest archaeological sediments (Noen U-Loke Sedimentation Phase 2 and Non Muang Kao Sedimentation Phase 2) grade downwards into the alluvial substrate, demonstrating that the earliest human

TABLE 3:3 *Phases of sedimentation, as indicated by the lithology, and associated archaeological layers, as identified during excavation, at the archaeological sites of Noen U-Loke and Non Muang Kao. Note that numbering of the sedimentation phases is from oldest (1) to youngest, whereas the archaeological layers were numbered as encountered during excavation, thus being numbered youngest (1) to oldest*

Sedimentation phases	Archaeological layers
Noen U-Loke	
5	Layers 3 & 2
4	Layer 4
3	Layers 6 & 5
2	Channel Infill
1	Alluvial substrate
Non Muang Kao	
4	Layer 1
3	Layer 2
2	Layer 4 & 3
1	Alluvial substrate

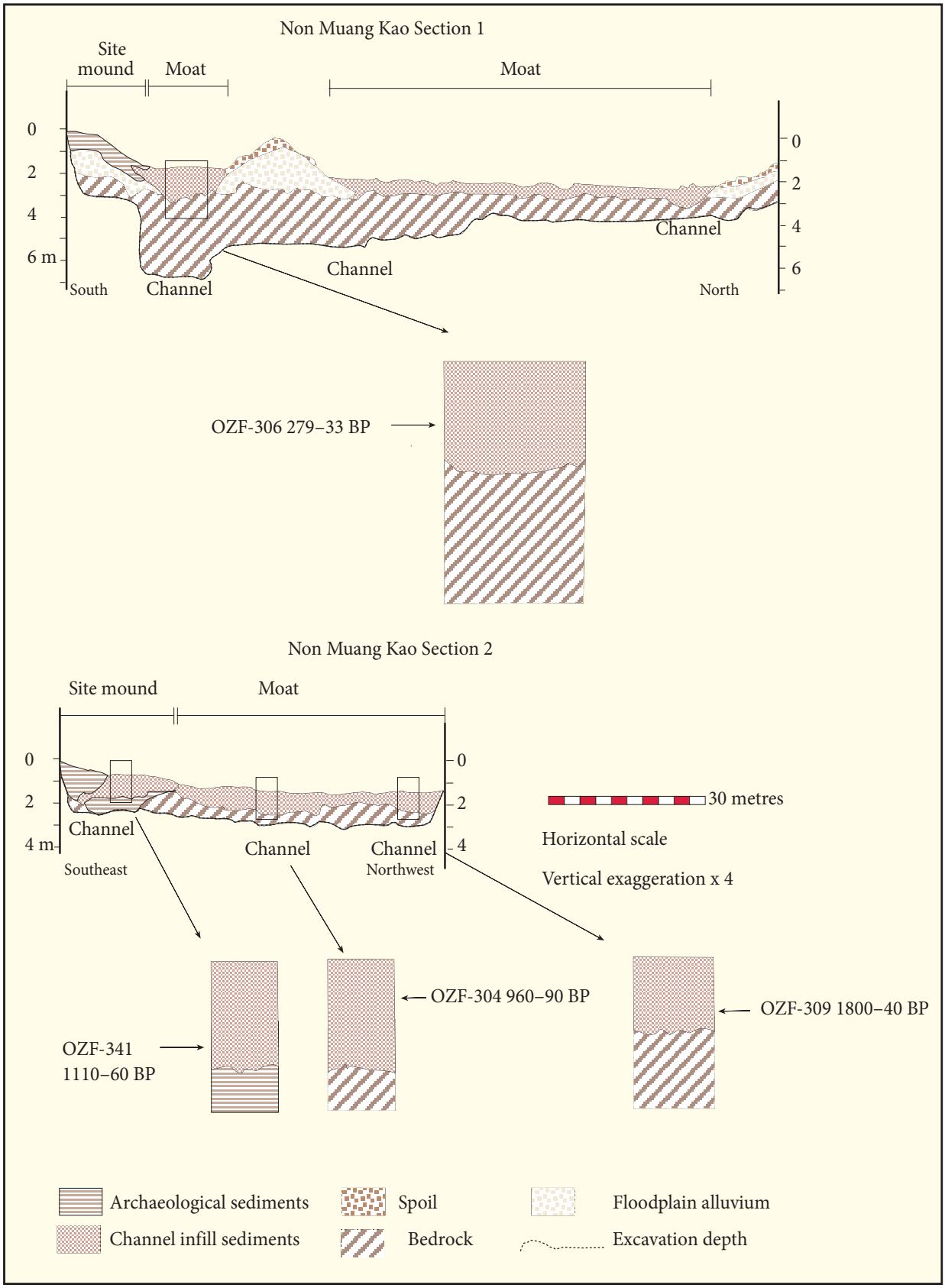


FIG. 3:12 The radiocarbon dates for moat infill sediments at Non Muang Kao (Table 3:2)

occupation of the sites was directly on the floodplain surface, with occupation disturbing the natural surface. The boundaries, however, between the sediments representing each of the remaining phases are sharp, indicating abrupt changes in sedimentation processes and, in some cases, interruption to the sedimentation. The closeness of the sedimentation phasing and the archaeological sequence implies that phases of sedimentation were critically linked to the archaeological occupations at Non Muang Kao and Noen U-Loke.

The particle size and geochemistry data provides diagnostic evidence for the sourcing of the floodplain and anthropogenic sediments. The obvious sources are for Sedimentation Phase 1 at both Noen U-Loke and Non Muang Kao, where the sediments are clearly deposited under floodplain alluvial conditions, and at Noen U-Loke where Sedimentation Phase 2 represents a high-energy river. At Noen U-Loke, Sedimentation Phases 3 and 4 are closely associated with recent alluvium (the New Alluvium, Unit 5; Boyd and Habberfield-Short, this volume), and represent the human modification of natural sediments. Noen U-Loke Sedimentation Phase 4 is also associated with significant anthropogenic activity, augmented by possible aeolian deposition of salts. At the top of the sequence, Noen U-Loke Sedimentation Phase 5 is associated with the redeposition of weathered Old Alluvium (Boyd and Habberfield-Short's Unit 4, this volume).

At Non Muang Kao a slightly different picture of the sedimentary sources emerges. All phases are inferred to represent the deposition or reworking of weathered Old Alluvium (Unit 4), although Non Muang Kao Sedimentation Phases 2 and 3 also represent the redeposition of significant amount of lateritic and polycrystalline sediments that are sourced from deep weathered alluvial and channel sources. The upper zone of Non Muang Kao Sedimentation Phase 3 (Archaeological Layer 1) is also associated with the deposition of cobbles and gravel of red Mahasarakham bedrock (Unit 1). Interestingly, the sediments associated with deposition in the early stages of Non Muang Kao Sedimentation Phase 2 and 3 (Archaeological Layers 2 and 4 respectively) appear to correlate, geochemically, with slightly less weathered alluvium; the colour of the clays in these sediments suggests a more recent (New Alluvium, Unit 5) source. This suggests that there may be cycles of sediment sourcing during the phases, with the earlier redeposition of sediments formerly closer to the land surface and later deeper sediments being brought to the site.

While variations are found in the sediments between the sites, a process common to both sites is the deposition, within the final phase of mound sedimentation, of sediments more normally associated with deeper buried horizons within the floodplain sediments. The evidence, however, is for these sediments in the mounds to be sourced from depositional environments, and thus re-deposited on the site, rather than being in their *in-situ* formation location. They are not, therefore, sediment deposited under natural conditions of floodplain sedimentation. There may, nevertheless be other natural processes that could account for their entrainment and deposition with mound contexts. Flooding, for example, is a seasonal event on the low-lying floodplain. However, it is unlikely that flooding has energy to entrain and deposit such materials up to 4 m above the level of the floodplain. The source of the salts in the mound profiles has been argued to have been derived from aeolian activity and capillary rise. Again, however, transport and deposition of significant quantities of sediments, especially the coarser-grained sediments, by aeolian processes is unlikely.

The stratigraphic location, within the mounds, of sediments similar to those normally found within the low-lying alluvial sediments, can best be explained as an anthropogenic effects, arising from the use of floodplain sediments as resources in mound construction. The deposition of specific layers of similar materials suggests phases of mound accumulation, linked to the use of specific natural resources at certain times in the period of occupation of the mounds. It has been argued, for example, that the presence of lateritic sediments within the mounds is associated largely with anthropogenic influences of mound-building (McGrath 2001) and iron smelting (Penny 1984).

It is possible to correlate discrete periods of rapid mound accumulation at both Noen U-Loke and Non Muang Kao with phases of archaeological occupation (Table 3:4). This relationship implies archaeological periods, during which at least parts of sites were unoccupied. The occupation at Noen U-Loke was probably interrupted by lengthy periods of abandonment or activity that did not involve sedimentation in its broadest sense. Initial occupation of Noen U-Loke occurred during the late Bronze Age and continued for some five to six centuries. After a period of abandonment lasting one to two centuries, settlement was re-established in this area and resumed for another one or two centuries at the most. This was succeeded by another period of at least one century of inactivity followed before the subsequent reoccupation, again for one to two centuries. At Non Muang Kao, initial occupation occurred in the early Iron Age and lasted for three centuries before a break in sedimentation. This is followed shortly, for a period of less than a century, by another period of settlement lasting for a century. The inversion of the sedimentary dates after this point makes it difficult to assess the age of the final period of sedimentation (and occupation). The phases of occupation and abandonment at the two sites do not appear to correlate, and there is a strong impression of inverse cyclicity in the occupation of the sites: when one was occupied the other was, by and large, abandoned.

OVERVIEW AND CONCLUSION

The lithology and chronology associated with the mound sediments at Noen U-Loke and Non Muang Kao indicate that these sites formed under periodic and rapid sedimentary processes. Periods of sedimentation correlate with periods of human occupation, and the close association between the archaeological dates and sedimentary dates shows a relationship between periods of occupation and sedimentary accumulation at both sites. In particular, each period represented temporally-confined periods of both anthropogenic and natural sedimentation. Furthermore, hiatuses in sedimentation are significant, reflecting periods during which parts or whole sites were unoccupied. There was also a temporal relationship between the infilling of the surrounding channels (at least as far as the limited chronological data allows this conclusion to be reached) and use of the mounds. At Noen U-Loke, for example, the infill of channels is associated with a period of sedimentation on-site. At Non Muang Kao the moats had started to infill as early as the first period of sedimentation on-site.

Importantly, while these patterns are similar at both Non Muang Kao and Noen U-Loke, the timing of the local events – occupation and abandonment, sedimentation and formation of non-conformities – indicate that sites were occupied and abandoned at different times. Examination of these two sites, at least, offers a suggestion of alternate settlement and abandonment, implying that not all sites were occupied on the floodplain simultaneously.

TABLE 3:4 *Chronological phases and hiatuses of occupation linked to mound and moat chronology, stratigraphy and archaeology for the sites of Non Muang Kao and Noen U-Loke, based on site sedimentation and chronology*

Calendar century BC/AD	Non Muang Kao mound chronology (sedimentation phases in brackets)	Noen U-Loke mound chronology (sedimentation phases in brackets)	Typical archaeology	Moat sedimentation
9 AD	Phase 3 (sed. phase 4) ?age			
8 AD				
7 AD		Phase 3 (sed. Phase 5)		Infilling of channel in first moat (NUL)
6 AD	Hiatus (6th C -?)		Late Iron Age (NMK, NUL)	
5 AD	Phase 2 (sed. phase 3); from 3rd C AD		Mid to Late Iron Age (NMK, NUL)	
4 AD		Hiatus		
3 AD	Hiatus			
2 AD		Phase 2 (sed. phase 4) from 1st C AD		Infilling channels under site margin (NUL)
1 AD	Phase 1 (sed. phases 1 & 2)	Hiatus (from 3rd C BC)	Early Iron Age (NMK)	Infilling of the channels in the first and second moats (NMK)
1 BC				
2 BC				
3 BC		Phase 1 (sed. phases 1, 2 & 3)	Late Bronze Age to Early Iron Age (NUL)	Infilling of buried channel within NUL archaeological layer 6
4 BC				
5 BC				
6 BC				
7 BC				
8 BC				
9 BC				
10 BC				

PART TWO. THE EXCAVATION OF NOEN U-LOKE

IV. INTRODUCTION: THE STRATIGRAPHY AND RADIOCARBON CHRONOLOGY

C.F.W. HIGHAM AND R. THOSARAT

Noen U-Loke belongs to the category of sites known as the moated settlements of Northeast Thailand. It was selected for an extensive excavation for several reasons. First, it was earlier excavated by Wichakana (1991), who encountered Iron Age graves associated with novel grave goods. These included a bronze head dress, a belt, and many ornaments of glass, carnelian and agate. Since these were found within several metres of deposit, they encouraged the hope that an unparalleled sequence of Iron Age graves might be present. Second, although not outstandingly large, air photographs revealed at least five "moats", more than any other known in the Mun Valley (Figs. 4:1-3). Finally, the site is situated to the south of the village of Ban Nong Na Toom in Tambon Phon Songkhram, Amphoe Non Sung, and is unoccupied. There is, therefore, no constraint upon where one can excavate. The area opened in 1997 and 1998 lies adjacent to one of Wichakana's two squares, and covers an area of 220 m^2. Since the excavation reached the basal substrate at a depth of *c*. 5 metres, we removed well over 1000 m^3 of cultural material.

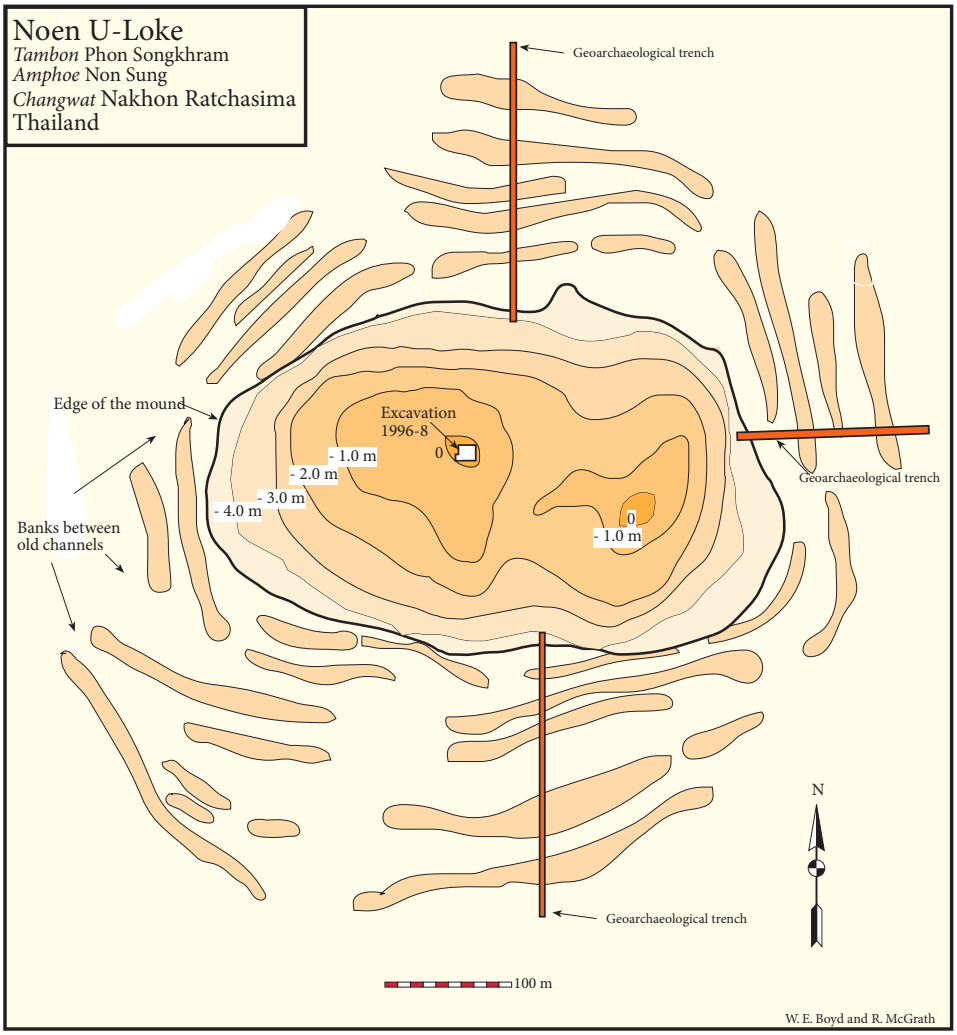


FIG. 4:1 Plan of Noen U-Loke, showing the location of the excavation of 1996-8



FIG.4:2 Air view of Noen U-Loke, showing the distribution of other major sites in its vicinity. A. Noen U-Loke, B. Ban Non Wat, C. Ban Makham Thao, D. Ban Non Ngiu



FIG. 4:3 Air view of Noen U-Loke (A), showing the site, the surrounding banks and channels, and (B), two salt-making mounds

1 km

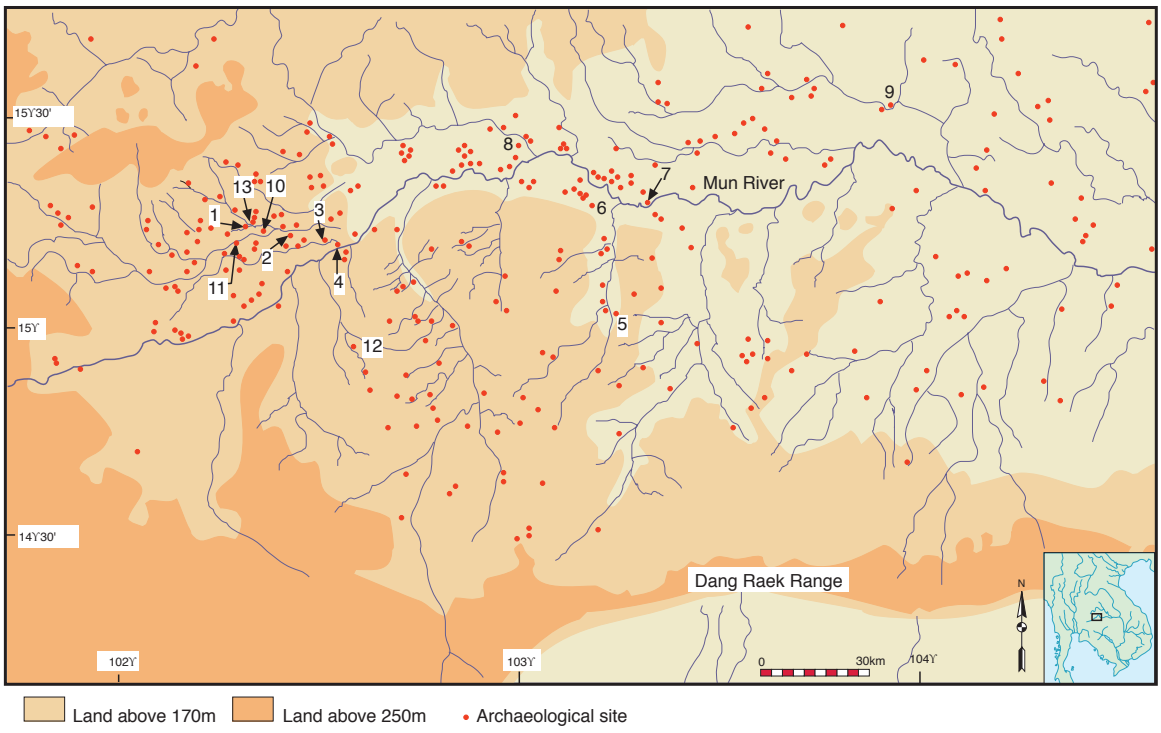


FIG. 4:4 The Mun Valley, showing the distribution of sites.
1. Noen U-Loke, 2. Ban Prasat, 3. Ban Tamyae, 4. Phimai, Ban Suai, 5. Ban Takhong, 6. Ban Don Phlong, 7. Non Yang, 8. Non Krabuang, 9. Non Dua, 10. Ban Lum Khao, 11. Non Muang Kao, 12. Muang Phet, 13. Ban Non Wat

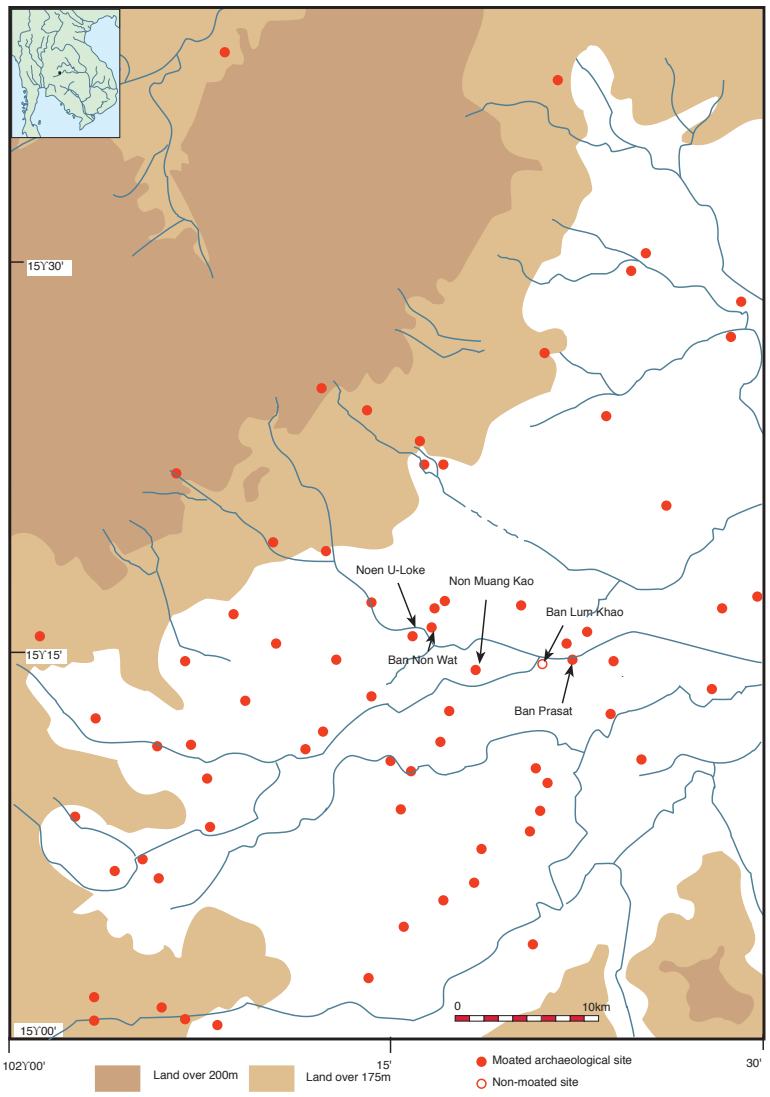


FIG. 4:5 The study area, showing the location of the principal sites

TABLE 4:1 *The radiocarbon determinations from the excavation of Noen U-Loke*

Laboratory Reference No.	Radiocarbon Age BP	Calibrated Age (2σ)	δ13C (‰)	Context in site
Wk-5365	2720±60	1010-790 BC	-26.0	A2 6:7 f. 3
Wk-6148	2180±45	390-90 BC	-25.7	X1 6:4 f. 1
Wk-5364	2280±130	800 BC-AD	-25.0	A1 6:4 f.3
Wk-5363	2360±60	800(097)-350 BC 300(003)-200 BC	-26.4	A1 6:1 f.1
Wk-5356	2090±50	350(004)-310 BC 210BC(096)-30 AD	-14.4	A1 4:9 f.2
Wk-5361	1880±60	AD(098)-260 AD 300AD(002)-320 AD	-25.3	A2 4:5 f.5
Wk-5357	1870±50	20AD(098)-260 AD 300AD(002)-320 AD	-25.4	A1 4:5 f.6
Wk-5355	1850±70	AD-350 AD	-27.3	A1 4:4 f.4
Wk-5351	1820±60	60AD-390 AD	-26.7	A2 4:4 f.18
Wk-5360	1770±60	80AD(001)-100 AD 120AD(099)-420 AD	-26.3	A1 4:4 f.1
Wk-5362	1650±70	230AD-570 AD	-24.5	A1/2 4:4 f.14
Wk-5358	1830±50	70AD-340 AD	-25.0	A1 4:3 f. 20
Wk-5354	1850±70	AD -350AD	-25.6	A1 4:2 f. 1
Wk-5359	1840±60	50AD-350 AD	-27.4	A1 4:1 f. 6
Wk-5352	1680±90	130AD -600 AD	-28.1	A1 3:2 f. 4
Wk-5353	1470±120	250AD-800 AD	-28.3	A2 3:2 f. 2
Wk-6147	200±50		-25.0	X1 2:2 f. 1

THE EXCAVATION

The initial layout of the excavated area involved an area of 10 by 9 m, divided by a baulk one metre wide. A wide variety of information was recovered, including about 55 inhumation graves of which the highest was only about 65 cm below the present ground surface, and the lowest at a depth of almost four metres. There were also many remains of industrial and occupational activity, including pits, furnaces, postholes and possible floors. These finds made a further season of excavation in 1998 highly desirable and in the event, a further series of inhumation graves was uncovered, bringing the total to 125. Small adjustments to the phases defined during the first season were necessary, while much further evidence for occupation, iron smelting and the possible local manufacture of glass beads was recovered.

THE RADIOCARBON CHRONOLOGY

The seventeen radiocarbon determinations were obtained from the laboratory of the University of Waikato. They were selected on the basis of security of provenance, most coming from layer 4, which yielded many *in situ* contexts. In the case of Wk-5362, the sample derived from carbonised rice grains within a pit. All others were based on samples of charcoal. It is noted that the sample based on rice was between one and two centuries later than other determinations from the same layer. This might prove significant for the dating of this and other sites in Southeast Asia, for to the authors' knowledge, no dated charcoal has been assigned to species. The possibility of inbuilt age must, therefore, be addressed.

Each sample taken was placed with a trowel into aluminium foil and then wrapped in a polythene bag. It was then stored before being sent to the laboratory for processing. As may be seen in figure 4:6, the resulting determinations conform well with the stratigraphic sequence. They suggest that the excavated part of the site was in use by the

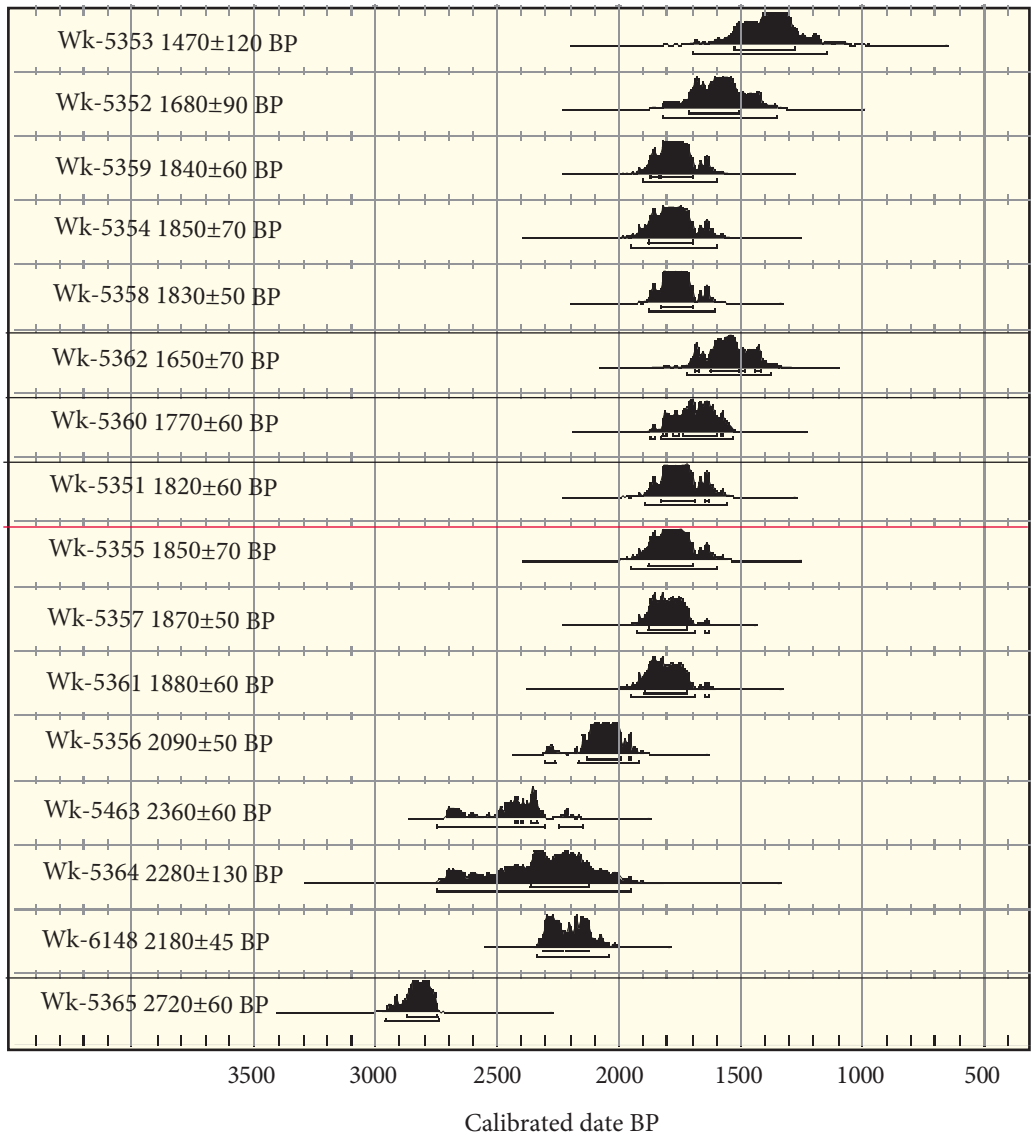


FIG. 4:6. The radiocarbon determinations for Noen U-Loke set out in stratigraphic order, commencing at the earliest context at the bottom. All are from the Waikato University laboratory

first half of the first millennium BC. This conforms well with Wichakana's finding that the upper part of the mound contains Prasat Phase Bronze Age graves. These were not recovered during our own excavations with the possible exception of burial 125. The most intense cultural activities in our own area belong to layers 4, 3 and 2. These belong in the Iron Age, and the dates indicate the accumulation of these deposits between 200-300 BC and the middle of the first millennium AD. The uppermost determination clearly derives from a recent event, and is not included in figure 4:6.

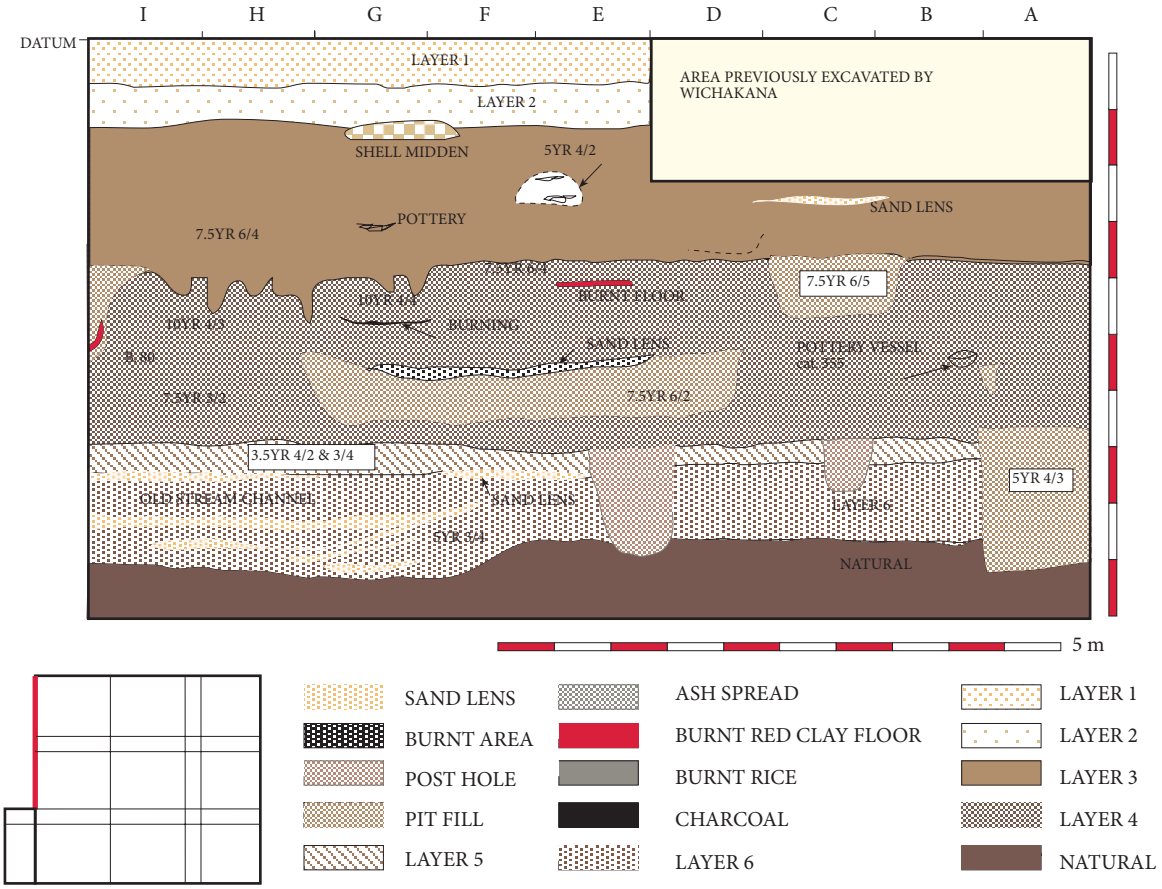


FIG. 4:7 The western section of Noen U-Loke

THE SECTIONS

Figures 4:7-11 illustrate the sections. It is seen that there are six principal layers over the sterile substrate. Habberfield-Short has taken sediment samples and his detailed analysis of the accumulation processes has been described in chapter 3. It is important to note that layers 5-6 appear to have been laid down under natural, swampy conditions, although the site was then occupied, since these natural deposits contain pits, burials, postholes and cultural material resulting from human interference. It is noted that Wichakana found Bronze Age ceramics and burials in his excavations on the summit of the mound, presumably during a phase of occupation not encountered during the 1997-8 excavations.

Layers 1-4, by contrast, represent human occupation activity, and details are set out in the following pages. The cultural activity included the excavation of many pits, deposition of pottery vessels, accumulation of butchered animal bones, interment of the dead in inhumation graves and ceramic vessels, evidence for the forging of iron and bronze casting as well as the possible manufacture of glass beads.

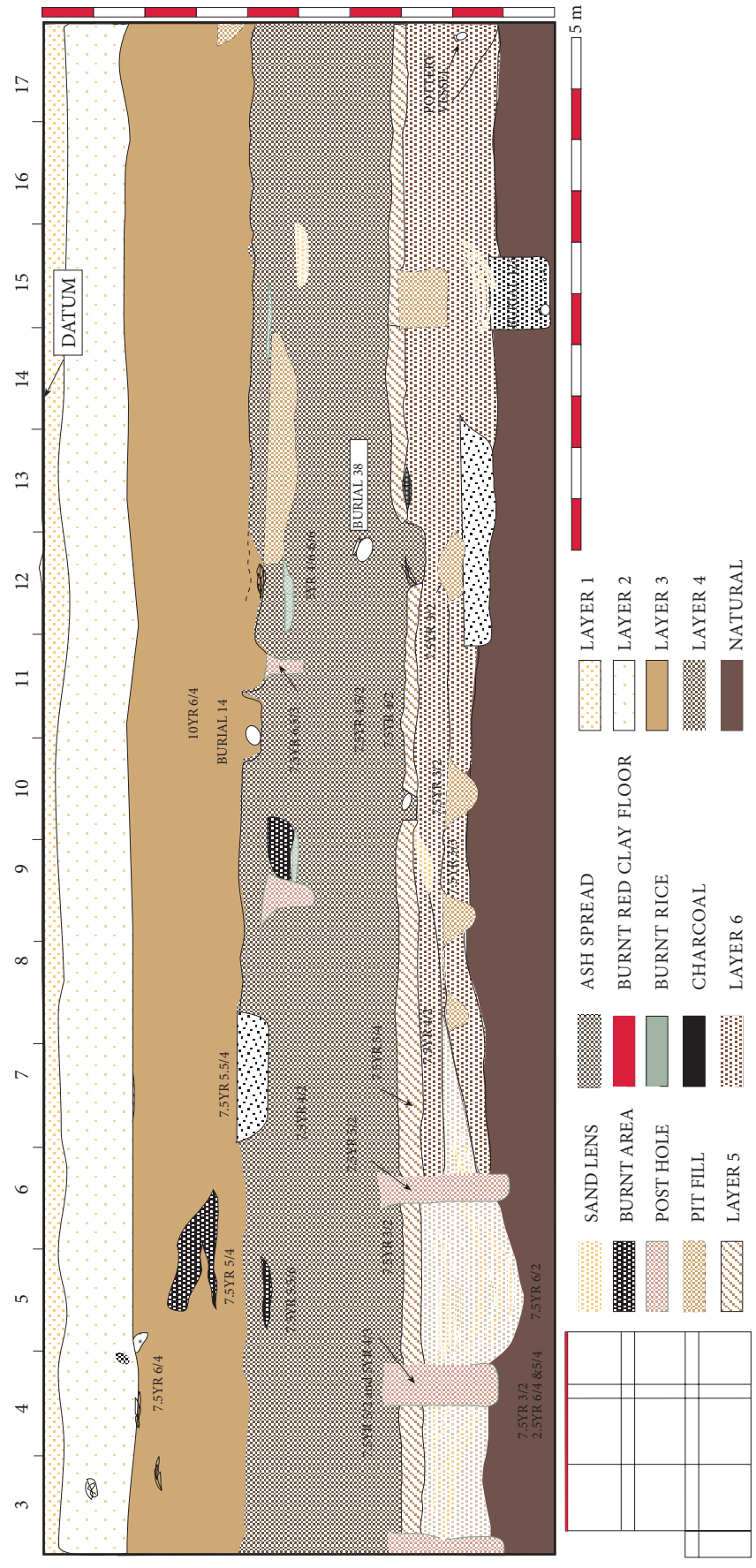


FIG. 4:8 The northern section of Noen U-Loke

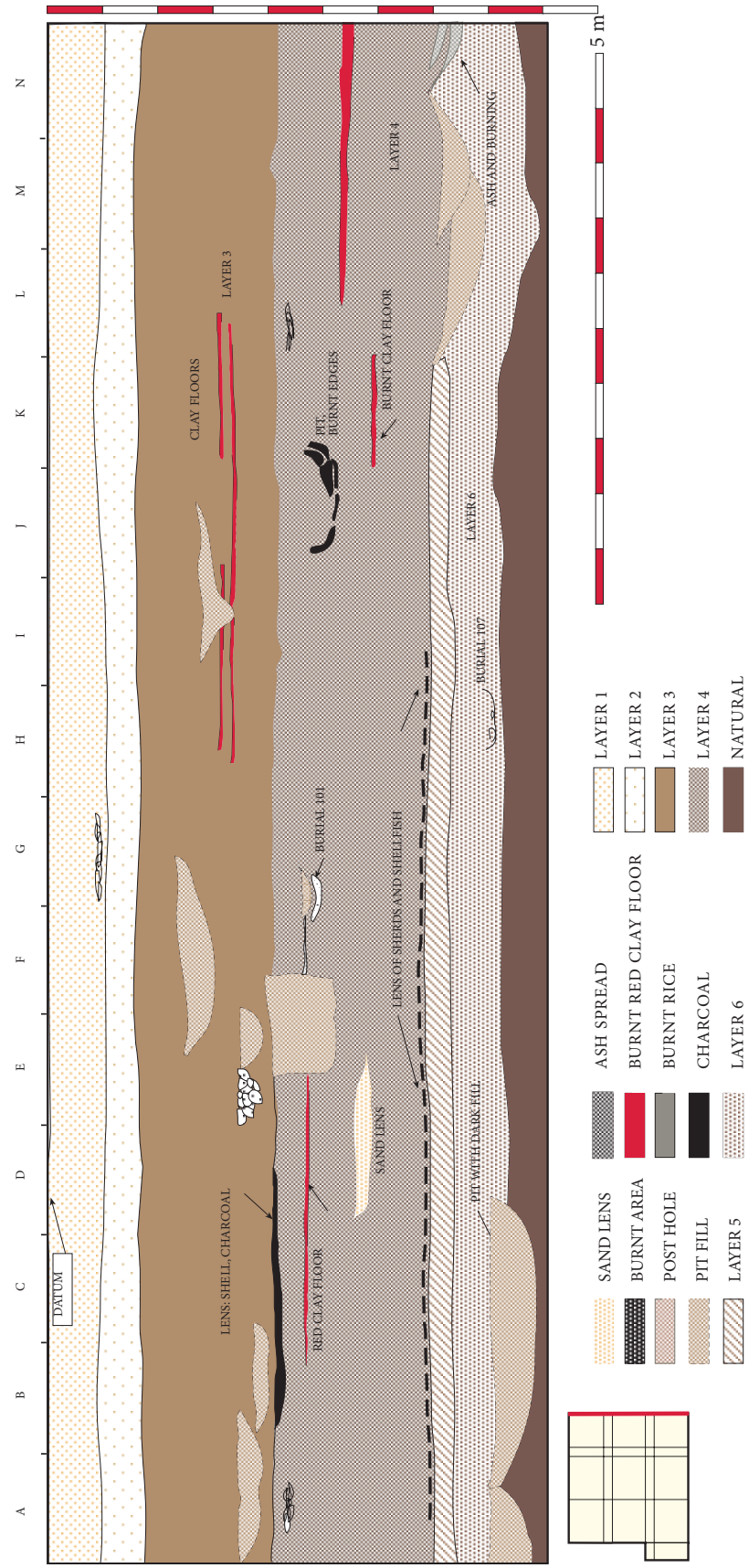


FIG. 4:9. The eastern section of Noen U-Loke

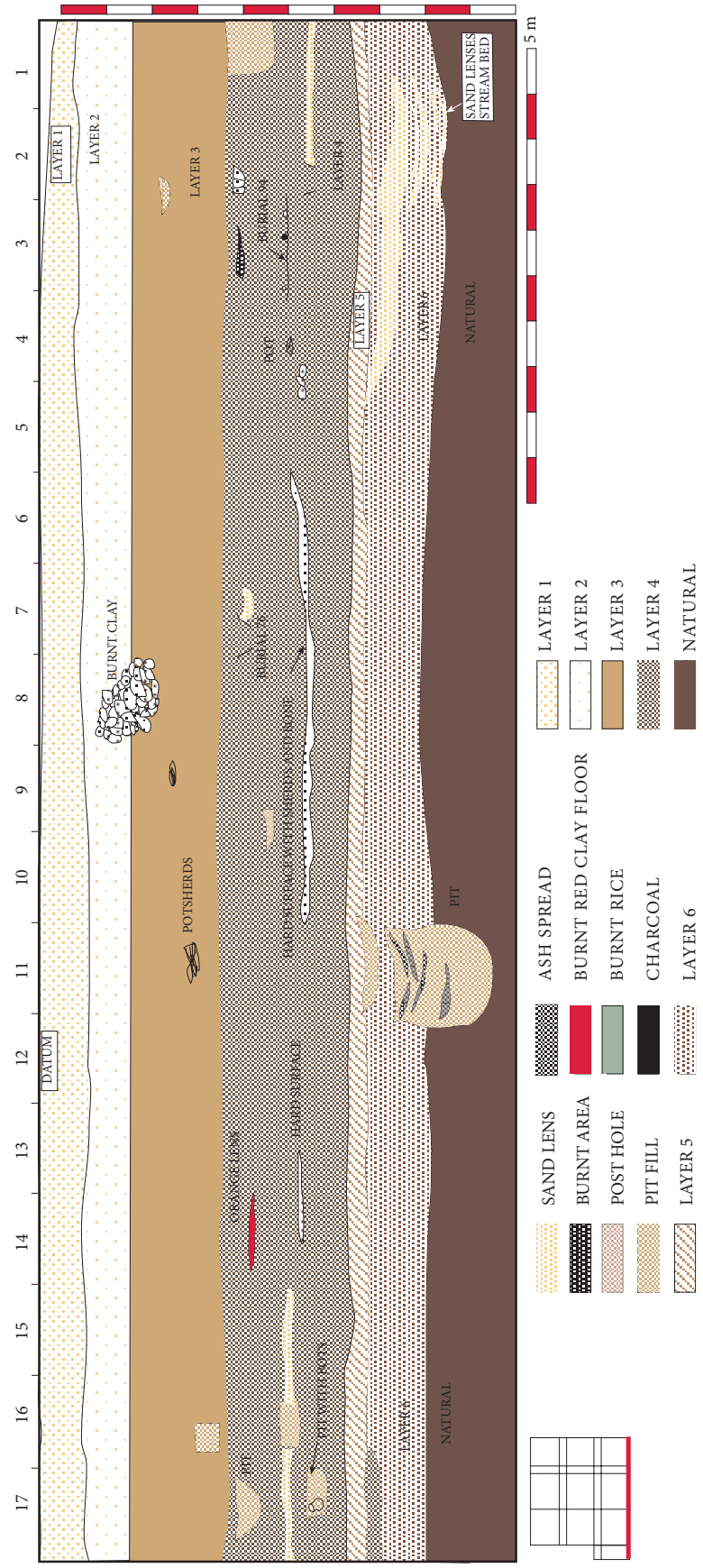


FIG. 4:10 The southern section of Noen U-Loke

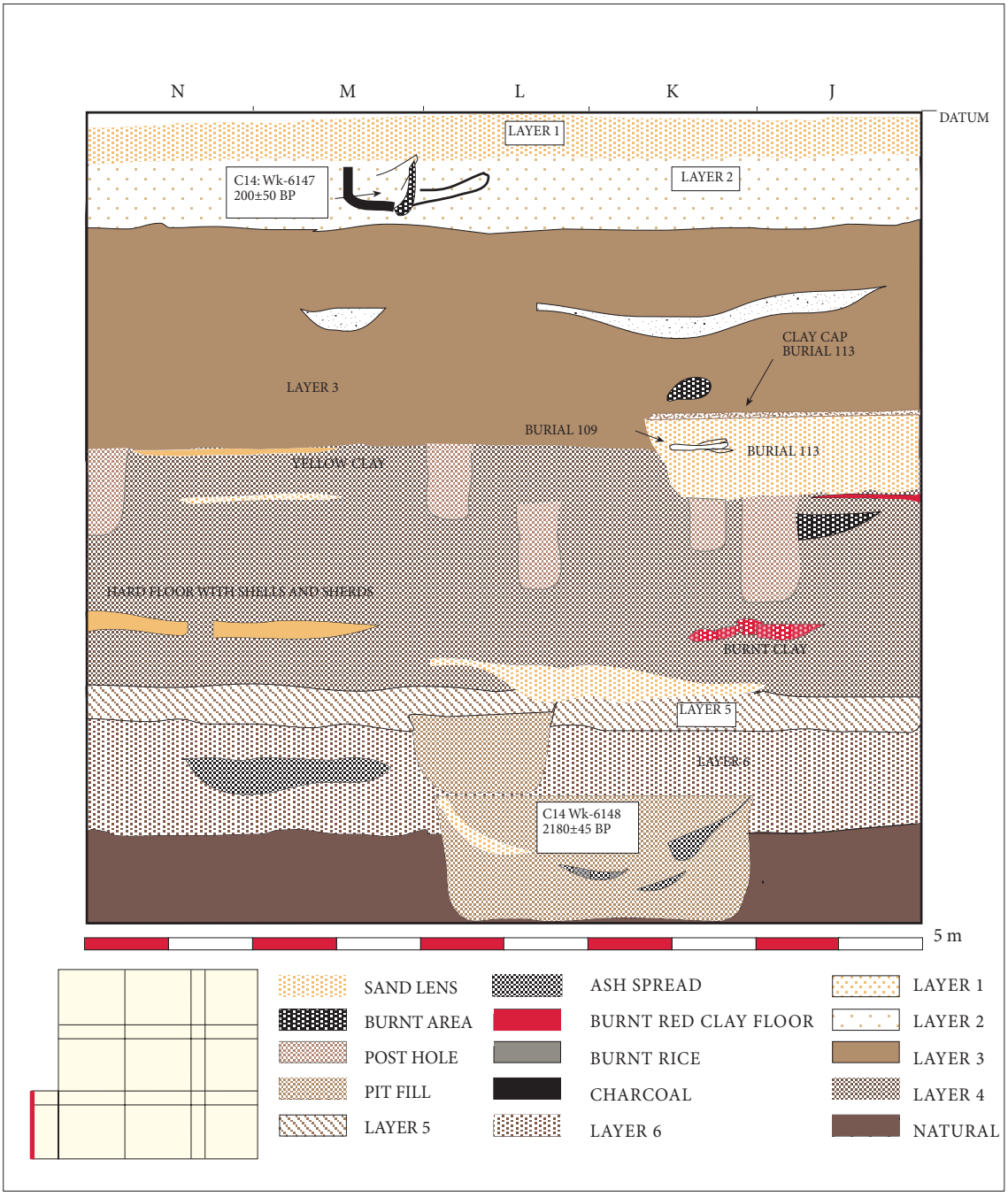


FIG. 4:11 The western section of square X1, Noen U-Loke

V. LAYERS FIVE AND SIX

In the following chapters, the detailed stratigraphic sequence is described, starting when a small stream crossed the area excavated, and ending with the latest prehistoric occupation. The sequence involves six layers, each divided into 10 cm spits where there was no clear stratigraphic distinction. However, all pits, postholes, furnaces, grave cuts and other features were mapped and planned when encountered and treated as distinct contexts.

DATING LAYER 6

Four radiocarbon determinations are relevant for the dating of the basal layer. Although probably naturally deposited, it also contained the remains of cultural activity in the form of postholes, hearths and pits. It is also evident, from Wichakana's two initial test squares, that there was Bronze Age occupation on at least the southeastern part of the site (Wichakana 1991). The lowest dated context is a small hearth or charcoal concentration is square A2, which at 1 sigma provides a date of 920-800 BC, and at 2 sigma, 1010-790 BC. This confirms a Bronze Age presence within the excavated area (Fig. 5:1).

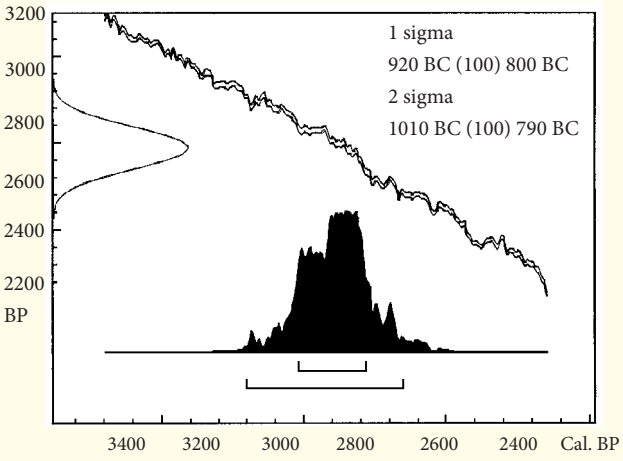


FIG. 5:1 Radiocarbon determination Wk-5365 from A2 layer 6:7 feature 3

The second relevant determination comes from square X1 layer 6:4 feature 1 (Fig. 5:2). This comprised a large pit rich in charcoal cut into the natural substrate. The result at 1 sigma is 360-280 BC (50%), and 260-170 BC (50%). At 2 sigma, the range is 390-90 BC. This suggests that this pit was cut and filled during the Iron Age. The third determination comes from square A1, 6:4 feature 3. The result is virtually identical with that from square X1, being 410-170 BC at 1 sigma and 800 BC - AD at 2 sigma. The fourth determination comes from A1 layer 6:1 feature 1, a hearth. The calibration curve is complex at this span, but the results again confirm a date in the second half of the first millennium BC (Fig. 5:4).

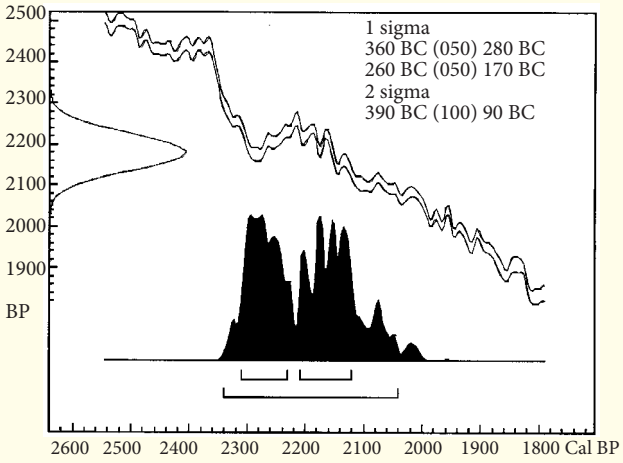


FIG. 5:2 Radiocarbon determination Wk-6148 from X1 layer 6:4 feature 1

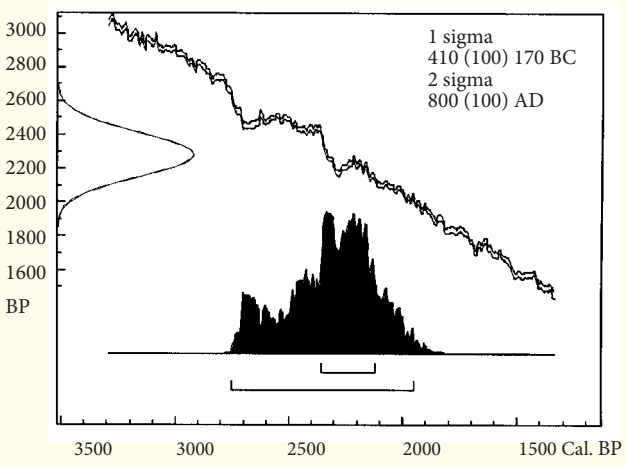


FIG. 5:3 Radiocarbon determination Wk-5364 from A1 layer 6:4 feature 3

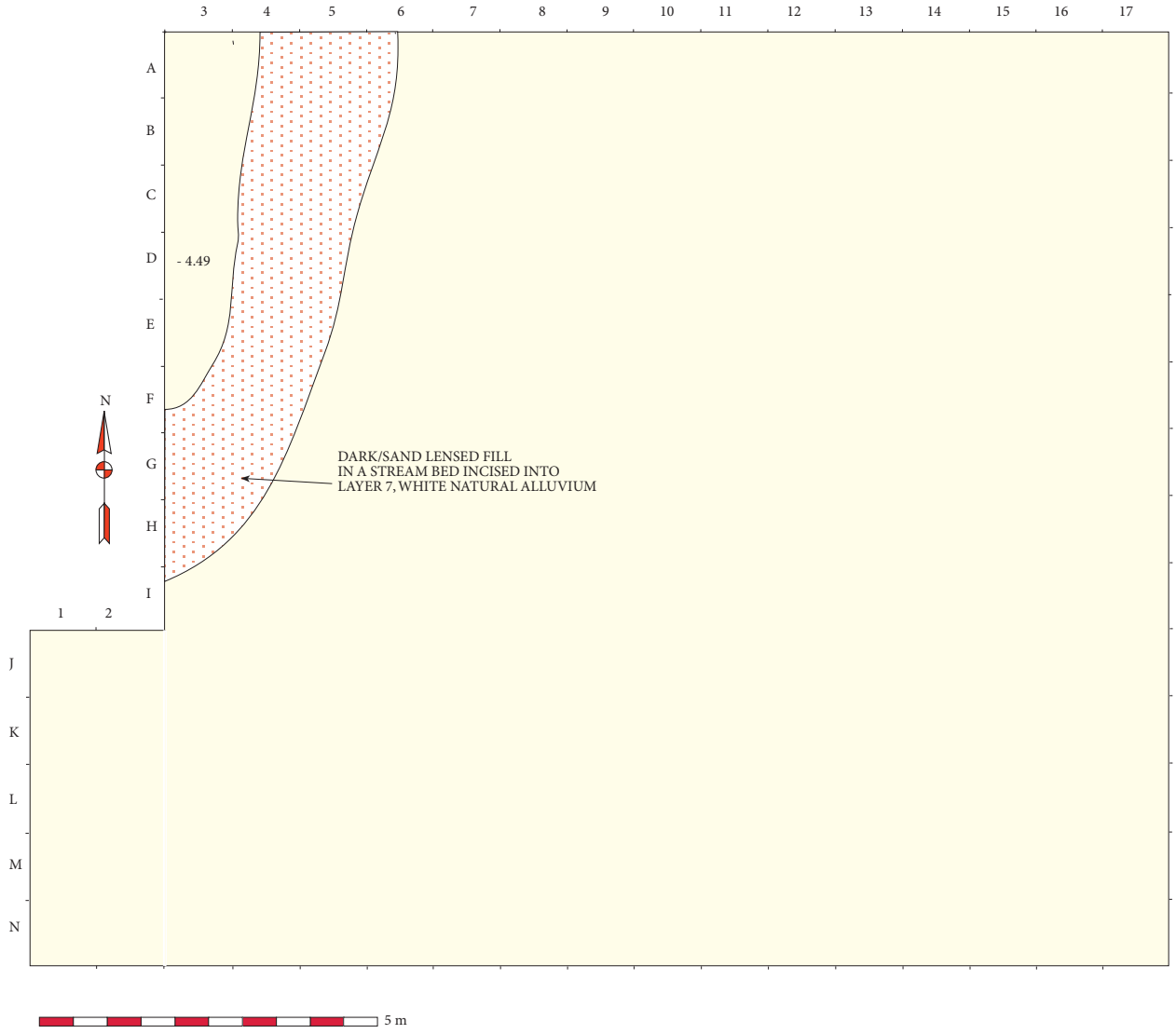


FIG. 5:5. Plan of layer 6:9

LAYER 6

Layer 6 is the lowest encountered above hard and culturally sterile deposits. It was naturally deposited, but contains cultural material in the form of pits or postholes cut into it. The lowest context, layer 6:9, comprised a stream bed incised into the natural substrate, which ran on a north-south orientation in the northwestern part of the excavated area. The lenses deposited within the stream bed by water action contained cultural material which must have been redeposited from higher on the mound as the stream either cut through occupation remains, or received potsherds and faunal remains from early occupants of the site.

Layer 6:8 is the lowest part of the excavated area to incorporate culturally *in situ* material. This concentrates in the northern part of the square, and incorporates a series of pits which contain pottery sherds and faunal remains, all

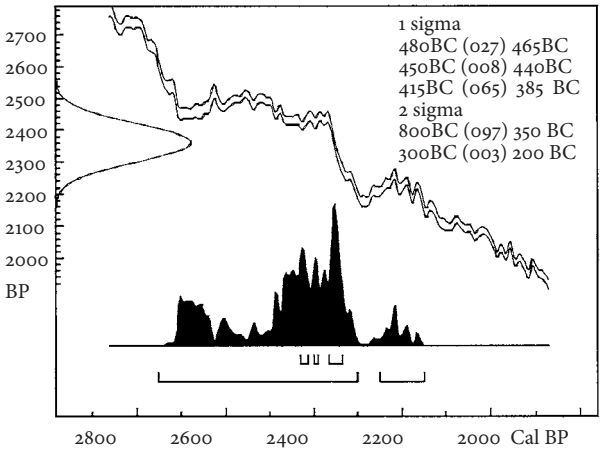


FIG. 5:4 Radiocarbon determination Wk-5363 from A1 layer 6:1 feature 1

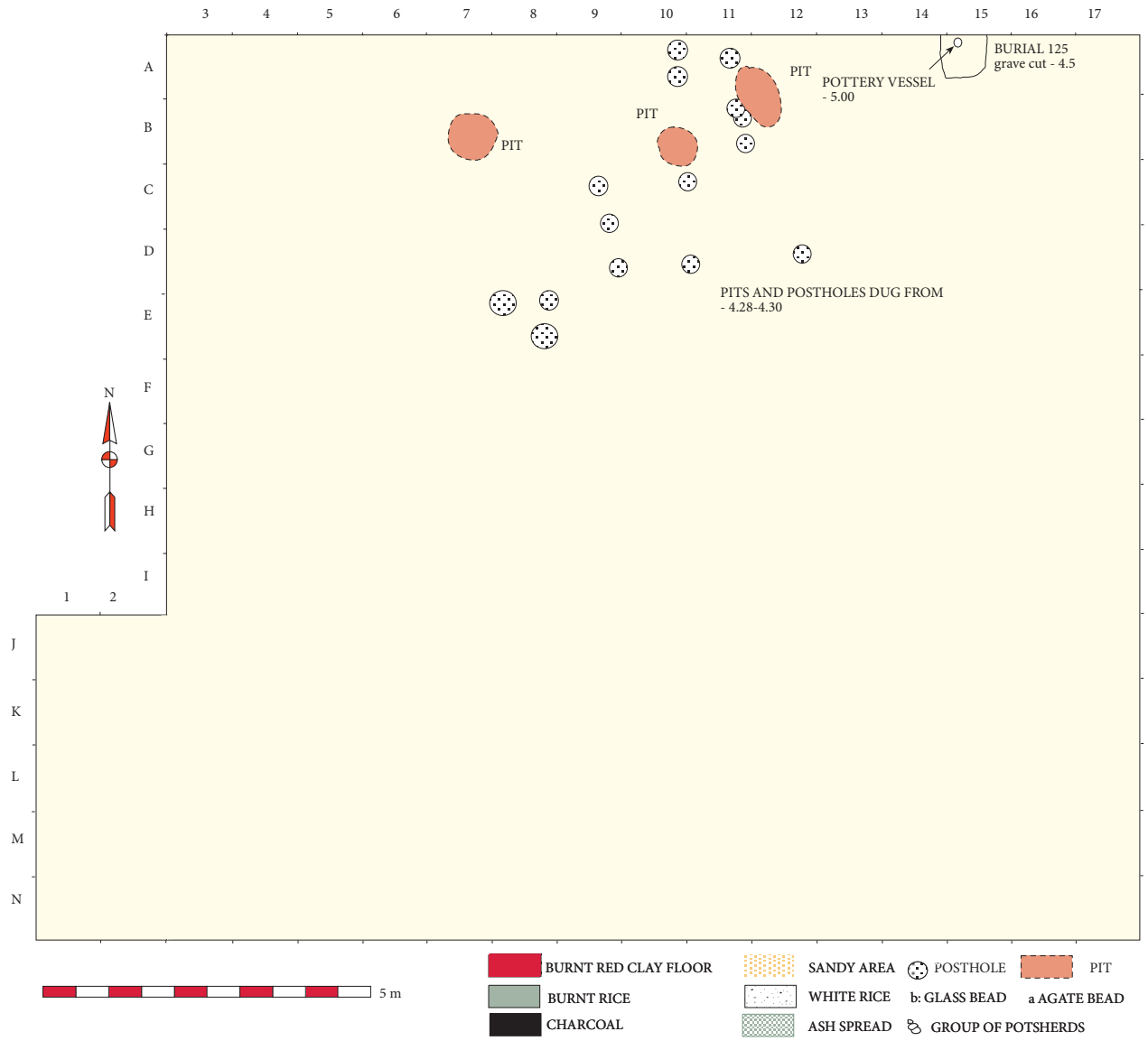


FIG. 5:6 Plan of layer 6:8

being dug within a naturally-deposited layer from a depth of 4.28-4.30 m below datum. The grid A 14-15 contains the grave cut for burial 125. This was recognised initially as a series of light-coloured sandy lenses filling a grave cut into natural to a depth of 5 m. The remains of a pottery vessel and the foot bones of an adult were found incorporated within the northern section. The style of the vessel suggests similarity with the late Bronze Age examples at Ban Lum Khao, and this grave is the only one ascribed to the first mortuary phase. It is most unfortunate that it has not been possible to extend the excavation square in order to recover the entire burial.

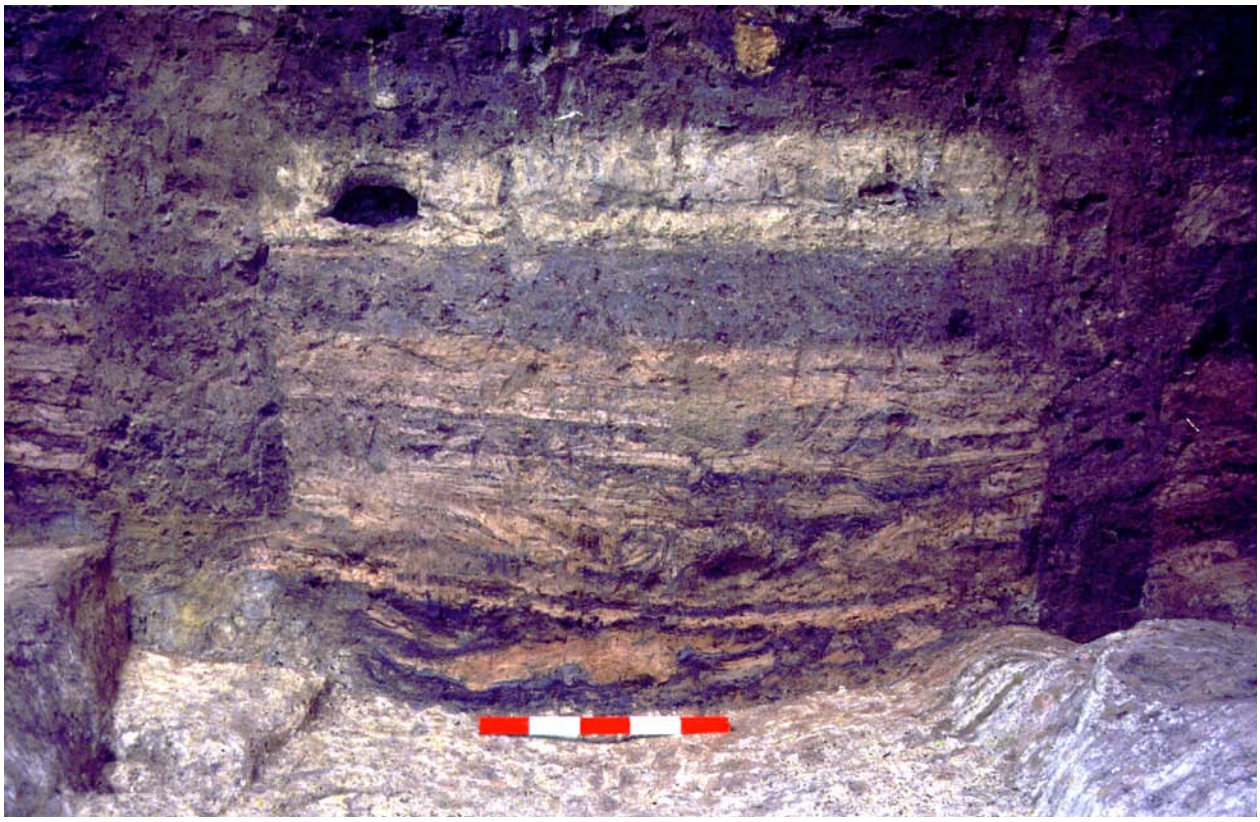


FIG. 5:7 View of the north section, to show the small stream bed cut into the natural substrate. This underlies layer 5, the yellow material, and the darker layer 6 below. Deep post holes cut from layer 4 into the substrate are clearly visible

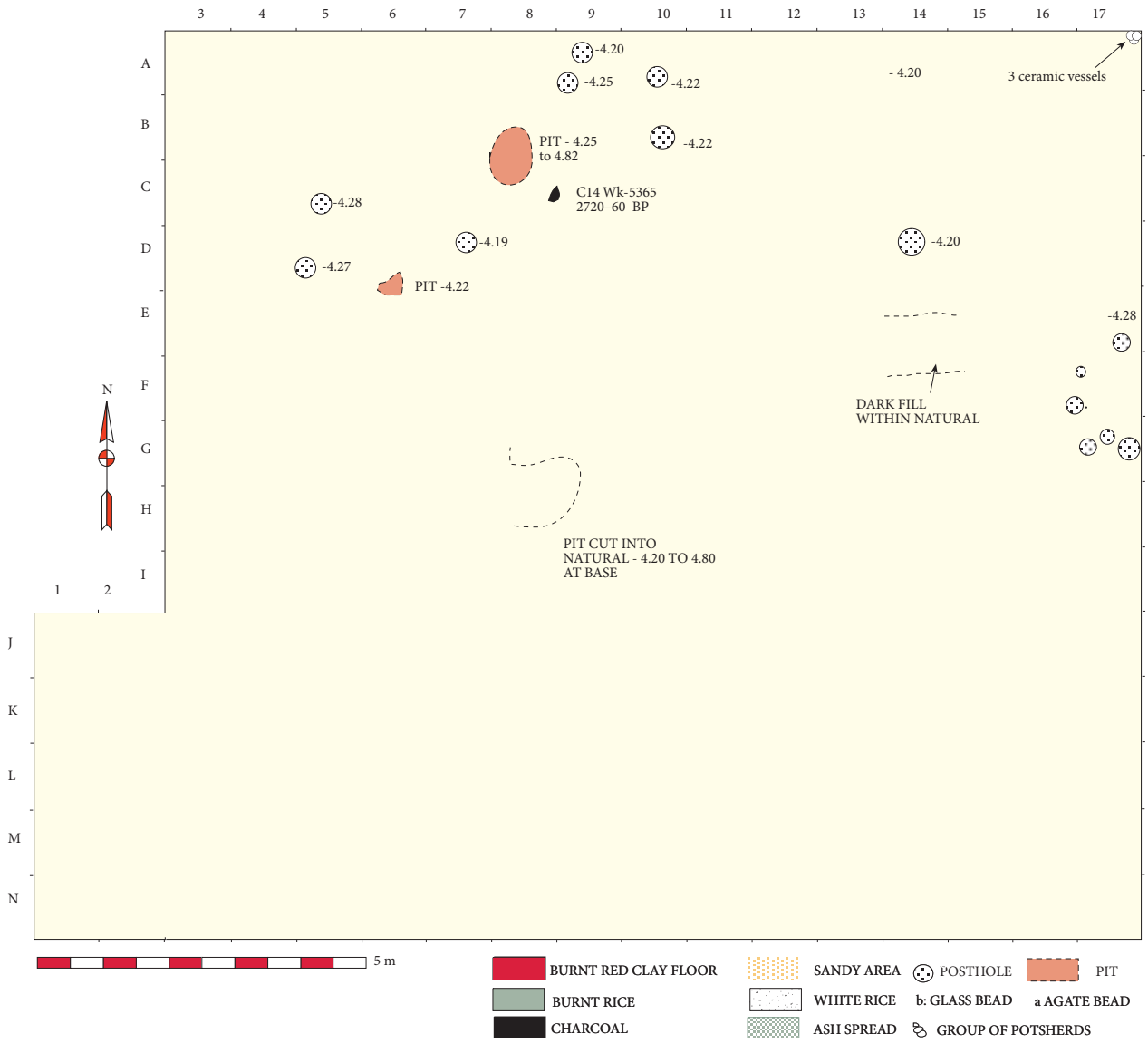


FIG. 5:8 Plan of layer 6:7

Layer 6:7 reveals a continuation of cultural activity in the northern half of the excavated area. The three pottery vessels in the extreme northeastern part of the square almost certainly indicate that a further early burial lies beyond the excavated area. Two of these remain in the section. A number of post holes had been cut down into the natural substrate from between 4.19 and 4.25 m below datum, while three pits were also present, one ending at a depth of 4.80 below datum. A radiocarbon date from C8 provided a determination of 2720±60 BP.

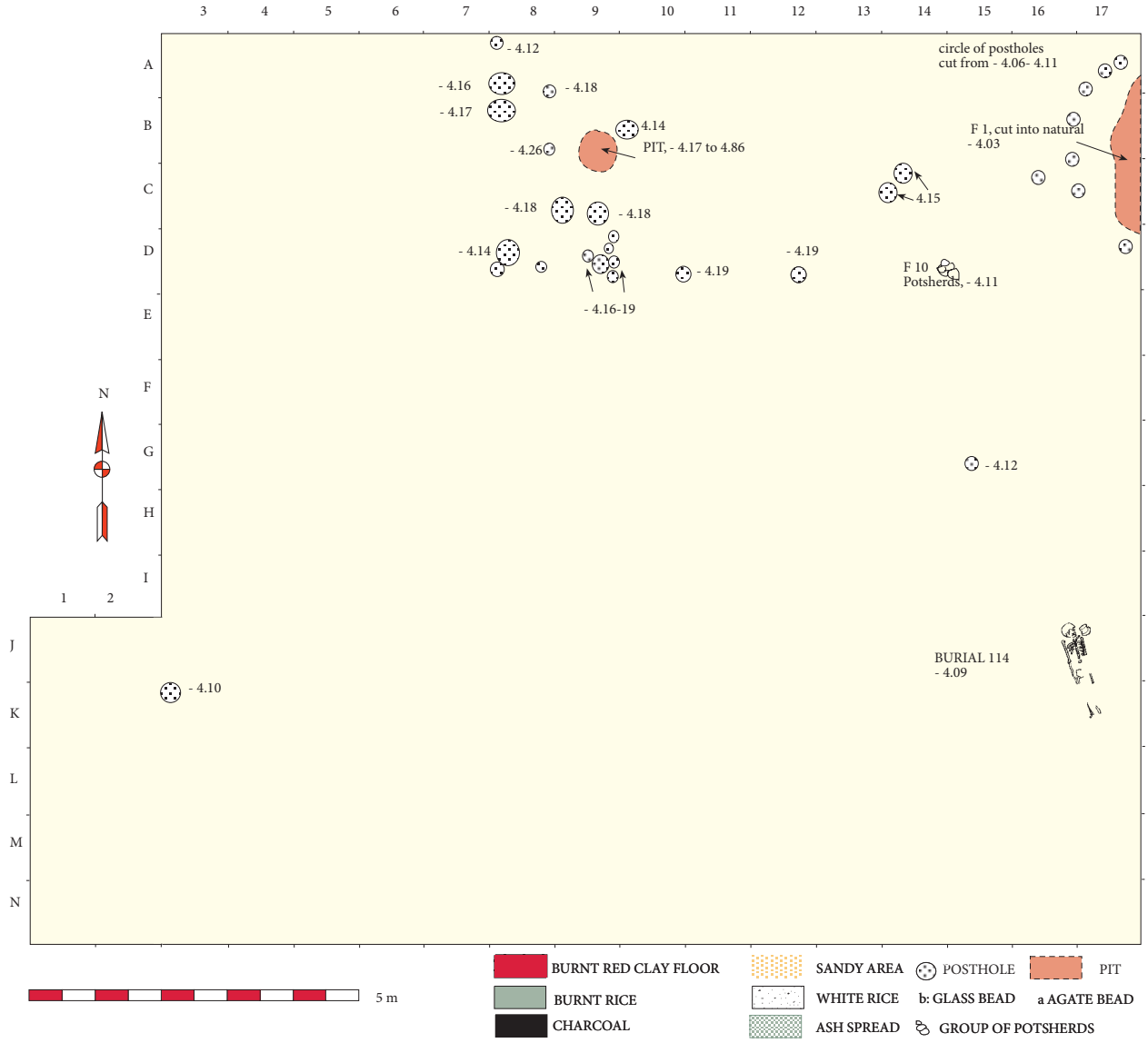


FIG. 5:9 Plan of layer 6:6

Cultural activity continued to be concentrated in the north-eastern part of the excavated area, with a series of postholes matching in their distribution, those seen in the slightly later context, these being cut from 4.06 to 4.19 m below datum. One group seems to form a circle round a shallow cut in to the natural substrate at B-D17. There is also a cluster of potsherds at D14 at a depth of - 4.11, and a shallow pit at B7. Burial 114 was encountered on a north to south axis. A 35-40 year-old female was found interred with one pottery vessel, cat. 1542, to the left of the cranium. A single posthole was encountered at K3 in the southwestern part of the square.

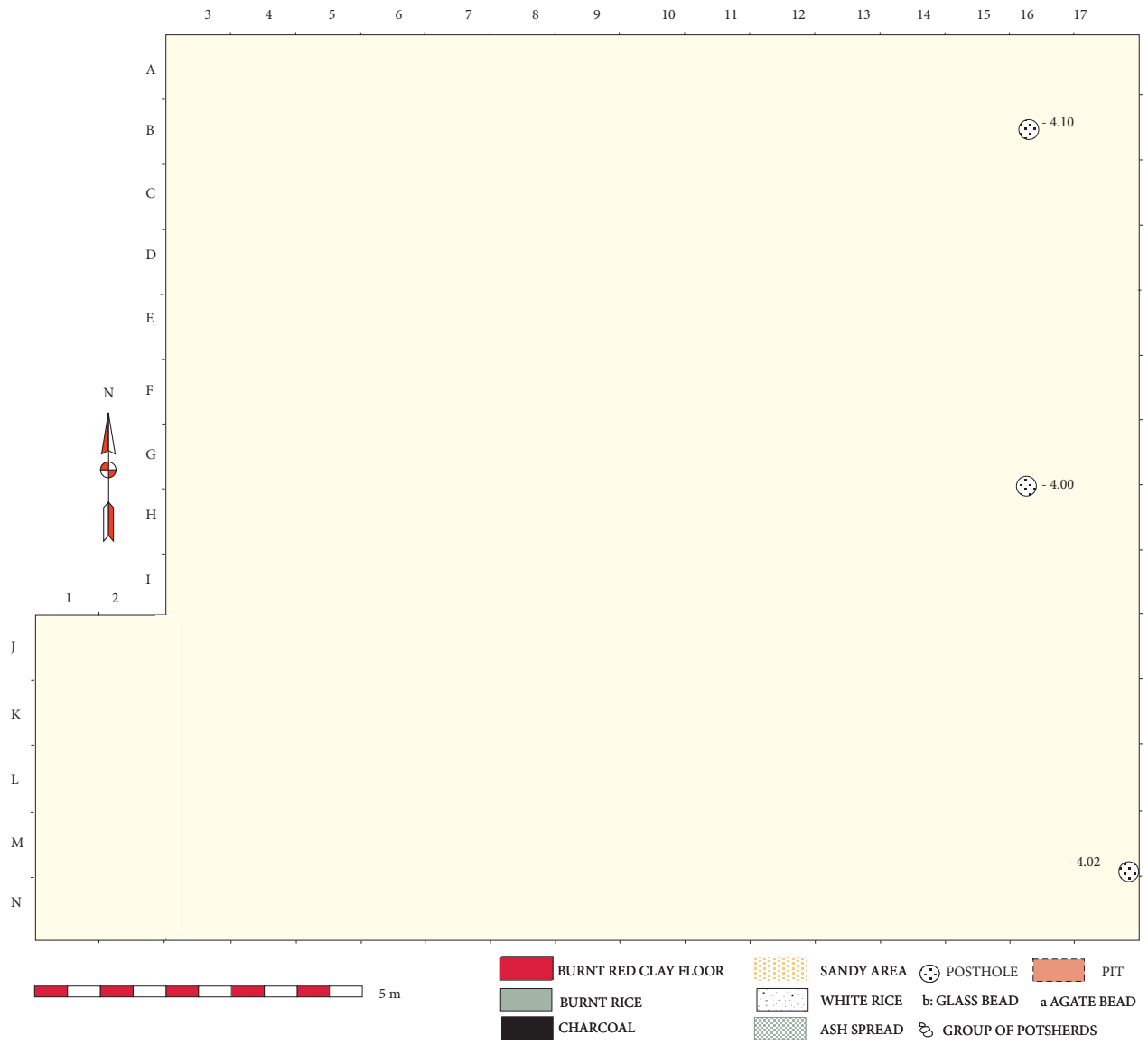


FIG. 5:10 Plan of layer 6:5

Only three postholes appeared in this context, all on the eastern edge of the excavated area, and found at depths of between 4.0 and 4.1 m below datum.

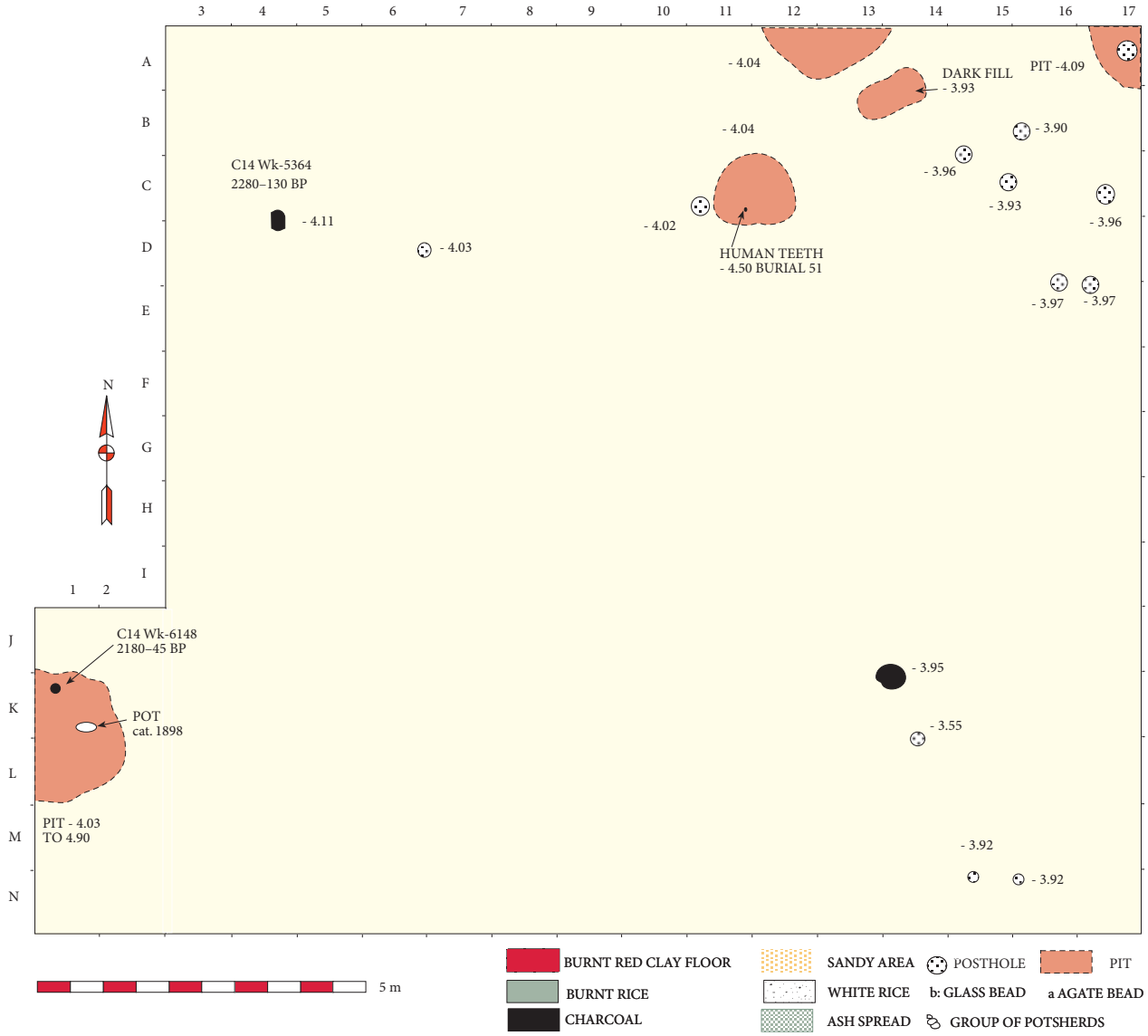


FIG. 5:11 Plan of layer 6:4

The postholes again concentrate in the northeastern corner of the excavated area. This part of the excavation also included a series of pits, one of which contained some human teeth. Three postholes were also found in the south-eastern corner, along with a hearth. A large and deep pit at KL 1-2 was found at a depth of 4.03, and it extended to a depth of 4.9 m below datum. It contained a rich assemblage of faunal remains and much pottery. Two radiocarbon determinations are available for this layer. Wk-6148 was obtained on the basis of charcoal found within a pit in square X1 (2180±45 BP). The second came from a hearth rich in charcoal at C4 (Wk-5364, 2280±130 BP).

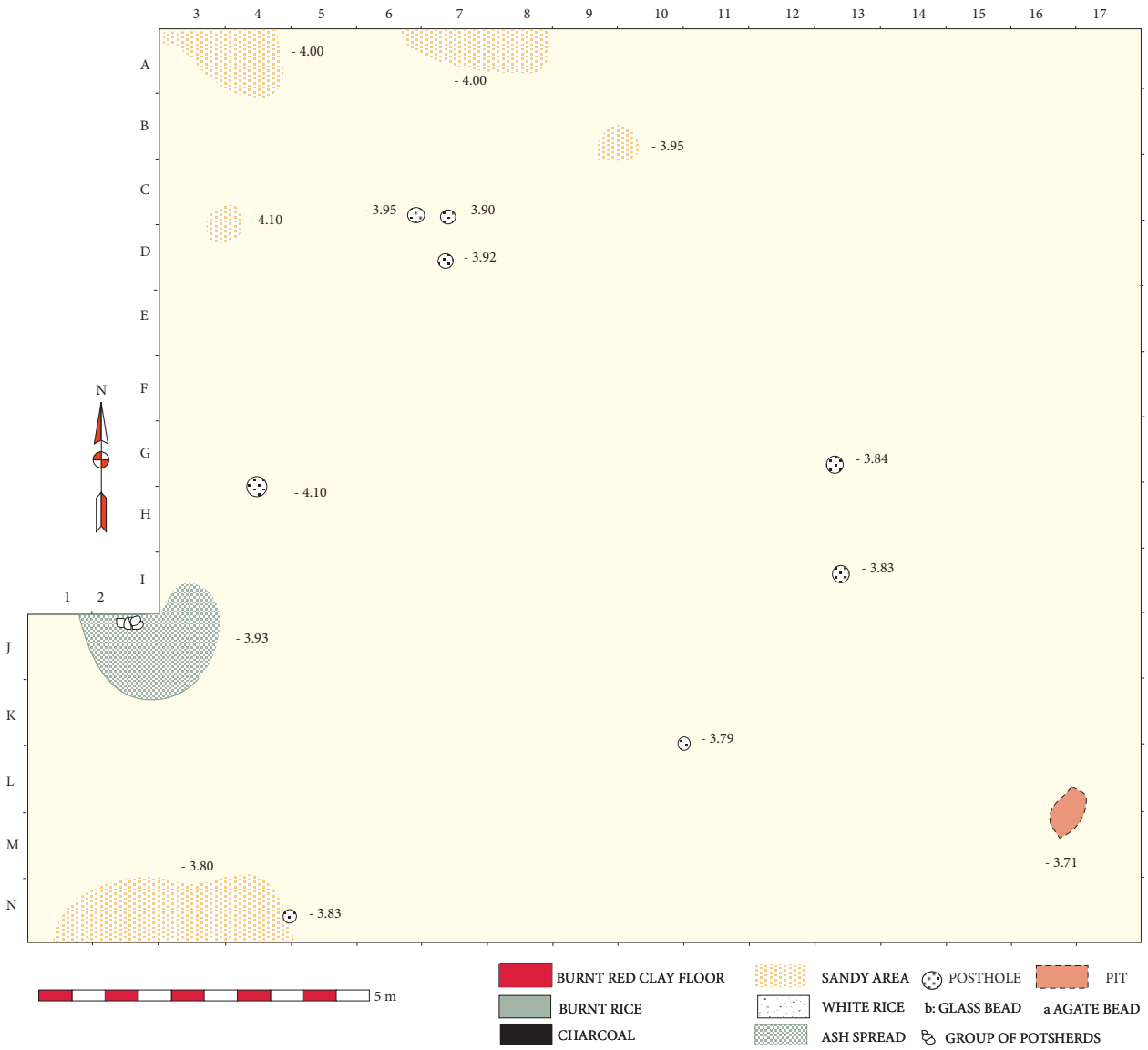


FIG. 5:12 Plan of layer 6:3

The main cultural item in this context was an ash spread, incorporating a concentration of pot sherds, at J1-3. There was also a scatter of postholes, and in the northwestern part of the excavated area, four thin lenses of sandy sediment.

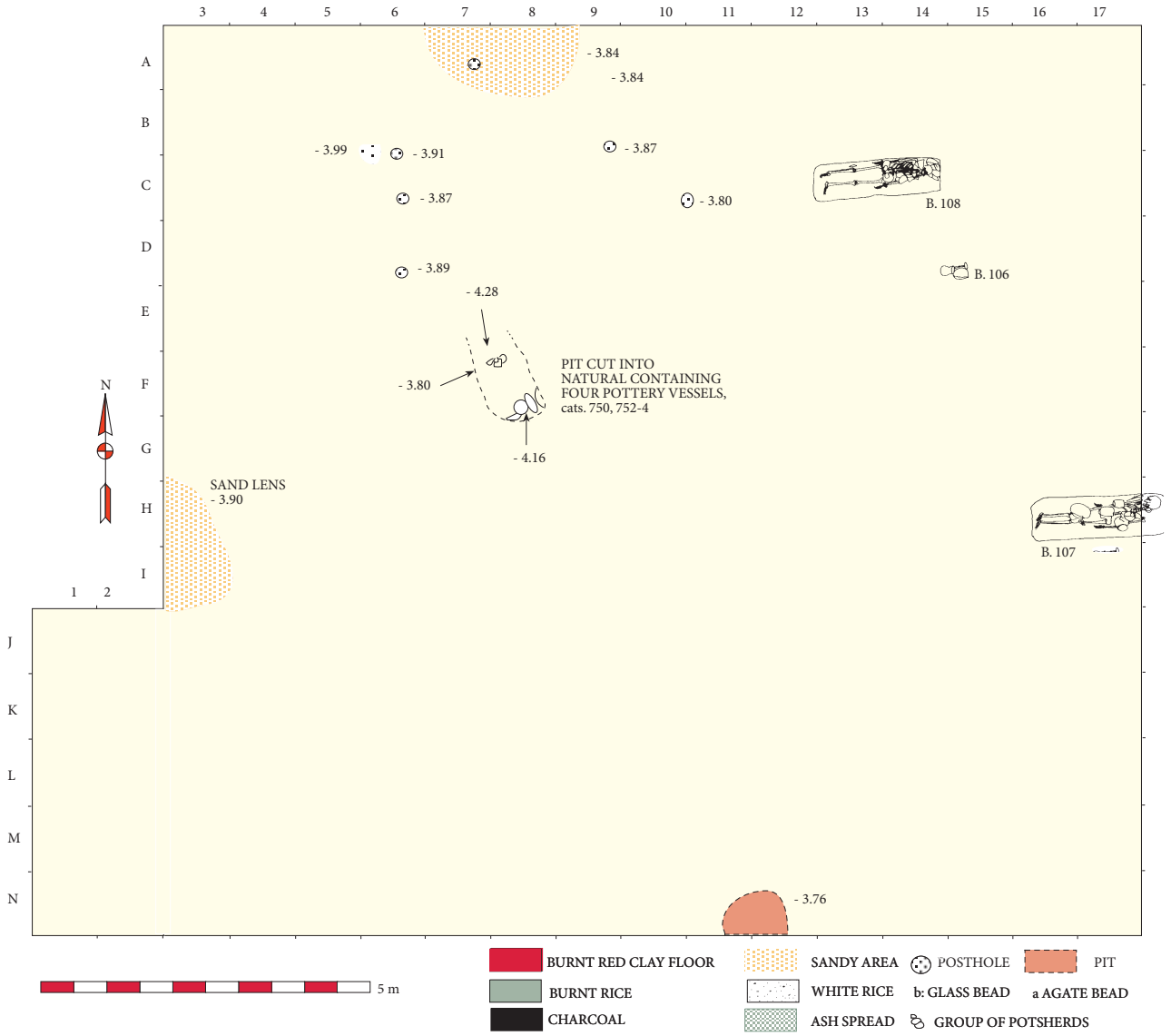


FIG. 5:13 Plan of layer 6:2

Further sandy lenses were found in this context, as well as a series of postholes again in the northern part of the excavated area. However, three and possibly four inhumation graves had been cut down to this depth. Burial 107 was found at H16-17, orientated with the head to the east and lying prone. It contained a young (16-20 year old) probable male, associated with several pottery vessels, the skeleton of a fish and the ulna of a deer. Burial 106, a neonate, was found on the same orientation at D14. It was accompanied by two pottery vessels, a fragment of bronze and a bivalve shell. Burial 108 lay just to the north. This relatively old (over 40 year-old) woman was also interred with the head to the east. She was accompanied by four pottery vessels, and iron jewellery in the form of a neck torc and bangles. Like the adjacent infant, her grave contained a bivalve shell, and in addition, pig and turtle bones.

A probable fourth burial was found at F7. A clear cut from higher into layer 6 contained four pottery vessels, and the cranium of a small mammal. One of these vessels (cat. 752) contained the complete skeletons of five fish, three *Ophicephalus striatus*, one *Notopterus chitala* and one *Notopterus notopterus*. No human bones were identified, however.

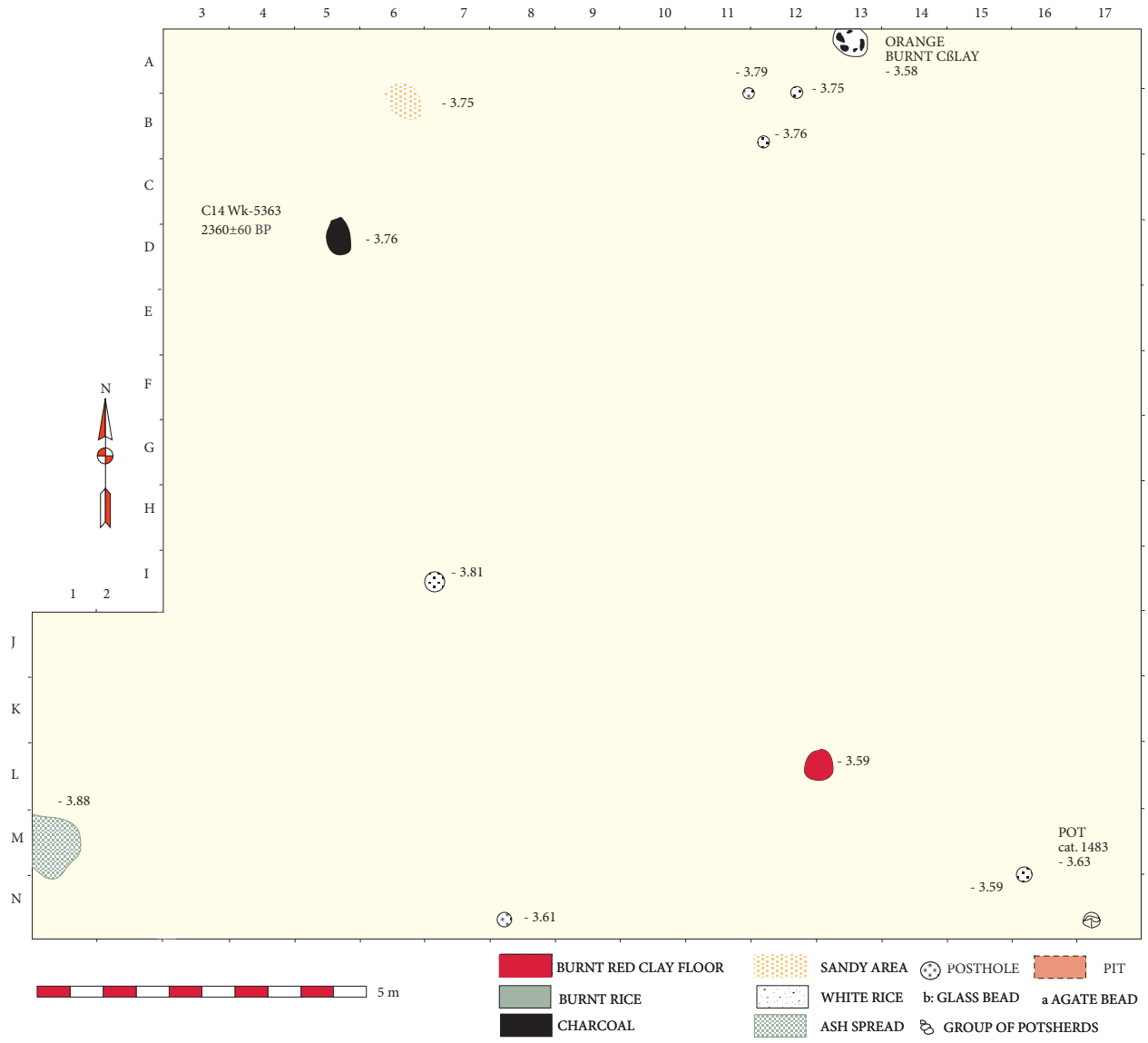


FIG. 5:14 Plan of layer 6:1

There was little evidence for cultural activity in this context. An ash spread was found at M1 and a number of scattered postholes were dug but with no evidence for patterning. There was also evidence for burning at A14, and a pottery vessel, cat. 1483, was recovered at N17. A hearth rich in charcoal at D5 has provided a radiocarbon determination of 2360±60 BP.

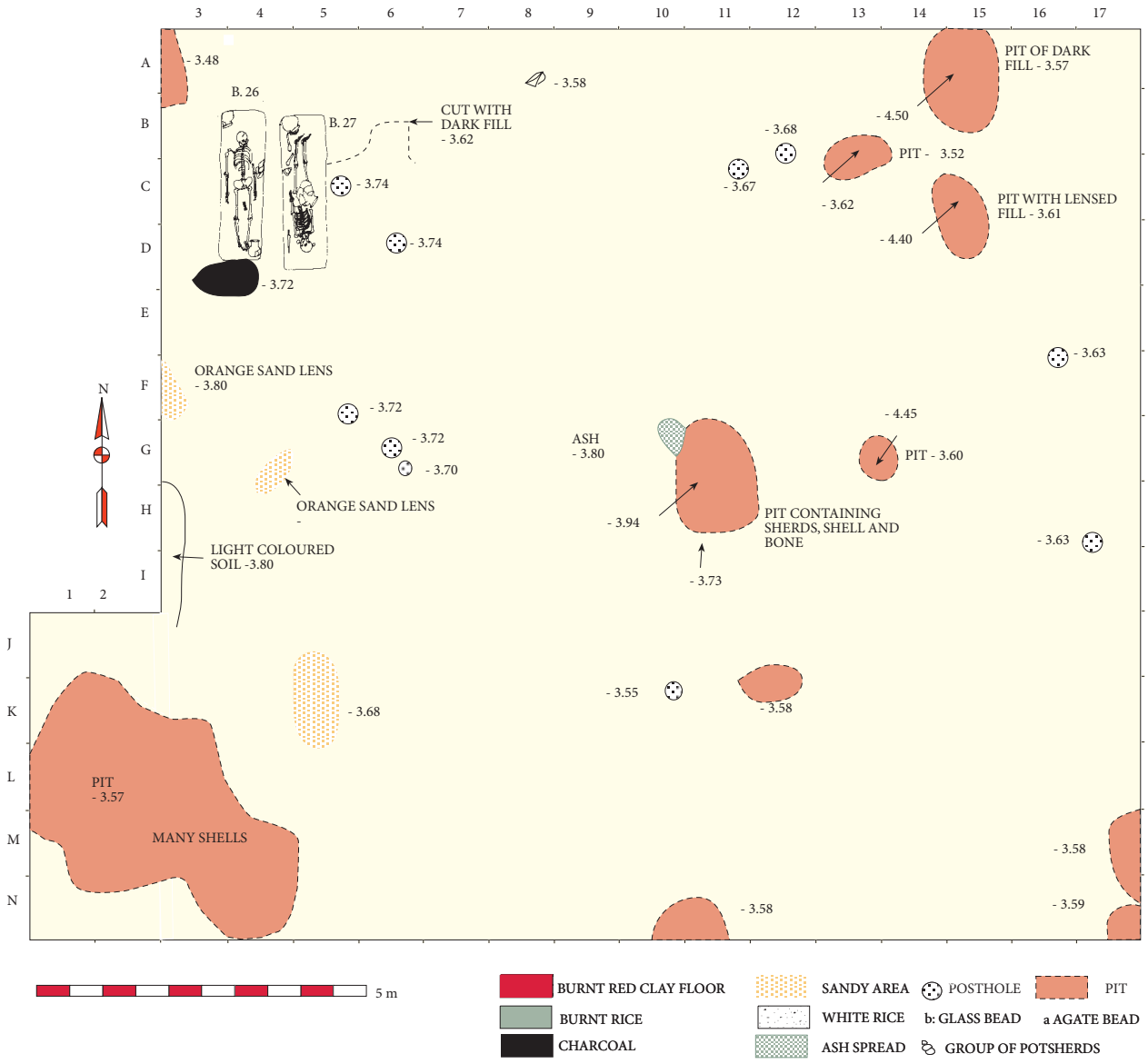


FIG. 5:15 Plan of layer 5:2

This layer incorporated a series of pits containing shellfish, faunal and pottery remains. There were also a number of postholes. Two burials were cut from or through this layer. Burial 27 was seen in the form of a clear grave cut at a depth of 3.76 m, and the cranium was encountered at 4.12 m. Burial 26 was recognised as a grave cutting at 3.50 m and the top of the cranium lay at a depth of 3.79 m. Both were male, the former being aged between 35-40 years at death, the latter 25-30 years. Both were well endowed with grave goods. The older man was interred with a large iron sword or spear next to his head, and an iron hoe or axe by the feet. He wore three bronze neck rings or torcs, and a bangle on each wrist. The torcs lay in association with a necklace of four pierced tiger canines. His earplugs were of shell. There were many pottery vessels, some containing fish, and pig bones in the grave fill. A shaped *Bos* ulna pierced at the distal end lay beside his left ankle, and shell discs with two socketed bronze spears were found beyond the feet.

Burial 26 was rather disturbed in the cranial area, but the man had been buried with many pottery vessels, fish remains, an articulating pig's foot bones between the thighs and a matching pair of shaped and pierced pig's canine teeth of considerable size.

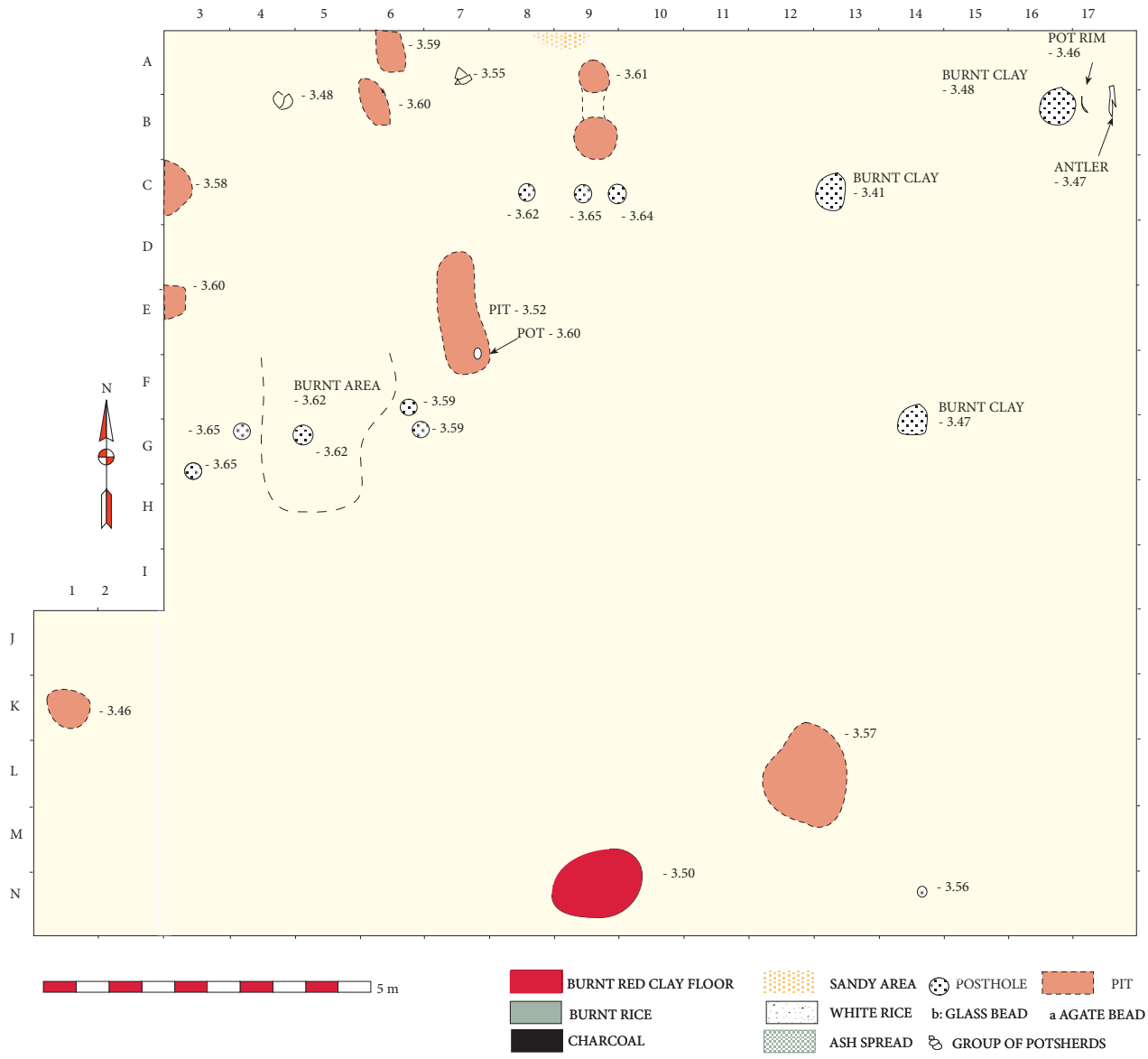


FIG. 5:16 Plan of layer 5:1

Layer 5 in the northern part of the excavated area presented a clear distinction from layer 4, in that it began to comprise a much lighter yellow colour. It incorporated a series of pits, and areas of burning together with a scatter of postholes. An almost complete deer antler was found at A17.

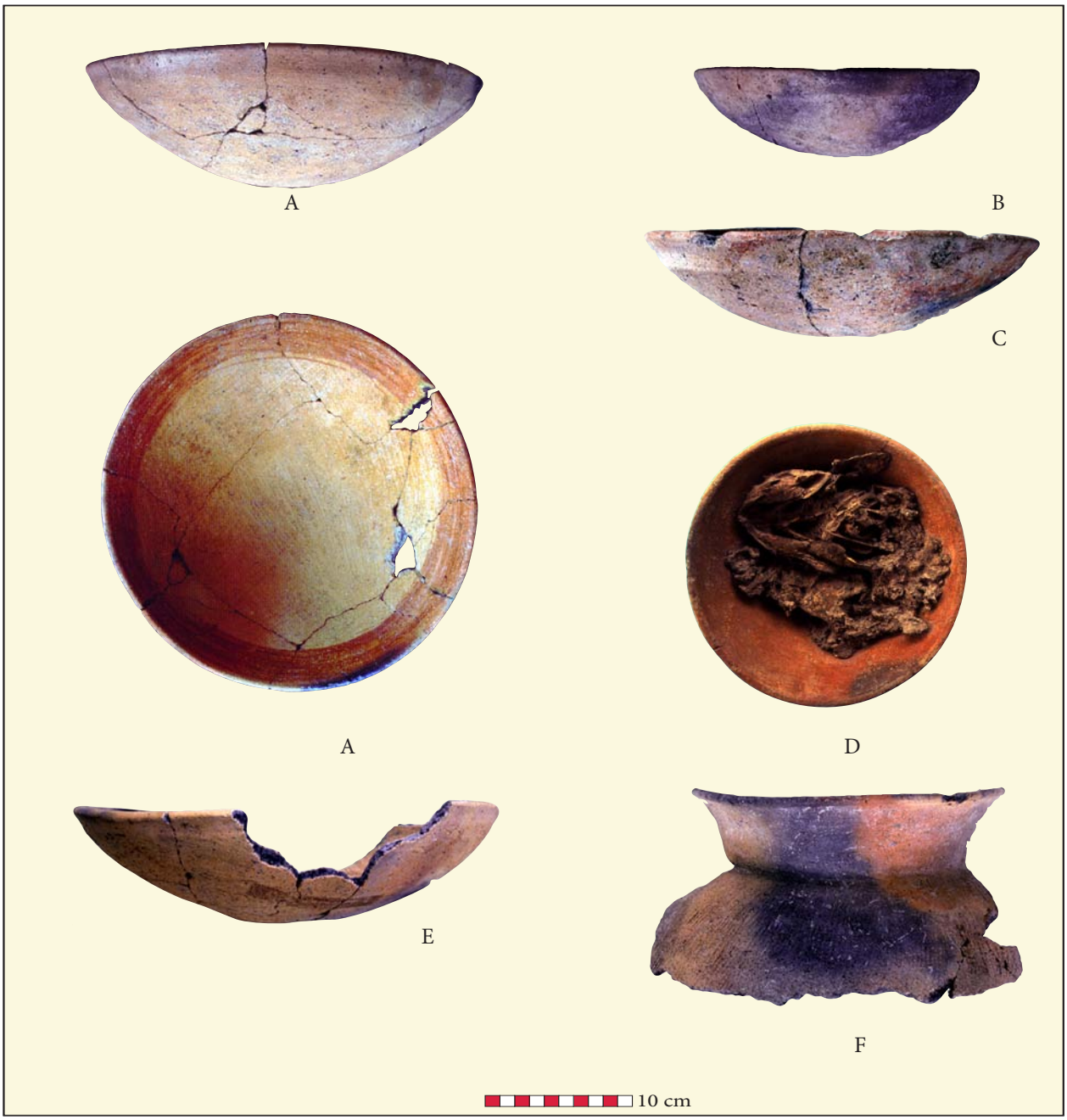


FIG. 5:16 Pottery vessels from layer 6. A. Cat. 750, B2 6:2 feature 1, B. Cat. 754 B2 6:2 feature 1, C. Cat. 753 B2 6:2 feature 1, D. Cat. 752, B2 6:2 feature 1 (note the contents of five fish skeletons), E. Cat. 1898 X1 6:4 feature 1, F. Cat. 1791 layer 5:1 feature 1

VI. THE SEQUENCE DURING LAYER FOUR

C.F.W. HIGHAM AND RACHANIE THOSARAT

Layer 4 saw much evidence for occupational activity. It is also evident that early Iron Age graves were cut from this layer into layers 5 and 6. It contained many pits, postholes, ash lenses and concentrations of pottery, as well as a number of lidded vessels placed without any obvious relationship to mortuary activity. Many burials were also cut down into layer 4 from above.

DATING LAYER 4

The earliest dated context for layer 4 lies in square A1, 4:8 feature 3, which was part of a collapsed, burnt daub structure rich in charcoal (Fig. 6:1). The result, which at 1 sigma is 180-40 BC, suggests that this layer was deposited

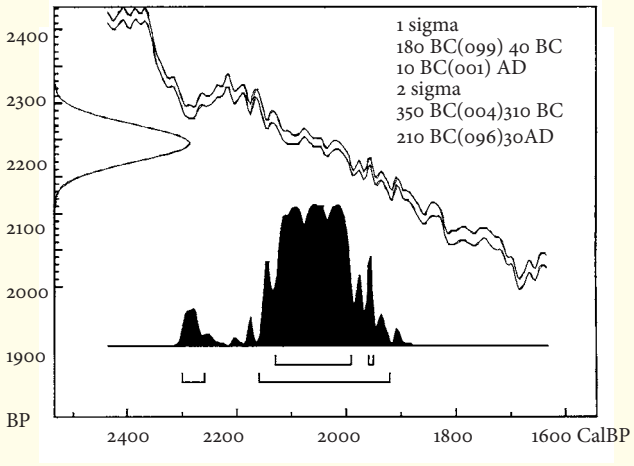


FIG. 6:1 The radiocarbon determination Wk-5356 from A1, layer 4:8 feature 3

during the first two centuries BC.

There are two determinations from layer 4:5 (Figs. 6:2-3). The first comes from A2 feature 5, a charcoal-rich *in situ* hearth. The result at 1 sigma indicates a date in the first two centuries AD. The second determination comes from A1 feature 6, another hearth solidly filled with charcoal. The result at 1 sigma is virtually identical, confirming a date in the first two centuries AD.

There are three radiocarbon determinations from layer 4:4 (Fig. 6:4). The first comes from A1 feature 4, the second from A1 feature 1 and the third from A2 feature 18. All three came from *in situ* contexts and the results are very similar, suggesting that this upper context in layer 4 dates to approximately 200-300 AD.

Layer 4:3 has furnished two determinations (Fig. 6:4). That from A1/2 feature 14 derives from a sample of carbonised rice grains which concentrated in a large pit. Its result at 1 sigma (81%) is 330-440 AD, whereas the second sample from this layer has a 1 sigma result of 120-250 AD. Further research is necessary in order to evaluate the pos-

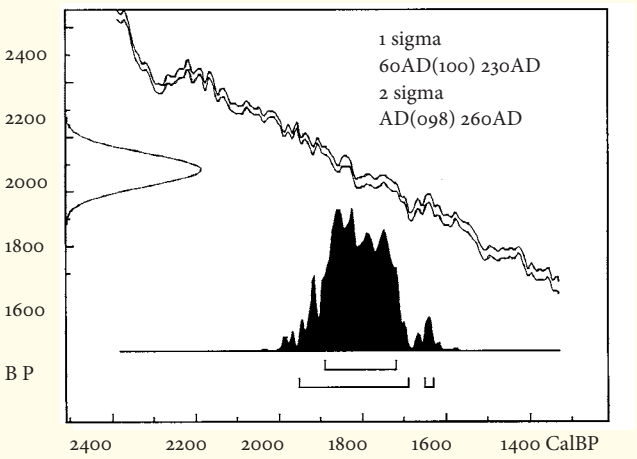


FIG. 6:2. Radiocarbon determination Wk-5361 from A2, layer 4:5 feature 5

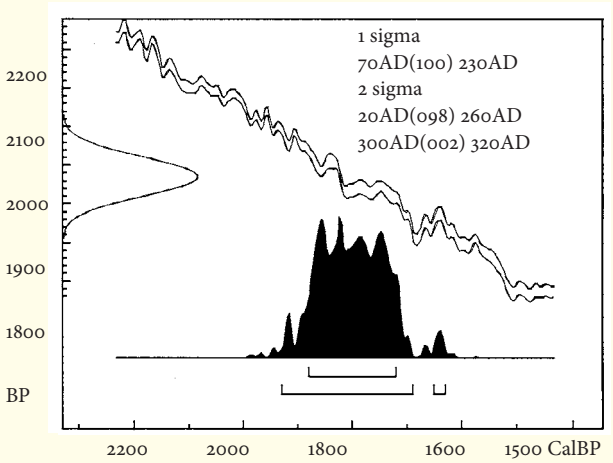


FIG. 6:3. Radiocarbon determination Wk-5357 from A1, layer 4:5 feature 6

sible impact of inbuilt age on the radiocarbon age of the wood against rice samples. It is possible that the former are liable to be too early. The single determination from layer 4:2 comes from feature 1 in square A1. The 1 sigma result of 70 to 250 AD is clearly aligned more with the charcoal-based dates than that derived from carbonised rice. Indeed, the result is identical with the result from layer 4:4 feature 4. The final determination from the uppermost context in layer 4 comes from A1 4:1 feature 6 (Fig. 6:5). The result at 1 sigma (90%) is 120-250 AD, again suggesting a date for the upper part of the layer in the region of the second or third century AD (Fig. 6:5).

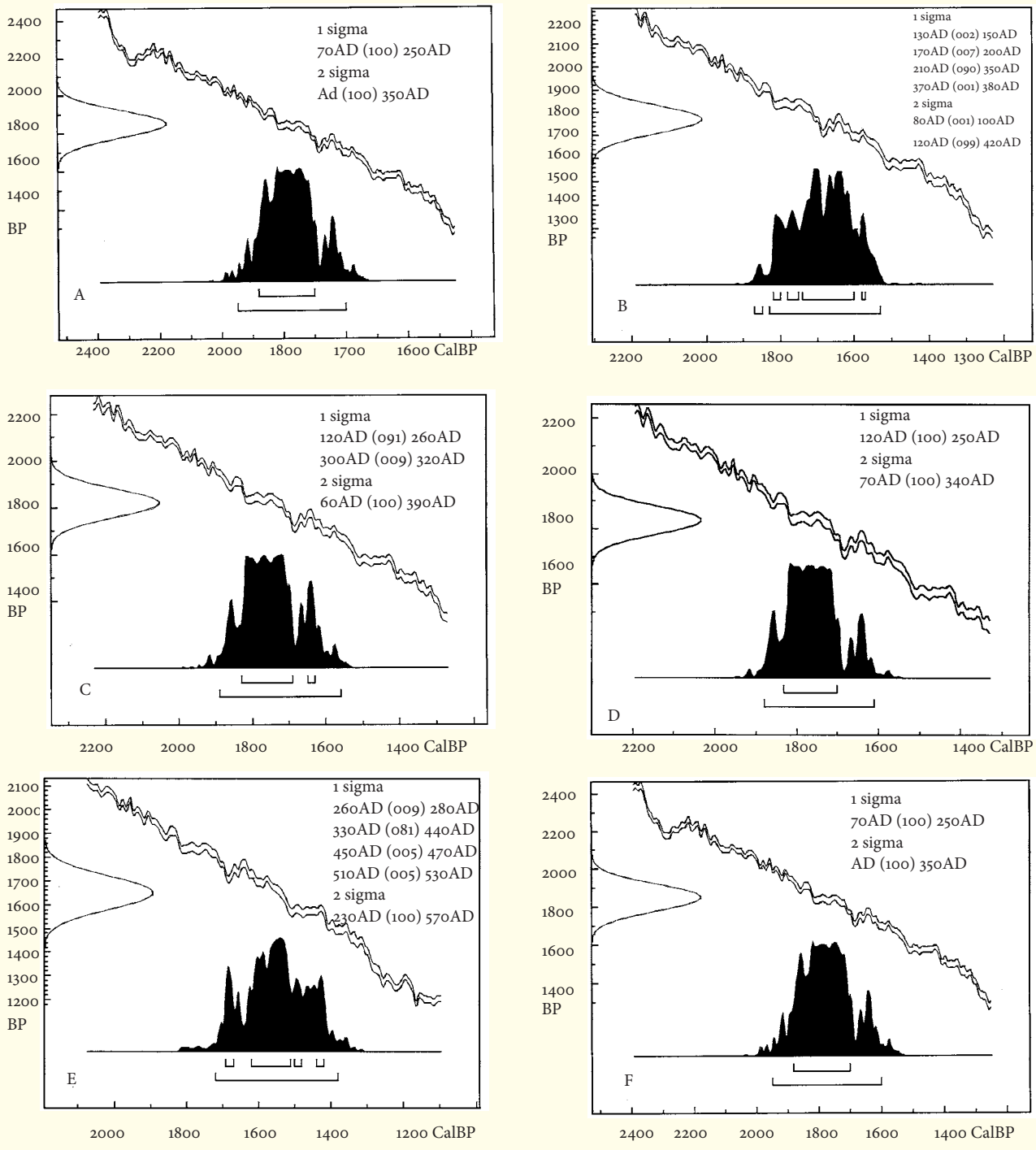


FIG. 6:4 Radiocarbon determinations from layer 4. A. WK-5355 A1 4:4 feature 4, B. Wk-5360 A1 4:4 feature 1, C. Wk-5351A2 4:4 feature 18, D. Wk-5358 A1 4:3 feature 20, E. Wk-5362 A1/2 4:3 feature 14, F. Wk-5354 A1 4:2 feature 1

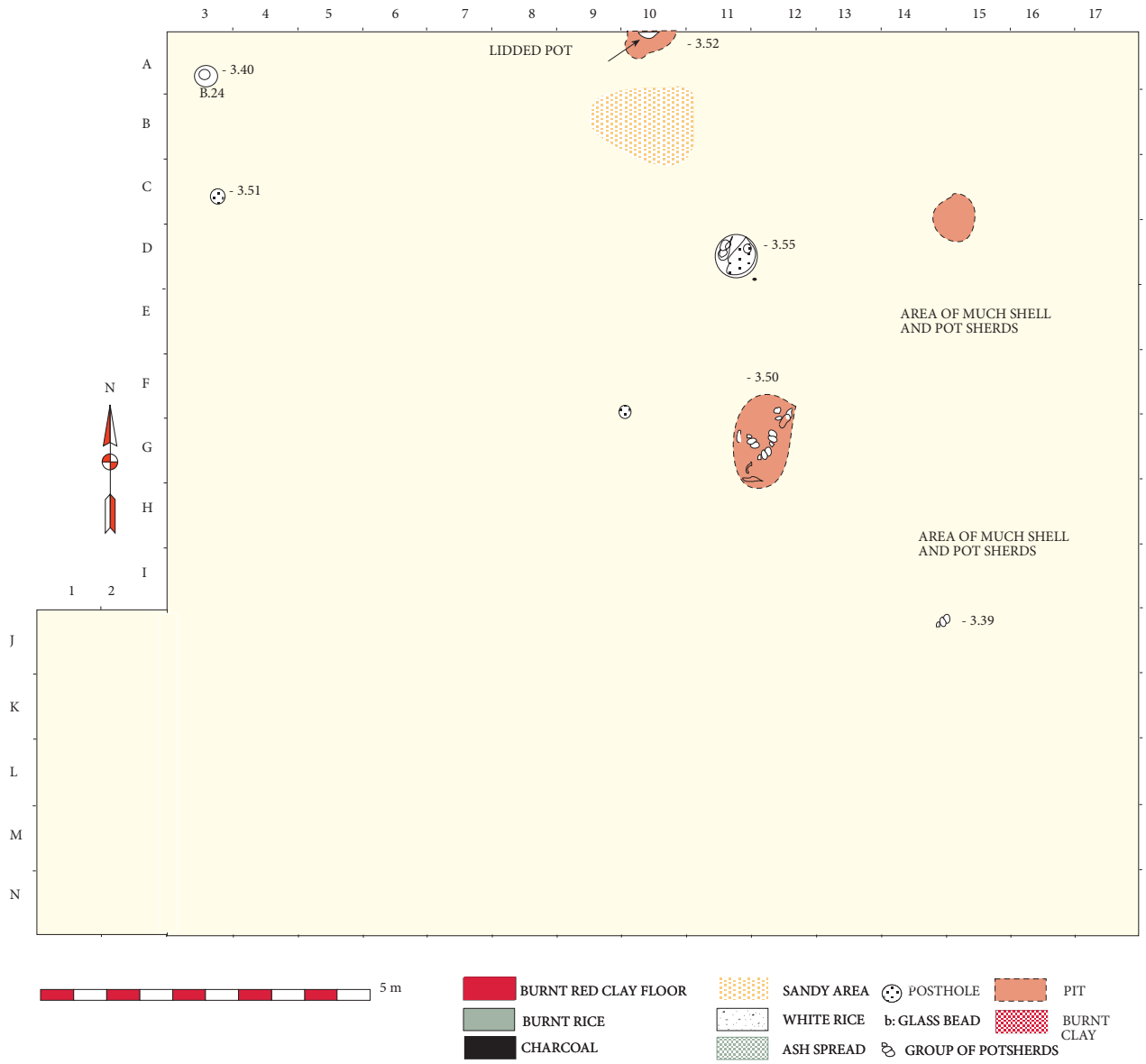


FIG. 6:6 Plan of layer 4:15

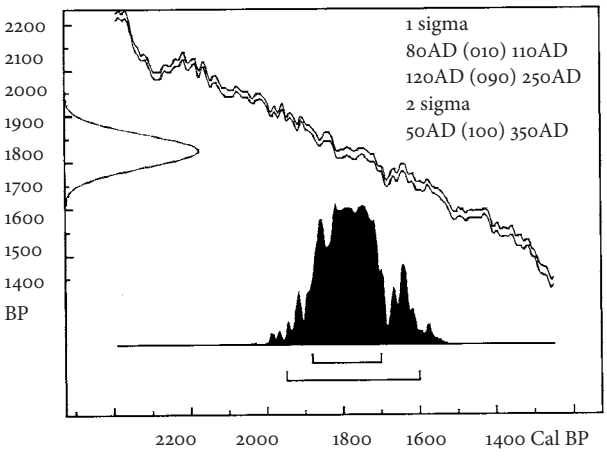


FIG. 6:5 The radiocarbon determination WK-5355 from A1 layer 4:1 feature 6

There was little evidence for cultural activity at the base of layer 4 (Fig. 6:6). Burial 24, a jar burial containing the remains of a neonate, was found at A3, but was presumably cut down from a higher level. There were some concentrations of pottery and shellfish, which became particularly dense in the eastern part of the excavated area. This continued from the same feature in layer 4:14 above.

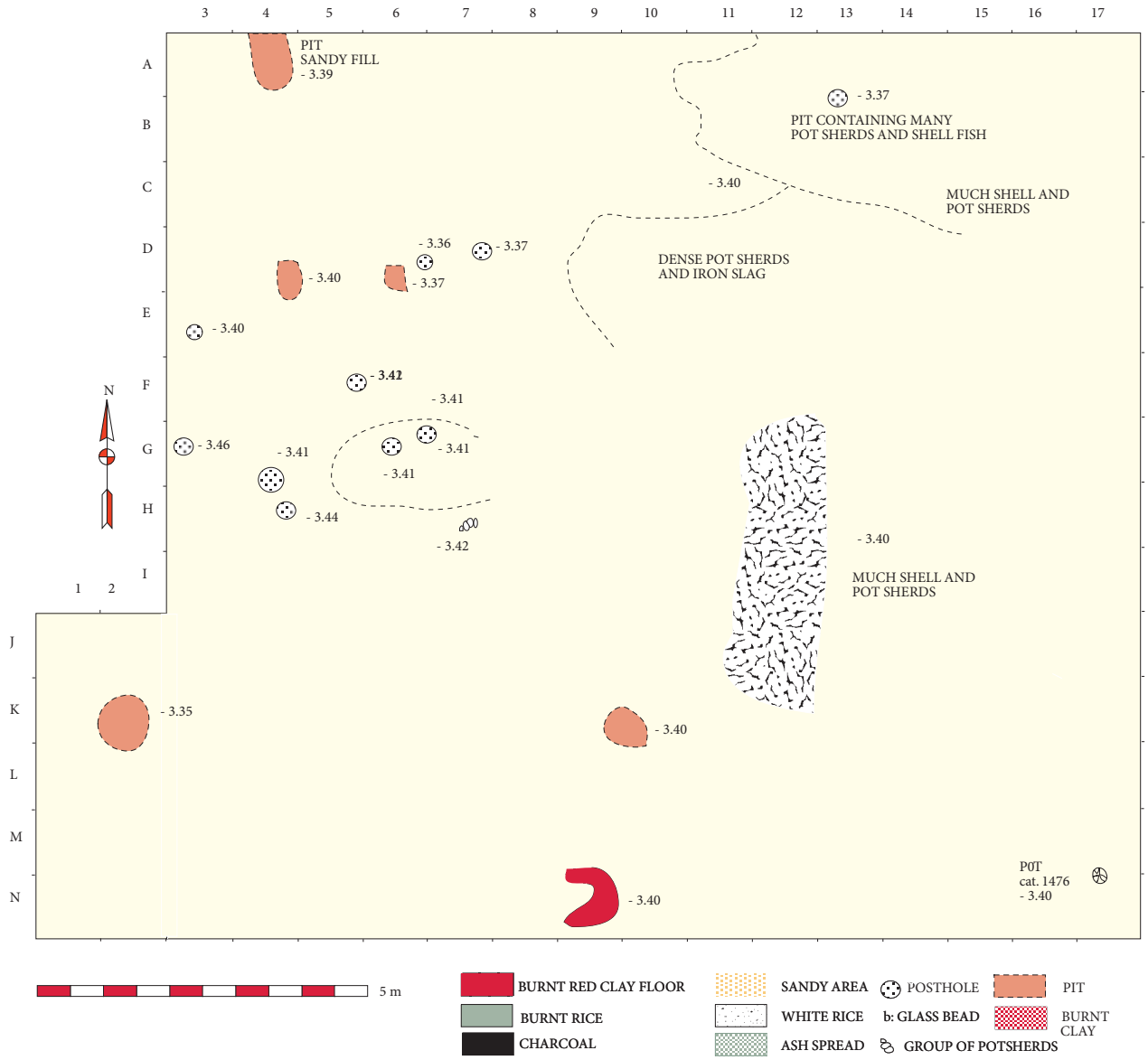


FIG. 6:7 Plan of layer 4:14

During this phase, a large spread of potsherds and shellfish accumulated in the eastern part of the excavated area. There was also a group of postholes in the northwestern area, together with a number of small pits. A pottery vessel was recovered from N17.

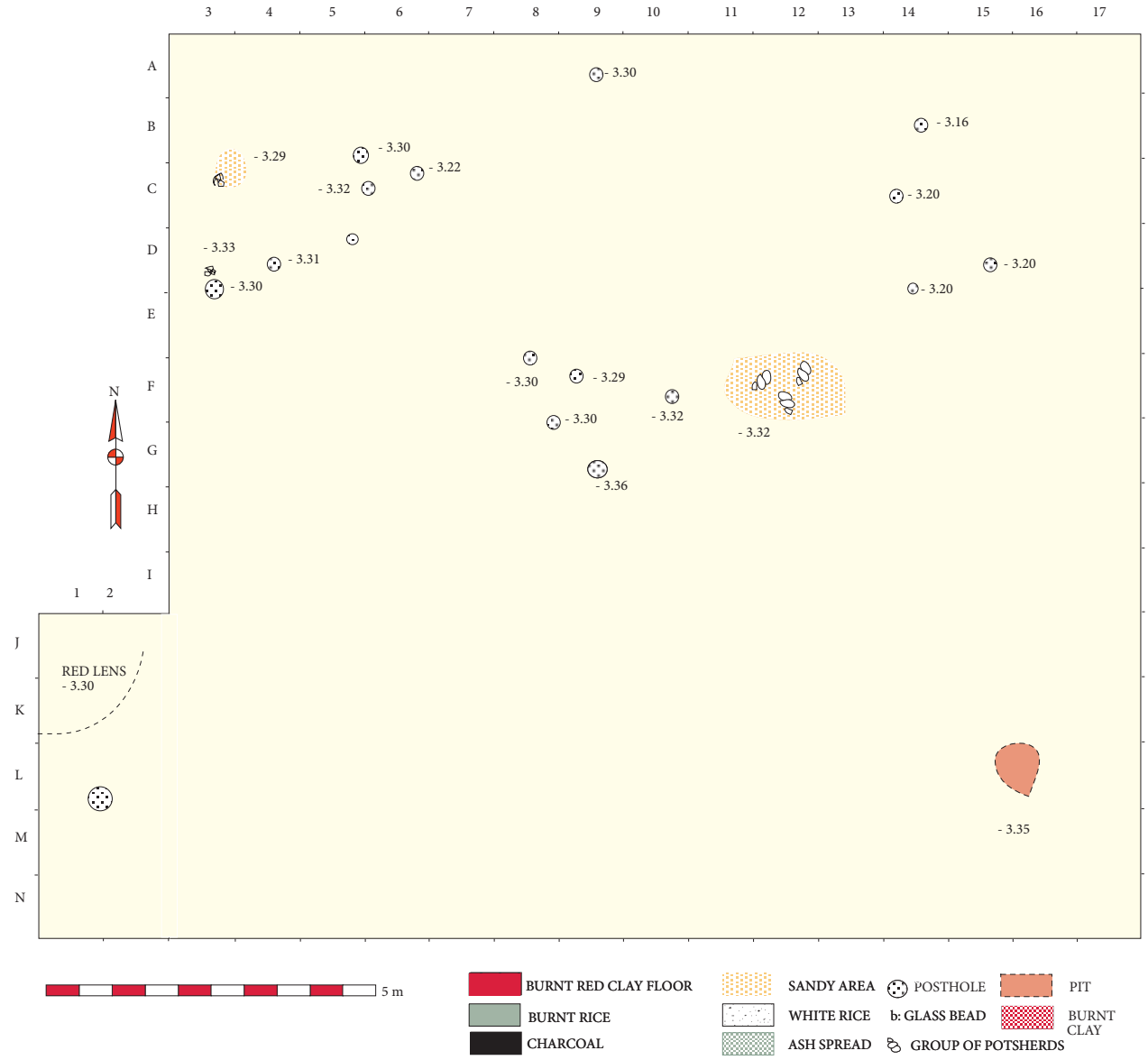


FIG. 6:8 Plan of layer 4:13

This layer revealed three concentrations of postholes, and two areas where burning had taken place.

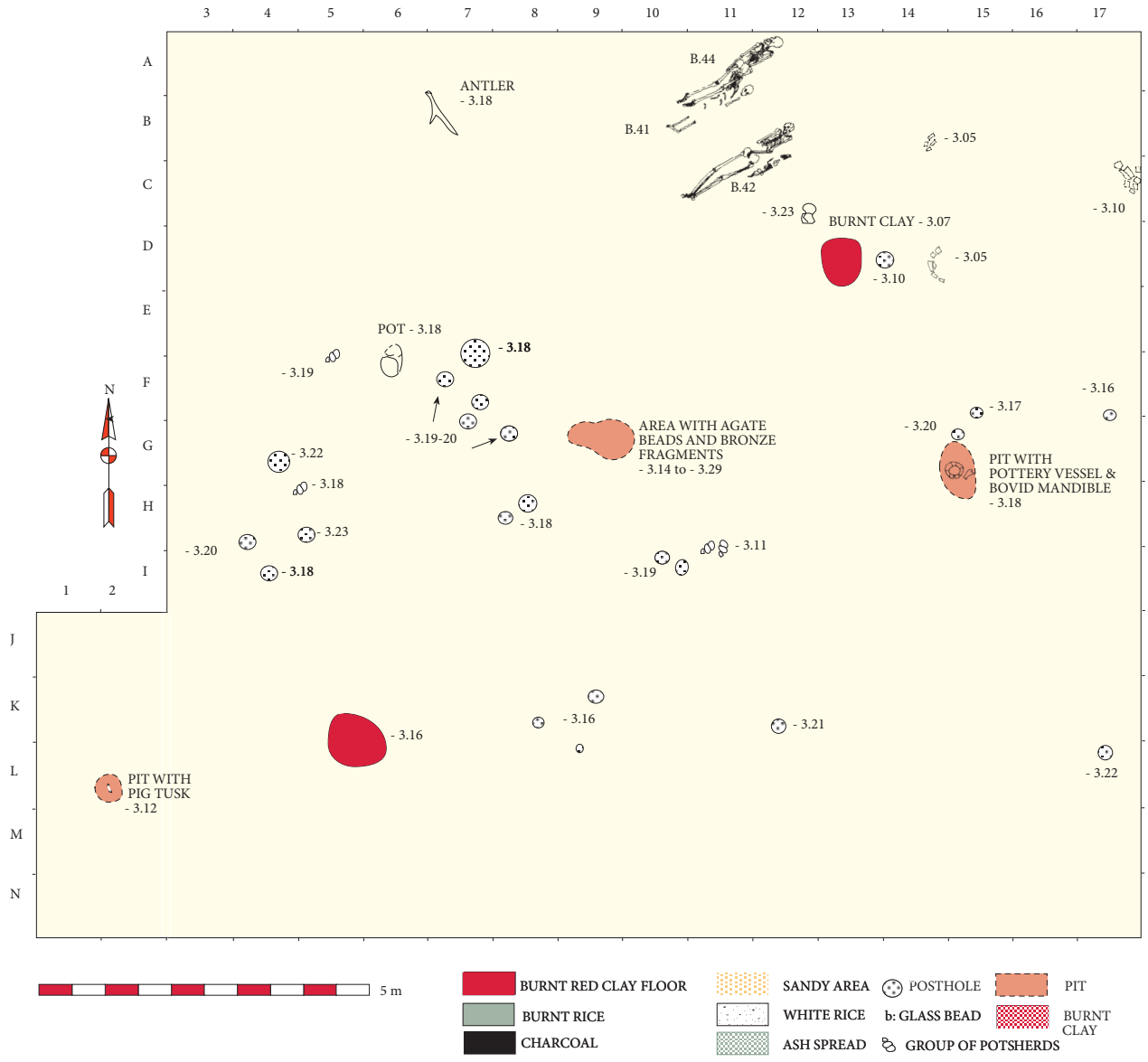


FIG. 6:9. Plan of layer 4:12

This context included clusters of postholes, and a number of pits or areas containing concentrations of material. Thus an area at G9 included a number of agate beads and fragments of bronze. A pit at L2 contained a large pig's tusk, and another was found at G15, with a pottery vessel and bovid mandible. Several mortuary phase 3A graves were cut down to this depth, orientated with the head to the northeast. Burial 41 contained the remains of a child aged about 7-11 years at death. There were few mortuary offerings: a few glass beads, a fragment of shell bangle and some pig bones. Burial 42 incorporated a male aged over 40 years at death. Compared with earlier burials, he too was poorly endowed with grave goods. An entire skeleton of a young pig was found on his left side, other grave goods being some glass beads, shell disc beads, and part of a whole pottery vessel. Burial 44 was probably that of a male aged between 20-25 years of age. Unusually, he was interred prone, with no grave offerings.

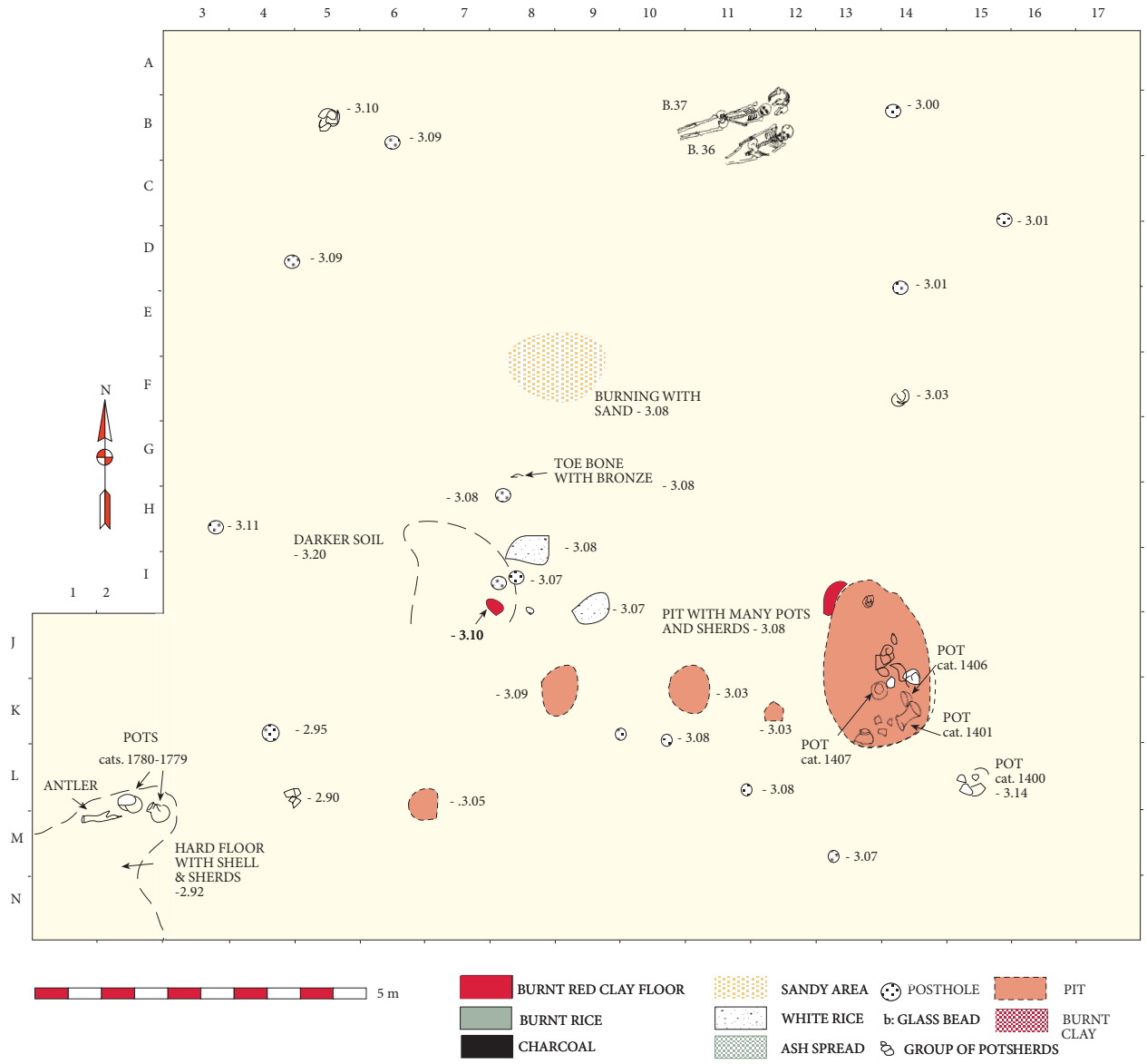


FIG. 6:10 Plan of layer 4:11

There is a scatter of postholes in this level, together with signs of occupation. At M-N 1-2, there is a hard surface containing shellfish and potsherds, together with a complete antler and two pottery vessels. There is evidence of burning at F9 and a series of pits in the southeastern part of the excavated area. One of these at K15 was particularly deep and contained several almost complete pottery vessels. Two mortuary phase 3A burials were found at B11. Burial 36 contained the skeleton of a 20-25 year-old female interred like the others in this cluster with the head to the northeast. Only three bronze finger rings were found associated as grave goods. The adjacent grave, burial 37, contained the remains of a woman who died when aged over 40 years. She wore glass beads, bronze finger rings and an agate pendant. A complete skeleton of a young pig had been placed beyond the cranium. There may well have been a further burial at H8, for a toe bone associated with bronze was recovered there, near two patches of the white burnt rice which so characterised graves at a higher level.

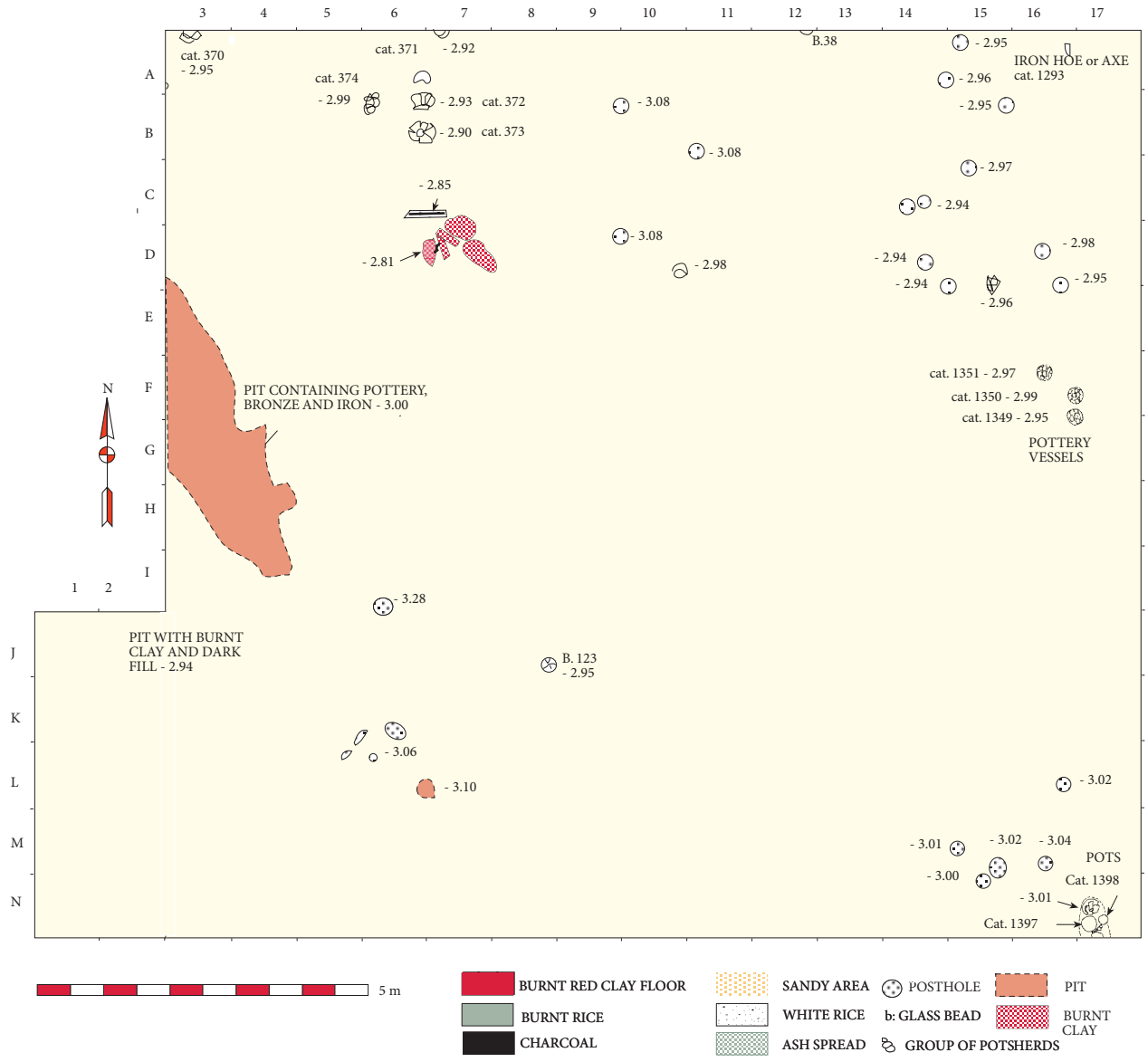


FIG. 6:11 Plan of layer 4:10

There are several signs of occupation in this level. Apart from the postholes, there is a concentration of burnt clay at D7 which looks like the remains of a floor and walls. There are also groups of complete though fractured pottery vessels. One set at B6 incorporated four such pots. It is not impossible that these were infant jar burials, but no human remains were encountered. There is another set of three at F16, while a further example at A12 did in fact contain the skeleton of an infant, and is designated burial 38. A further infant jar burial, B123, was found at J8. Neither included any grave goods. A socketed iron hoe or axe, cat. 1293, was found at A17.

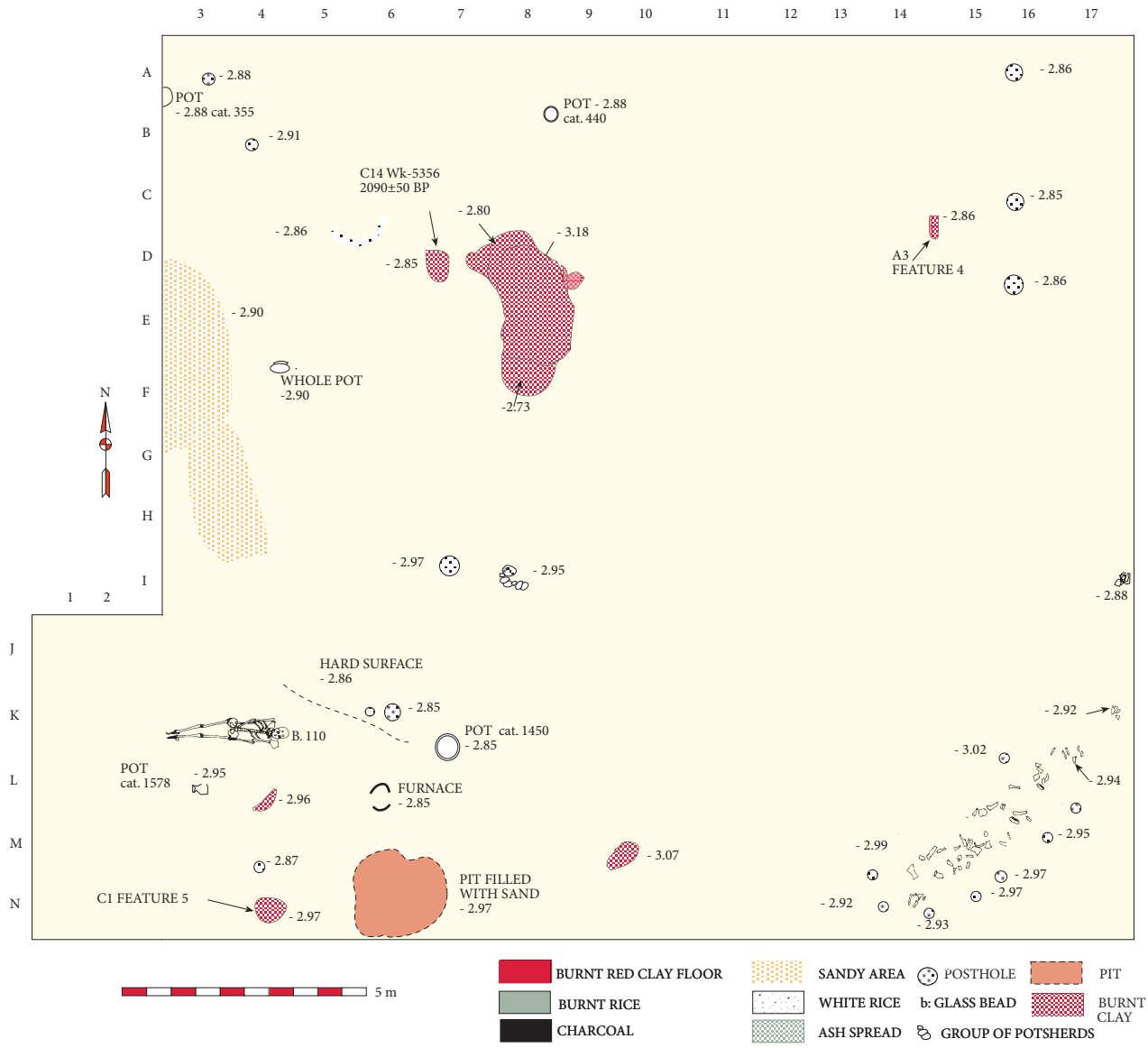


FIG. 6:12 Plan of layer 4:9

There is much evidence for occupational and industrial activity in this level. A rich bone midden located against a row of postholes was found in the southeastern corner of the excavated area. A large and deep pit at N6 was filled with fine sand and located next to a fired clay furnace. It is not impossible that this complex was associated with glass working. There are also several cases where isolated lidded pots were found. This phenomenon has not been satisfactorily explained. No evidence of association with burials has been encountered. At E8, a jumbled complex of burnt clay might well represent the remains of a structure. Many of the pieces of clay have flat surfaces which could represent floors, and others take the form of wall fragments. Charcoal from this structure has furnished a C14 determination of 2090±50 BP. Burial 110 was located at K3-5. It contained a 37-42 year-old female with few grave goods: some fragments of bronze rings, a glass bead and tridacna shell earring.

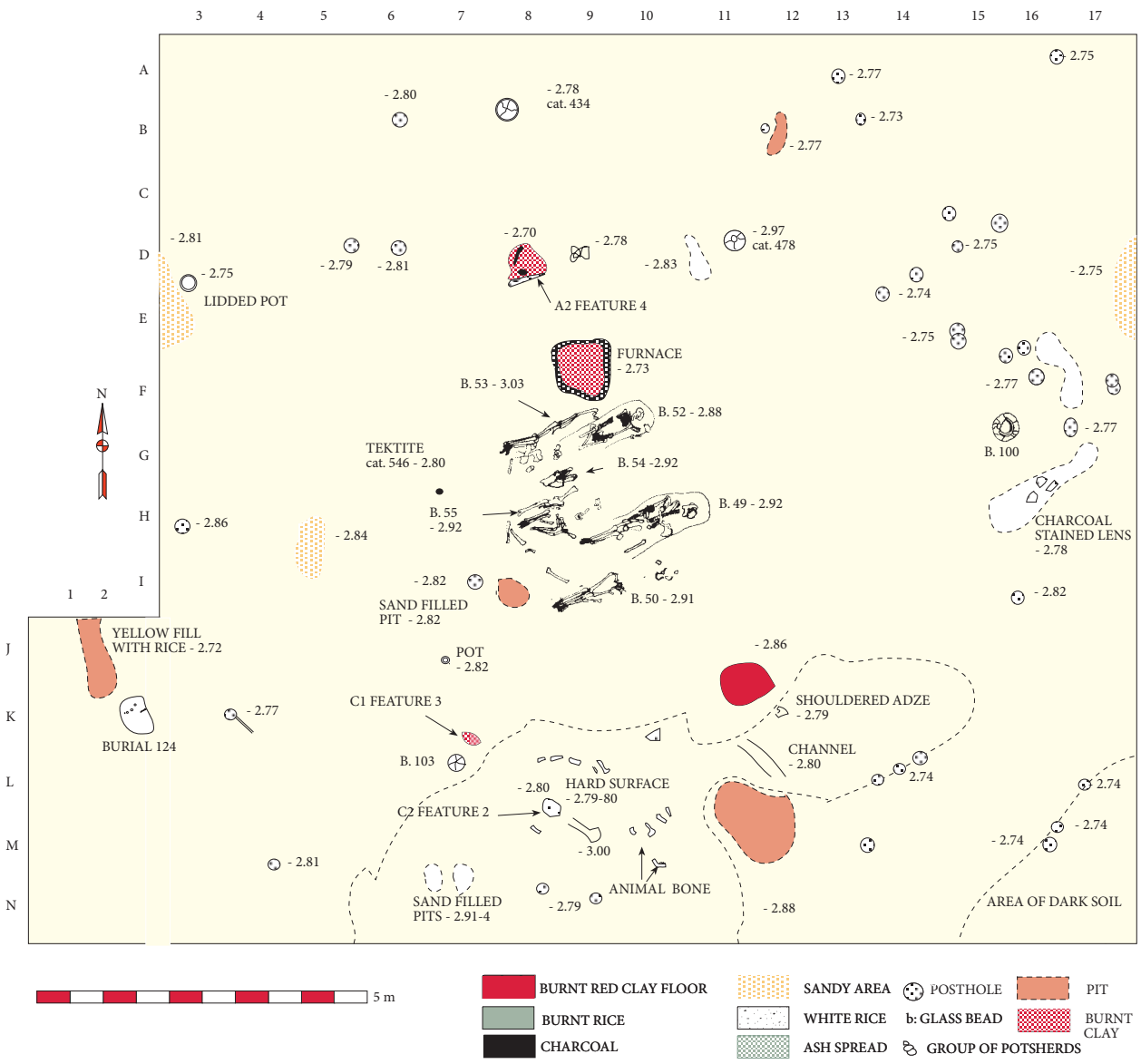


FIG. 6:13 Plan of layer 4:8

There are many signs of occupation activity at this level. A hard surface between N6 and K15 contained many large pieces of animal bone, a stone adze and areas of burning. Two small sand-filled pits were found at N7-8. There was a parallel-sided channel within this surface at L12. A second area with a hard dark surface was found in the southeastern corner of the square. A furnace was present at F9. It incorporated a series of layers of red burnt clay separated by thin layers of asbestos fibres. The latter were probably incorporated to direct the heat generated upwards. Many postholes were traced, and solitary pottery vessels were identified at E1, B6, D11 and J7.

Several burials were cut down to this level. Burial 124 at K2 comprised little more than a human tibia and series of bronze bells. Burial 103 at L7 is an infant burial jar. A third burial might well lie at J1-2, a possible grave cut including white burnt rice, but no human remains was found within. Burial 100 is an infant jar burial. The main group of graves represents part of a major cluster first encountered in layer 4:7. Skeletons were found in close conjunction spatially and in terms of depth. The earlier ones found in 4:8 begin, from the south, with burial 50, a probable male aged 20-25 years at death. Only the lower part of the skeleton remained relatively undisturbed. He was found associated with beads of glass, agate and carnelian, and bronze rings.

Burial 49, located just to the north, was a female aged 35-40 years at death. She, too, was interred with carnelian, glass and agate beads, together with a pig's jaw. Burial 55 is the very disturbed bones of an adult. Two spindle whorls and a glass bead were found in the vicinity. Again to the north, the foot bones of burial 54, another adult, were found in association with bronze anklets embellished with bells. Burial 52 was the relatively complete skeleton of a

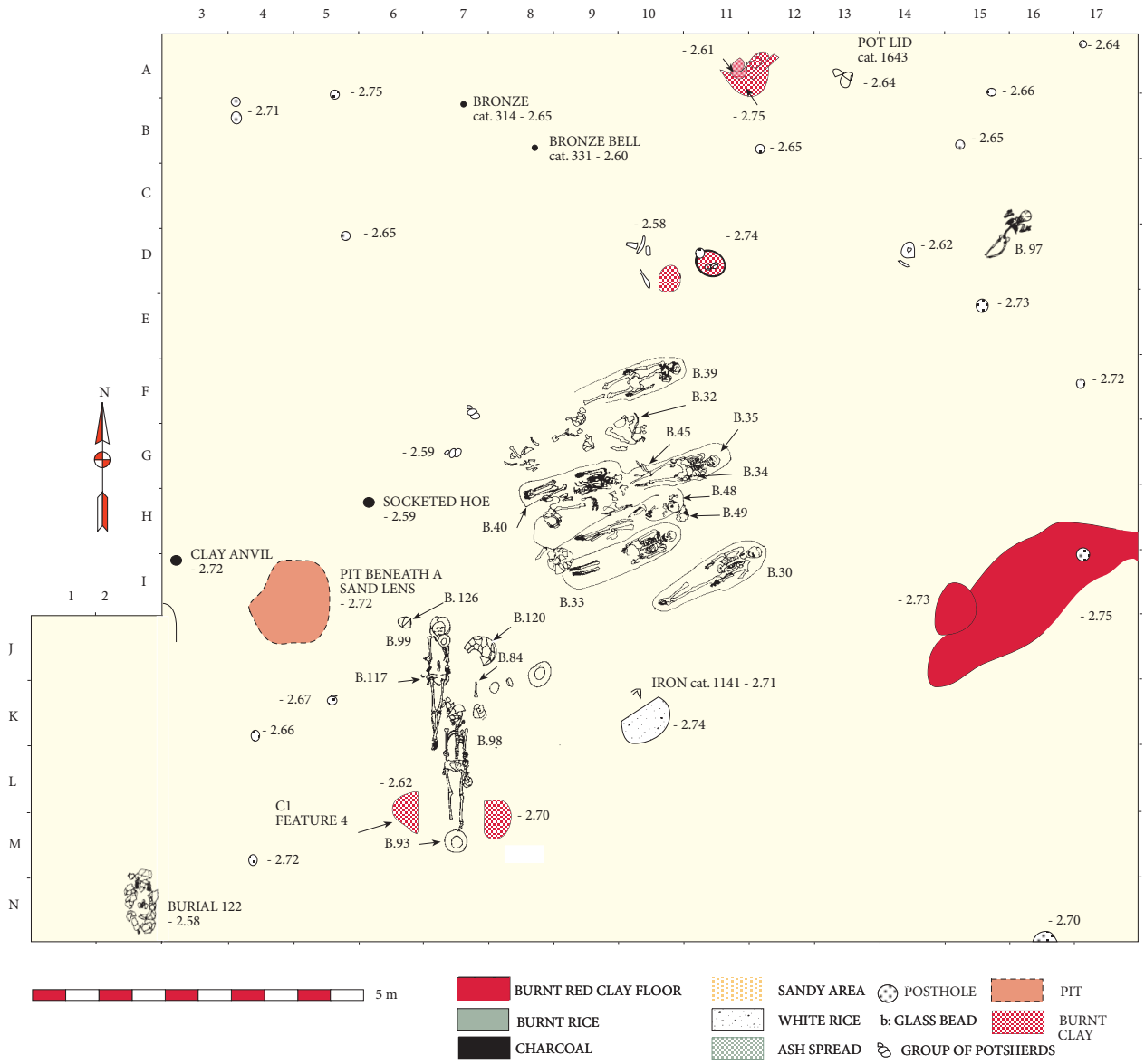


FIG. 6:14 Plan of layer 4:7

female aged over 40 years at death. She was interred with a carnelian bead, two agate neck pendants and glass beads, bronze bangles and a spindle whorl. Finally, burial 53 was that of an adult with carnelian and glass beads, and bronze rings on the fingers and toes.

Layer 4:7

Domestic and industrial activity is evidenced in layer 4:7. A burnt assemblage of clay at M6-7, severed by later burials, might represent the remains of a building. There are also several pits and postholes, a clay anvil at I3 and bronze bell at B8. The principal feature of this level is the number of mortuary phase 3B graves, most containing quantities of burnt rice. The central part of the excavated area was filled with a tight cluster of interments which continued into 4:8 below. From the southeast to northwest, the first is burial 30, a female aged under 25 years at death. Her grave goods included glass and agate beads, an agate pendant, a young pig's skull, bronze bangles and spiraliform bronze earrings. Burial 33 contained probably a male aged between 25-30 years. He, too, wore an agate pendant and glass beads, as well as a bronze bangle, while the grave fill included a spindle whorl. Burial 49, a female aged 35-40 years, was very fragmentary, having been disturbed by burial 48. The latter was relatively intact and contained a female aged between 25-30 years. She was associated with carnelian beads, a spindle whorl and a bronze bracelet. Burial 35 is that of a 35-40 year-old female. She wore an agate pendant, agate and glass beads and bronze bangles, finger and ear rings. Three spindle whorls were also found in association. Burial 34 comprised only an infant or child's cranium resting on this woman's left forearm. Burial 45 contains the fragmentary and incomplete remains of probably a man aged about

25-30 years. Burial 40, a 35-40 year-old woman, was found relatively intact, together with two spindle whorls, an agate pendant, a glass bead, bronze bangles and the skeleton of a pig. Burial 32, that of a 35-40 year-old male, was very disturbed and some of the grave goods found in the area of the human bones might not be in firm association. Thus, seven spindle whorls were recovered. The carnelian and glass beads in the neck area, albeit in the absence of a cranium, are probably associated. Finally, burial 39 was that of a male aged 20-25 years, who was found in association with bronze finger rings, a glass bead necklace and a large spiraliform bronze ear ornament. It is noted that not one pottery vessel was found in primary asociation with these burials, which include men to women in the ratio of 5:4.

There is a second cluster of graves comprising mortuary phase 4B, orientated with the head to the north, at K7. Burial 98 involves a male aged over 40 years. He was interred with a pottery vessel partially over his head and another just to the left of the cranium. Two spindle whorls were in place on the left shoulder, and he wore bronze bangles, ear- and finger rings. An iron knife lay at his left hand, over another pottery vessel. Burial 93, an infant jar burial, lay beyond his feet. Burial 99 lay on the same orientation and just to the north. This woman, aged over 40 years, wore an agate pendant, bronze bangles and earrings, and was associated with at least four spindle whorls. Her head lay within a large pottery vessel, and another vessel had been placed on her left shoulder. She was surrounded by the remains of three infants, burials 126, 84 and 120, while the mandible of a child, burial 117, lay on her right hip.

The grave of a 3-9 month-old infant was found at N2, and this burial clearly belongs to the cluster which was found in this part of the site. At least seven pottery vessels ringed the skeleton, and jewellery included an agate pendant, and bronze foot, toe, ear and armrings.



FIG. 6:15 This burnt clay floor was uncovered at B3 layer 4:10. The burnt clay and charcoal can clearly be seen at bottom left. Burial 90, and infant jar burial, is visible at the top left of the picture

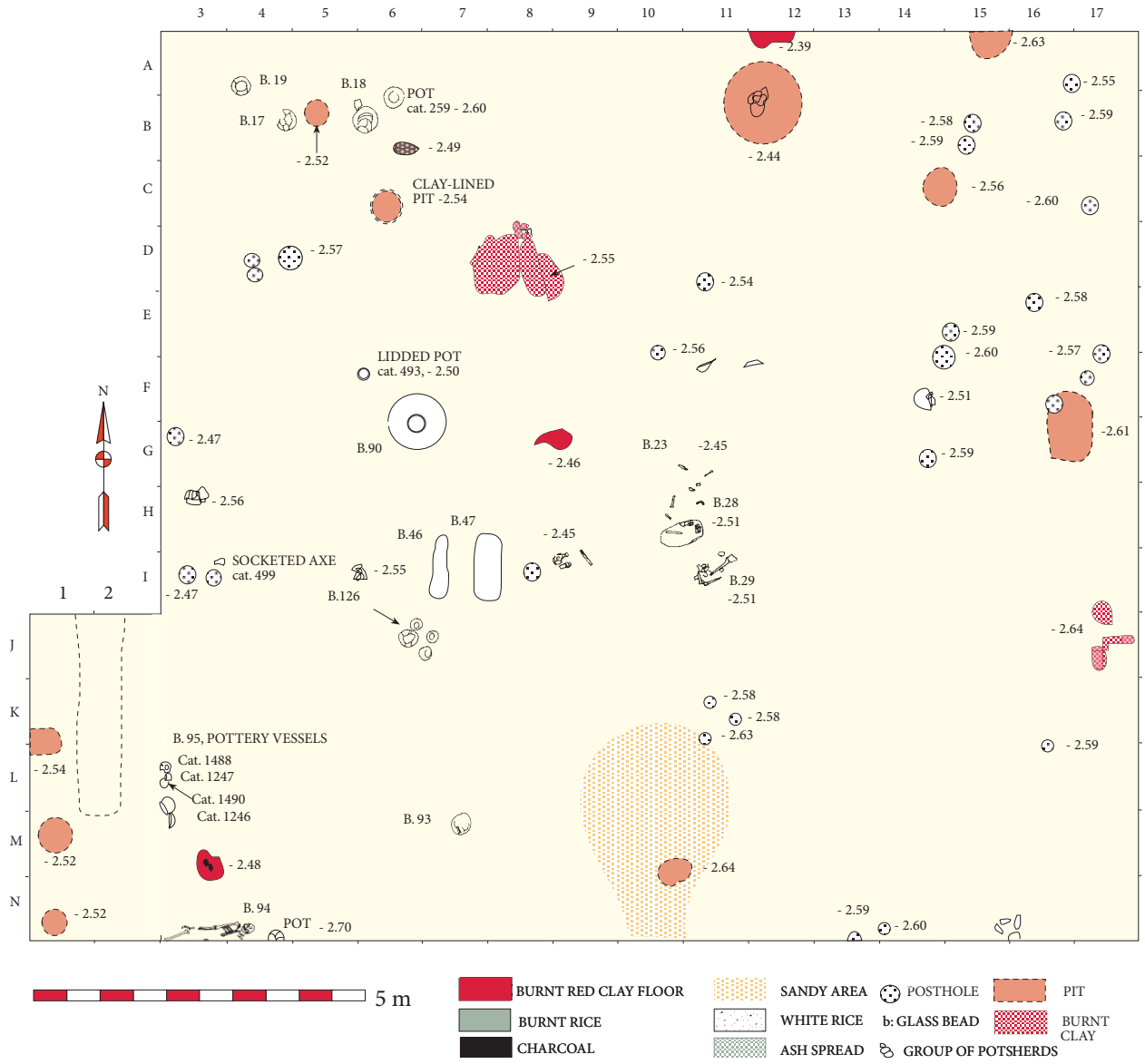


FIG. 6:16 Plan of layer 4:6

The considerable number of postholes at this level, in conjunction with the remains of a burnt clay structure at D8 and a number of pits, indicate an occupation layer. However, many burials were also cut down to this context. At A4-6, three infant burials jars were found in a group with no clear association with adults. A further jar burial was found at G7. The two jar burials 93 and 126 lie in the area of a cluster of inhumation graves two of which are seen as burials 46-7. Both incorporated burnt rice and the human remains were very poorly preserved. The former contained a child aged between 1.5-4 years at death.

A line of pottery vessels at L2 was associated with burial 95. A probable grave sillhouette was visible at JL 1-2. A further major cluster of burials centred at G9 was first encountered in this level with the discovery of burials 22-3, 28 and 29. These were all associated with burnt rice and human remains were poorly preserved, if evident at all. Burial 22 incorporated a child aged 3-5 years. Burial 23 included some glass beads. Burial 28, which to judge from its size can only have contained an infant, was found to contain the articulating phalanges of a water buffalo, potsherds which may belong to a complete vessel, a spindle whorl and some pig's bones. The 3-6 year-old child in burial 29 was associated with a spindle whorl, glass beads and a bead of agate.

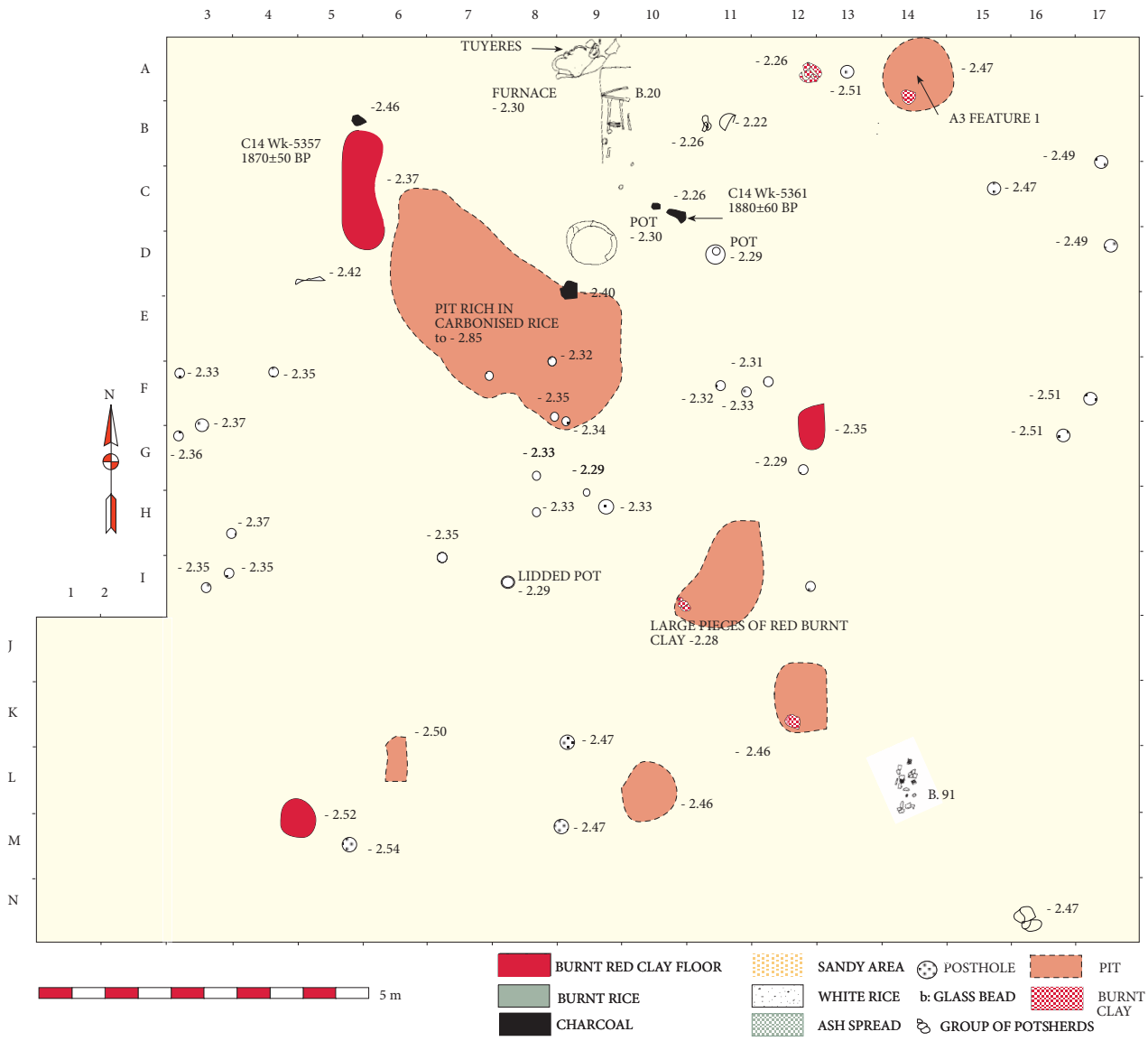


FIG. 6:17 Plan of layer 4:5

This level contains much evidence for occupational activity. There is a series of hearths in the northern part of the excavated area, two of which have provided radiocarbon results of 1870±50 and 1880±60 BP. They lie alongside a large and deep pit which contained many carbonised rice grains. The remains of a burnt clay wall or structure of some sort on the northern edge of this pit suggest that it might have been contained as a rice store. A furnace was enountered at A9, with heavily-burnt red clay and tuyeres. A large pottery vessel, one of several found in this level, lay at D9, just north of the rice pit. It did not have any visible contents.

Burial 91 at L14 contained the remains of an infant aged approximately 3 months. Grave goods included two pottery vessels and bronze bangles, anklets and an ear ring, an agate pendant and bivalve shellfish. The poorly-preserved burial 20 at B9-10 was associated with bronze rings, a bangle and a circular agate bead or stud.

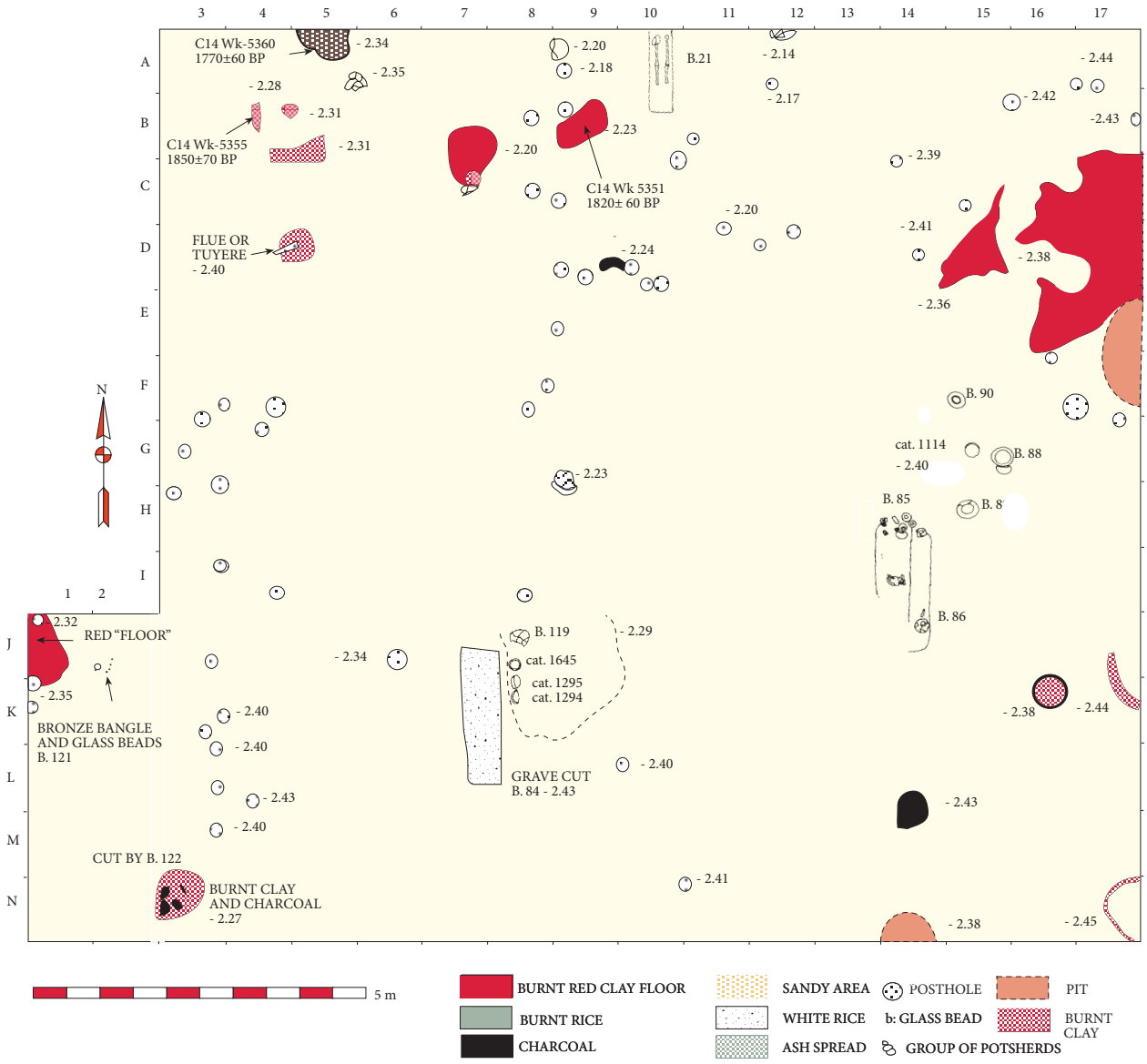


FIG. 6:18 Plan of layer 4:4

This level incorporates much evidence for occupation. At C-E 15-17, there is a reasonably large exposure of burnt clay floor which probably comprised part of a domestic structure. Another area of floor lay at J1. There are also several pits one of which, at K8, contained several complete pottery vessels and much carbonised rice. Three of the many hearths or other concentrations of charcoal have been radiocarbon dated to 1850, 1820 and 1770 BP. Several mortuary phase 4C burials were cut down to this level. Burials 85-6 are part of a larger cluster, both involving graves filled with burnt rice. The former contained the remains of neonate associated with a rich array of grave offerings which included several whole pottery vessels, glass beads, bimetallic (bronze and iron) bangles and an iron blade. Burial 86, that of a 25-30 year old male, also included a wide range of offerings foremost of which was a socketed iron spade found in a pottery vessel filled with rice. There was also an agate pendant, glass beads, several further pottery vessels, bronze rings and an iron knife. Three infant jar burials lie adjacent to these inhumation graves.

At K7, the outline of the grave for burial 84 is evident, and burial 119, a further infant jar burial, is located just to the northeast.

Burial 21 lies at A10, and is only partially present within the excavated area. Grave goods include glass beads, a pottery vessel and bronze items represented only as fragments.

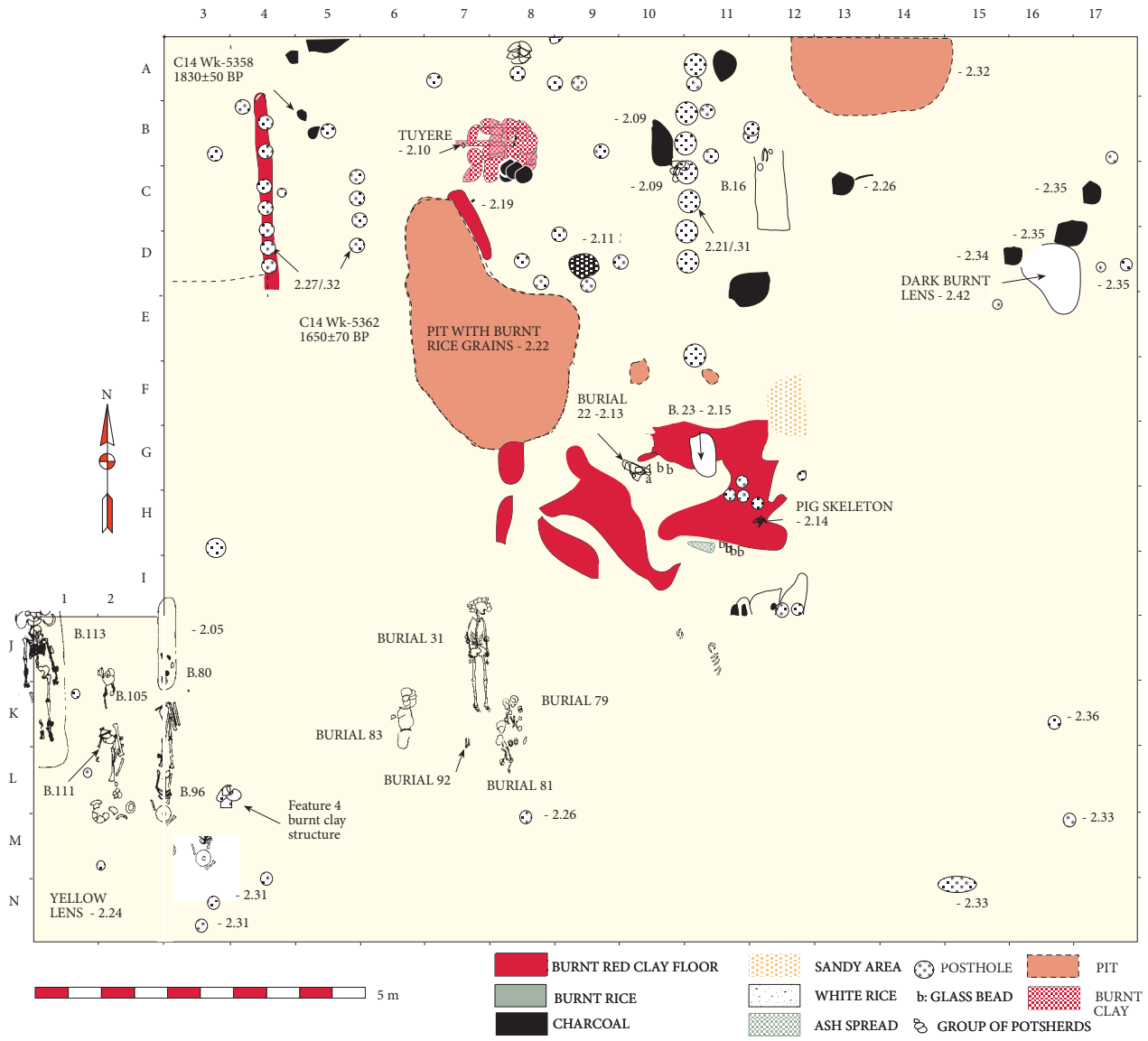


FIG. 6:19 Plan of layer 4:3

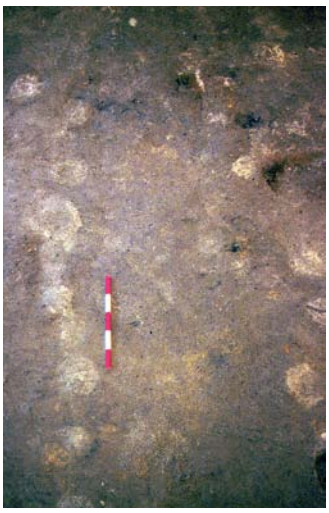


FIG. 6:20 The clay wall and postholes seen in the above plan in square A1

Layer 4:3 contained the most complex and structured occupation remains found. Normally, postholes fail to reveal a clear pattern, but in this instance, three or four sets of postholes are set out in rows. Moreover, that from A-D4 was associated with a line of clay which takes on the form of a timber-reinforced clay wall. A second row of postholes, two metres to the east, runs parallel to this set, both having a north-south orientation. A third row on a similar bearing starting at A10 comprises much bigger posts. Definition of the size and nature of the buildings represented would require the excavation of the area lying to the north. A deep pit begins at this layer, and its contents included much carbonised rice. A sample of this has been radiocarbon dated to 1650±70 BP. Two other samples from this layer have also been dated to 1830±50 and 1850±70 BP. The difference between the date obtained

from rice and those from charcoal is interesting, in that the former will have no or little inbuilt age whereas the latter could come from old wood. An extensive area of burnt clay floor lies southeast of this pit. Many potsherds lie on the surface, which also includes much ash, a pig's skeleton, dog's mandible and other animal bones. Burial 23 appears to have been cut through this floor from a higher level. This layer also includes many charcoal concentrations and furnaces, one at B7 having a clay tuyere entering it from the west.

There are also burials from two clusters. In the area J-H 1-2, burial 113, a female aged 25-30 years, lies only partially within the excavated area. She was one of the richest interments encountered, having a necklace of gold and agate beads, silver finger and toe rings, bronze anklets, bangles, ear, toe and finger rings, a bimetallic ring, agate pendant, iron blade and many pottery vessels. Burial 105 lay adjacent and on the same north to south orientation. This grave contained an adult male also with rich grave goods, including a silver bangle, glass beads, parts of a bronze belt, bronze toe rings, a spindle whorl and pottery vessels. Burial 96, that of an adult, was found in a rather disturbed condition, but nevertheless incorporated parts of abronze belt and torc, bronze finger rings, bells, armlets, earrings and bangles, glass beads, an iron blade and pottery vessels. Burial 80 was also found in a disturbed condition, but the grave goods included bronze anklets and bangles, glass and agate beads, a spindle whorl and a pottery vessel.

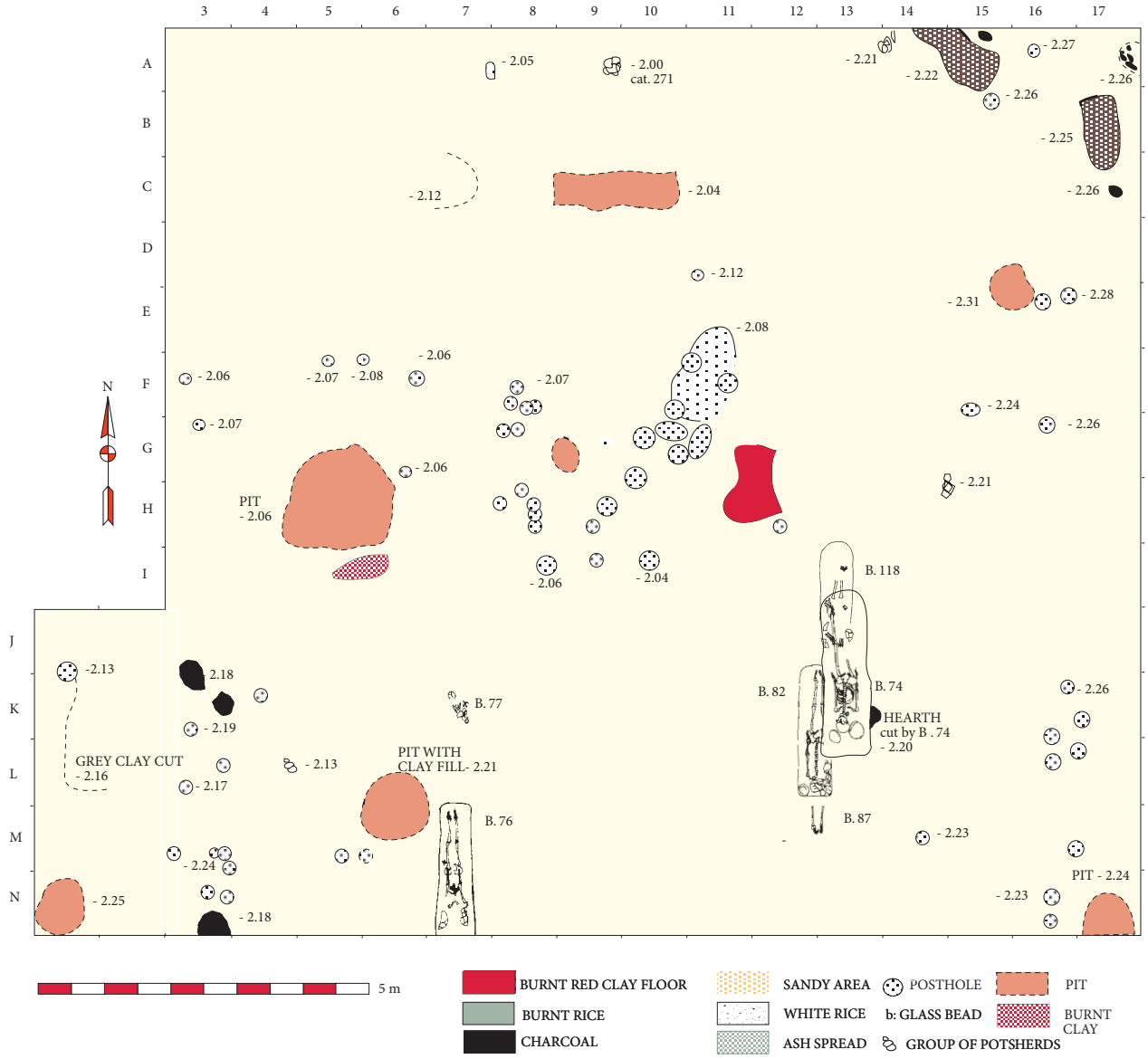


FIG. 6:21 Plan of layer 4:2

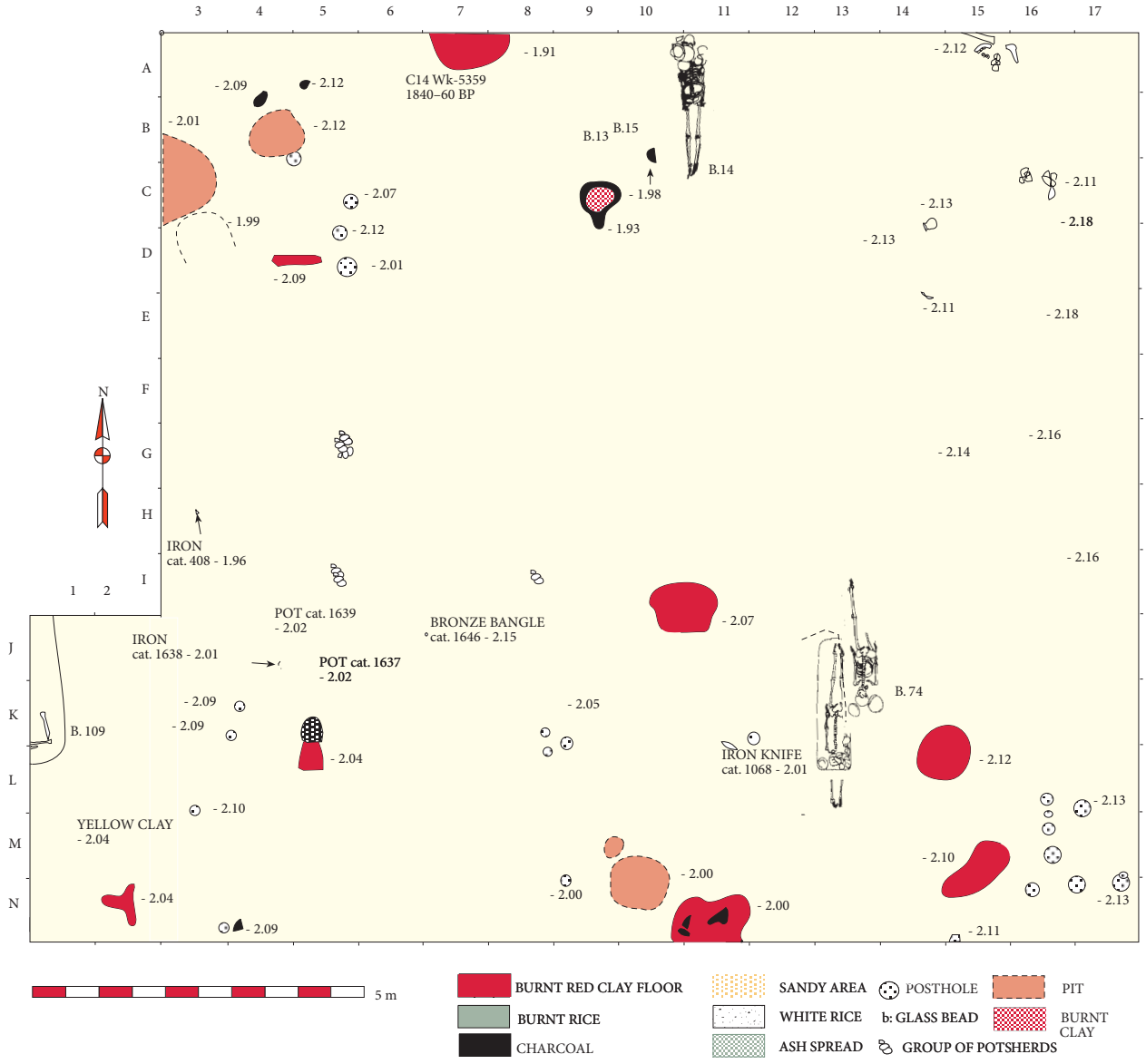


Fig. 6:22 Plan of layer 4:1

The second cluster of interments lay four metres to the east and on the same north to south orientation. Burial 31, that of a child aged about 12 years at death, was associated with bronze finger and earrings, bangles and a pottery vessel. An egg, the size of a duck or hen's egg, was found beside the pelvis. Burial 83 included two pottery vessels and glass beads in a rice bed grave, but no identifiable human remains. Burials 92, 79 and 81 were of infants. None was interred in the customary mortuary jar. The first was very fragmentary but the other two were found complete. Burial 79 included as grave goods bronze bangles, a ring, anklets, two bivalve shellfish and a whole pottery vessel. The infant had died when aged between 3-9 months. Burial 81 was that of a neonate interred with glass beads, bronze anklets and bracelets, finger rings and a ceramic bowl placed over the skull.

Occupational remains are seen in layer 4:2 in the form of concentrations of postholes, particularly in the vicinity of H8, hearths, pits and ash concentrations. Several burials were also cut down to this layer. Burial 78 at K3 contained a 30-35 year-old adult. While the grave cut was very clear, the burial itself was bundled into a tight concentration of bones. Glass beads, a bronze spiral earring and fragments of bronze rings were found in the vicinity of the bones. Burial 76 at N7 involved an adult aged 35-40 years, interred with two pottery vessels, a spindle whorl, iron knife, bronze finger rings and a bronze earring. To the east, four graves comprising part of a cluster C of mortuary phase 4 were found at K13. Burial 118 was poorly preserved, but grave goods were numerous. A rare circular carnelian bead lay in the neck area, as did two sets of unique iron implements or ornaments. There were many bronze bangles and finger and toe rings and two pottery vessels. This skeleton had been disturbed with the interment of burial

74, probably that of a male aged from 25-30 years. He was accompanied by three pottery vessels, glass beads, a bimetallic ring and a toe ring. Burial 87 had been disturbed by the grave of burial 82, that of a 35-40 year-old woman. The latter was buried with at least four pottery vessels, a spindle whorl, bronze bangles, an ear ring and toe rings.

The surface of layer 4 was recognized for its much darker colour and less sandy texture than layer 3 above. The uppermost context included much evidence for occupational activity, including postholes, pits, hearths and a clay-lined furnace filled with white ash at C9. Charcoal from a nearby feature at A7 furnished a radiocarbon determination of 1840±60 BP. Three inhumation burials were dug down to this level. Burial 74 contained a 35-40 year old adult, associated with two pottery vessels, a spindle whorl, iron knife and bronze finger and toe ring. Burial 14 is among the richest found at Noen U-Loke. It involved a 35-40 year-old man whose weight of bronze jewellery was remarkable. He wore 75 bronze bangles on each arm, and three bronze belts. There were numerous bronze toe and finger rings and ear coils were made of silver under gold foil. An agate pendant lay at his neck, while glass beads were found in the area of the head and ankles. An iron knife lay beside his left hand. Many pots were placed beyond the head and upper torso. Beside him lay the disturbed remains of a woman of similar age and an infant who died when about three months old. The last grave contained two agate pendants, a mass of glass beads, a bronze bangle and part of a bronze ear ring, a whole pottery vessel and a possible iron spear. Part of what looks like an infant jar burial was also contained in the area of burial 13.



FIG. 6:23 Noen U-Loke incorporated many pits, which contained complete or virtually complete pottery vessels. This example comes from C2 layer 4:10. Their function is not known. They may simply have been rubbish pits, but the fine ceramics found within hint at a ritual function, perhaps associated with the burials



FIG. 6:24 The surface of layer 4:9 in square C3 was dominated by a bone midden containing in the main, the remains of cattle



FIG. 6:25 The clay floor in square B2 layer 4:3. For a close up, see below

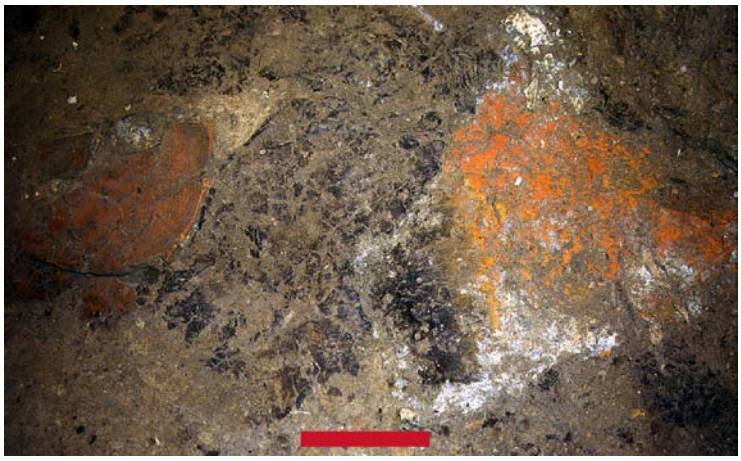


FIG. 6:26 A close up view of the burnt clay "floor" in square B2 layer 4:3 reveals a thick deposit of charcoal and a pottery vessel. Scale 10 cm



FIG. 6:27 A row of massive and deep postholes was encountered in square A2 layer 4:3. Two rice bed graves, burials 20 and 21, can be seen in the foreground



FIG. 6:28 This hearth in square A2, has been sectioned to reveal the quantity of charcoal and the white ash in the centre. This is an excellent and typical source of radiocarbon dating samples at Noen U-Loke. Scale 10 cm

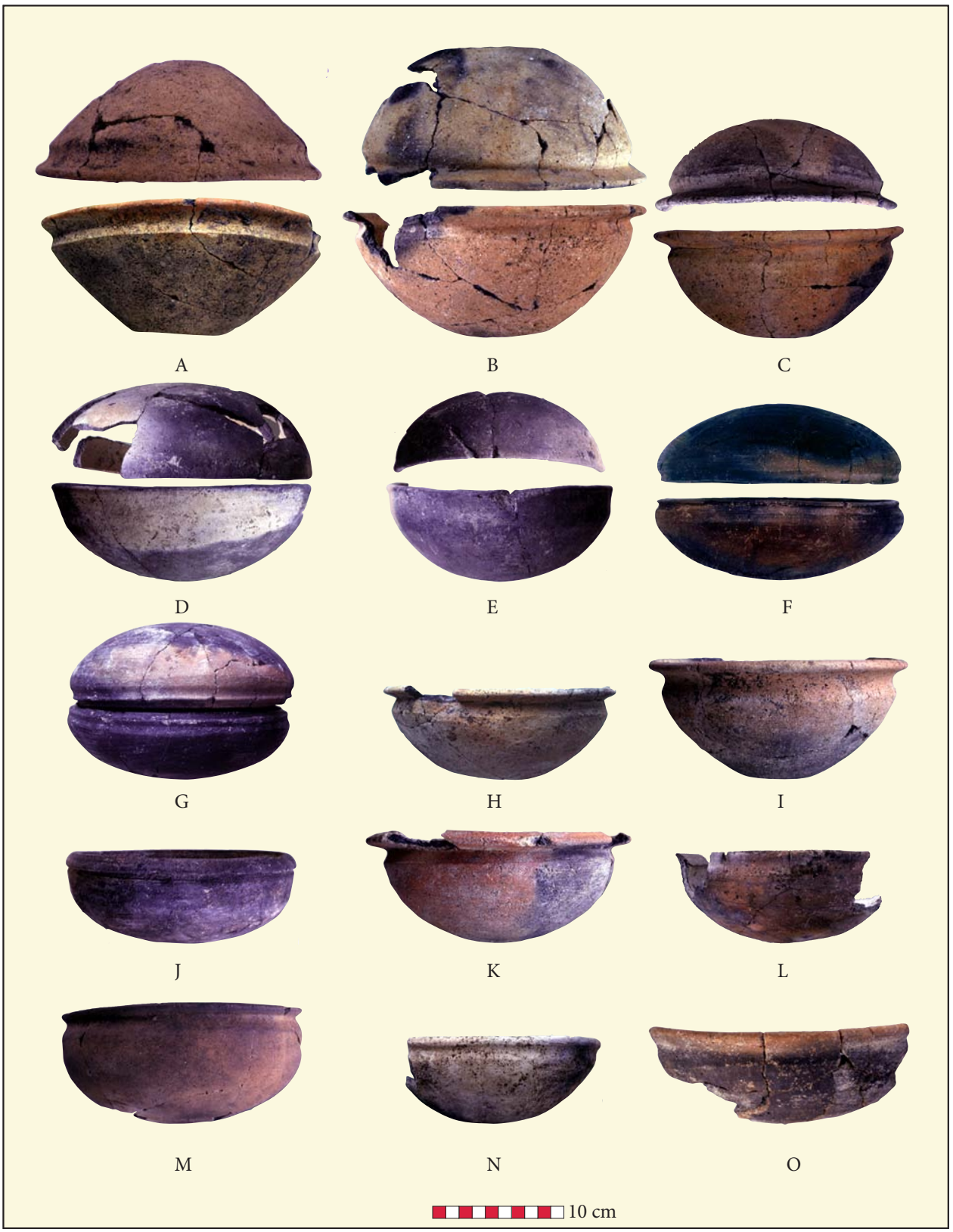


FIG. 6:29 Pottery vessels from layer 4. A. cat. 1449&1450 C1 4:9 F7, B. cat. 1903 a&b A1/B1 4:8 F. 1, C. cat. 439&440 A2 4:9 F.1, D. cat. 1731 a&b B1/C1 4:6, E. cat. 1899 a&b B1 4:6 F.1, F. cat. 1907 a&b B1 4:1 F.4, G. cat. 1639 a&b B1/C1 4:1, H. cat. 433 A2 4:8 F.5, cat. 438 A2 4:8 F.7, I. cat. 434 A2 4:8 F.5, J. cat. 302 A2 4:3, K. cat. 438 A2 4:8 F.7, L. cat. 1904 B2 4:7 F.3, M. cat. 391 B2 4:6 F.1, N. cat. 1200B A1 4:6, O. cat. 1729 B1/C1 4:6



FIG. 6:30 Pottery vessels from layer 4. A. cat. 270 A2 4:3 F. 16, B. cat. 268 A2 4:1, C. cat. 63 A1 4:1 F.1, D. cat. 1111 B3 4:4, E. cat. 1900 F. cat. 1400 C3 4:10 F.2



FIG. 6:31 Pottery vessels from layer 4. A. cat. 437 A2 4:8 F.7, B. cat. 1124 A3 4:1, C. cat. 1401 C3 4:10 F.1, D. Cat. 332 A2 4:5 F.5

VII. THE SEQUENCE DURING LAYERS 3 AND 2

C.F.W. HIGHAM AND RACHANIE THOSARAT

DATING LAYER 3

There are only two radiocarbon determinations from layer 3 contexts, due to the rarity of *in situ* charcoal (Figs 7:1-2). More are needed before this vital layer is properly dated. The two available results, however, suggest that this layer accumulated within the period 250-650 AD.

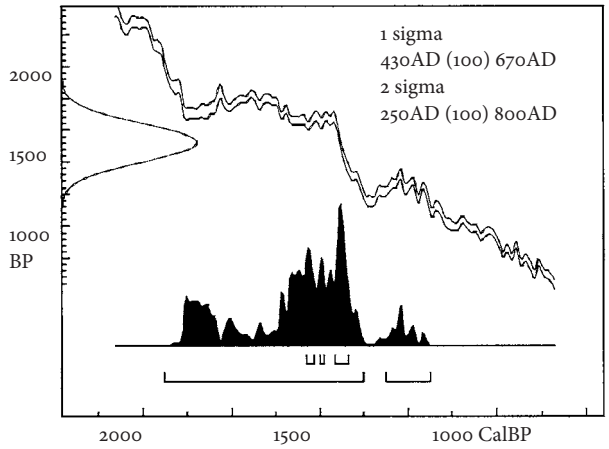


FIG. 7:1 The radiocarbon determination Wk-5363 from A1 layer 3:2 feature 4

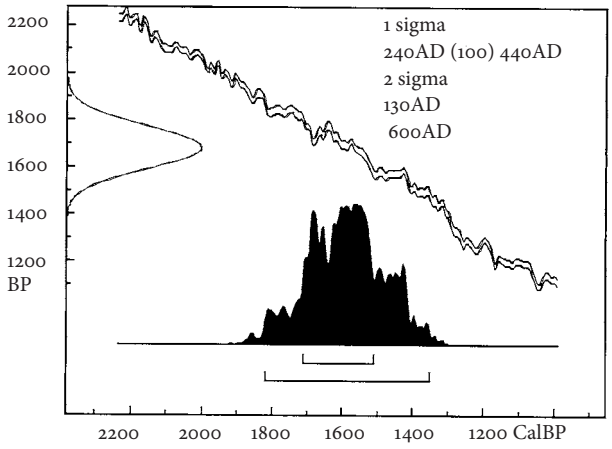


FIG. 7:2 The radiocarbon determination Wk-5352 from A2 layer 3:2 feature 2



FIG. 7:3 Layer 3 incorporated many remains of industrial or occupational activity. This illustration shows two circular areas of burning, notable for the red scorched clay and ash. They have been severed with a clay-lined pit, A3/B3 3:11 feature 3, containing excellent examples of black burnished pottery



FIG. 7:4 The pit above contained fine black-burnished pottery vessels. Scale 10 cm

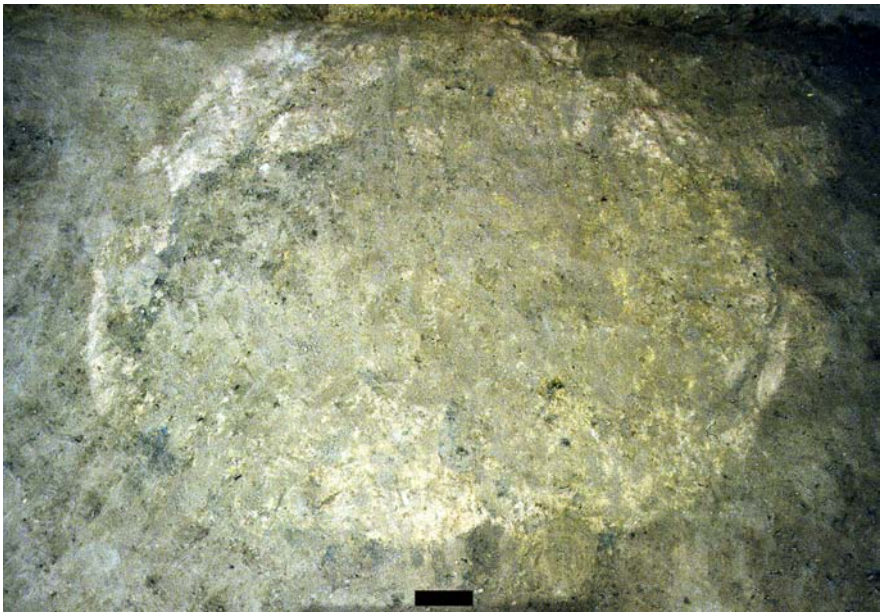


FIG. 7:5 This circular clay covered pit was discovered in C3 layer 3:14, at a depth of 2.04 m. It lay adjacent to the foot of the clay-capped grave of burial 75, and can be seen to sever two postholes. Its proximity to burial 75 suggests a possible mortuary function. Scale 10 cm

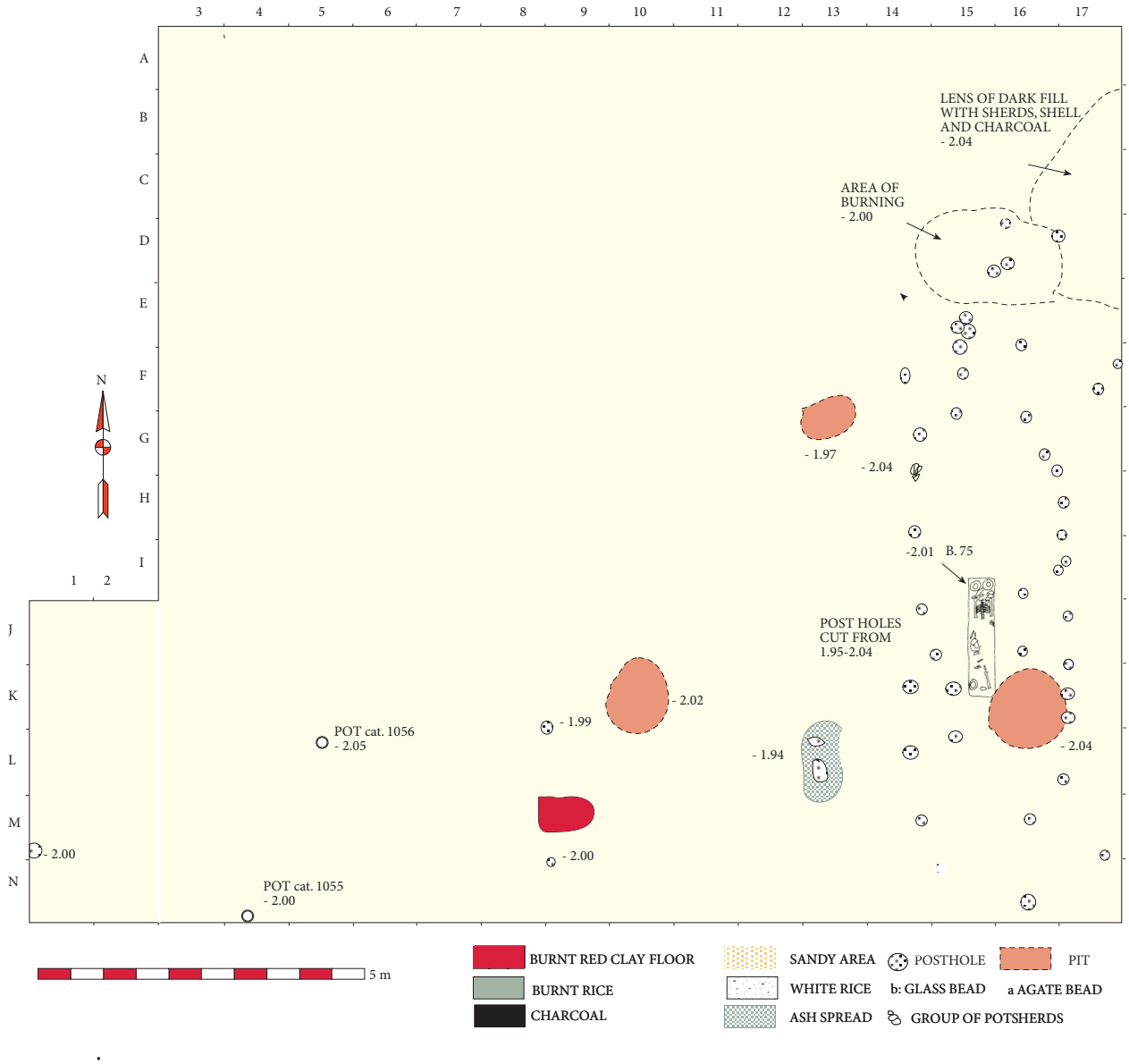


FIG. 7:6 Plan of layer 3:14

Because layer 4 tended to be encountered at a higher level to the northwest of the exavated area while much activity was represented in lower layer 3 to the east and south, a more fine-grained appraisal of the remains in the latter may be presented. In basal layer 3 in the southeastern area, the grave cut for burial 75 was seen as a rectangle of clay, suggesting that the burial had been deliberately capped. The human remains of a young adult aged between 16-20 were, unfortunately, found to be rather disturbed. Burial goods included five complete pottery vessels, an iron blade and a bronze earring. A further feature of this grave was the surrounding oval configuration of postholes which were dug from the same layer as the grave. Thus, the clay capping for the grave was found at a depth of -2.01 m while the human bones rested at -2.48 m. The post holes were dug between -1.99 and -2.04 m below datum, and reached a maximum depth of -2.63 m. An area of burning with many sherds, shellfish and charcoal remains was found to the northeast of this mortuary comples. Two lidded vessels were found at N4 and L5.

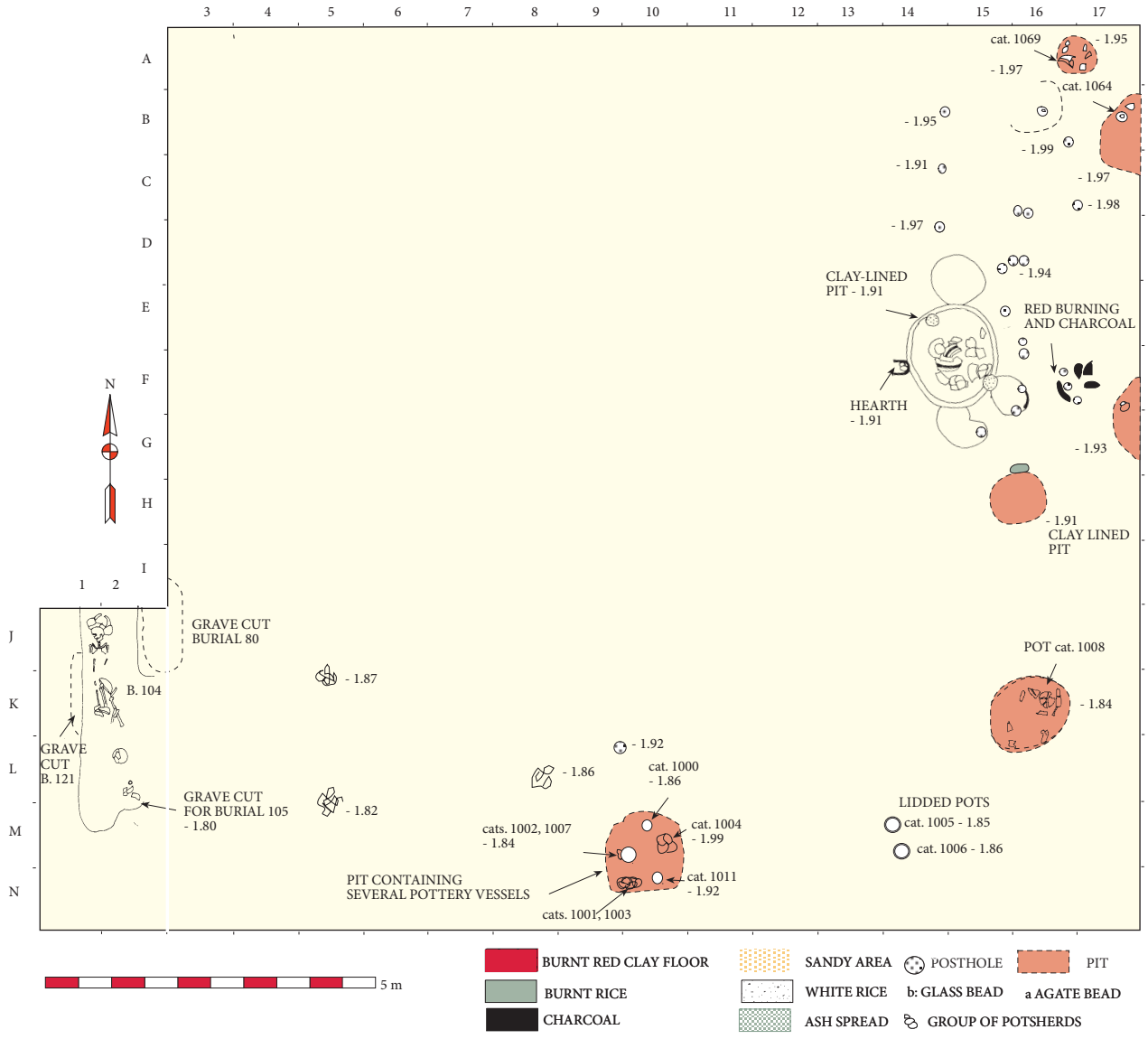


FIG. 7:7 Plan of layer 3:13

The southeast corner of the excavated area included two pits containing complete pottery vessels and a number of postholes. Burial 104, mortuary phase 4 cluster A, was found at K1. The woman aged between 25-30 years was accompanied by at least five pottery vessels, three agate pendants, glass beads and bronze and bimetallic rings.

There is a concentration of hearths or furnaces at F15. These are characterised by charcoal and much white ash, surrounded by soil burnt red. A circular pit had been cut through these furnaces. Clay lined, it contained a concentration of complete pottery vessels (cats. 1027, 1028, 1030, 1036, 1037). There are three further pits containing whole pottery vessels at B16-17, and a concentration of postholes.

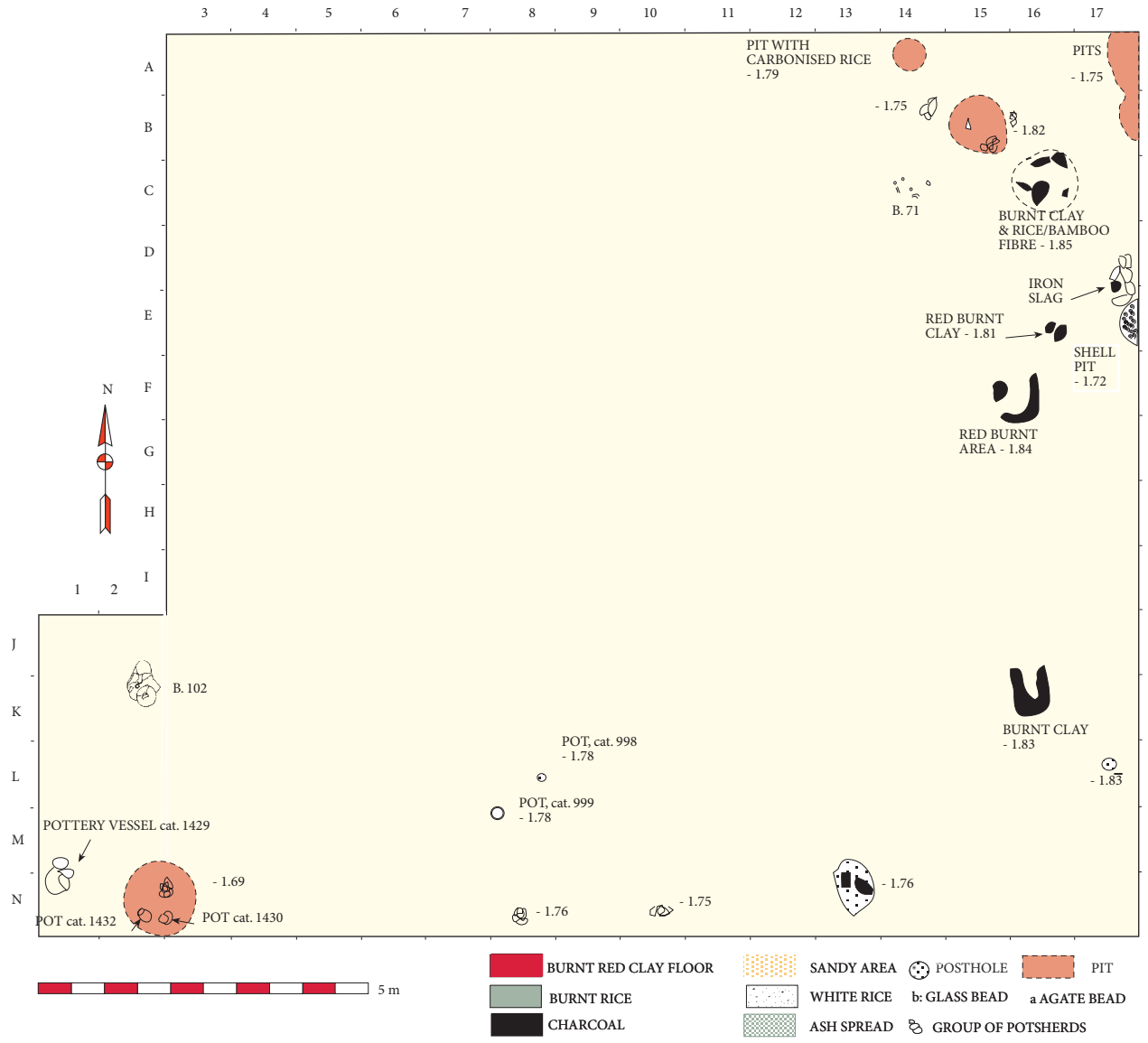


FIG. 7:8 Plan of layer 3:12

There is much evidence for industrial activity involving considerable heat in the northeastern part of the excavated area. One furnace at D17 has a plug of iron slag within, suggesting that iron smelting or forging was being undertaken. This lies adjacent to a number of pits one of which was rich in shellfish remains. A further burnt clay feature is seen at K16.

Two complete lidded pots are present at L8-9. A pit containing at least two complete pots is found at N2, and a pottery vessel in the form of an infant mortuary jar is seen at N1. Just to the north lies burial 102. This infant jar burial contained, as mortuary offerings, a whole pot, glass beads and a large number of bronze rings or bangles. The only other burial in this level lies at C14. Burial 71 was probably a neonate associated with two or three pottery vessels, bronze and bimetallic rings, an iron knife and a glass bead.

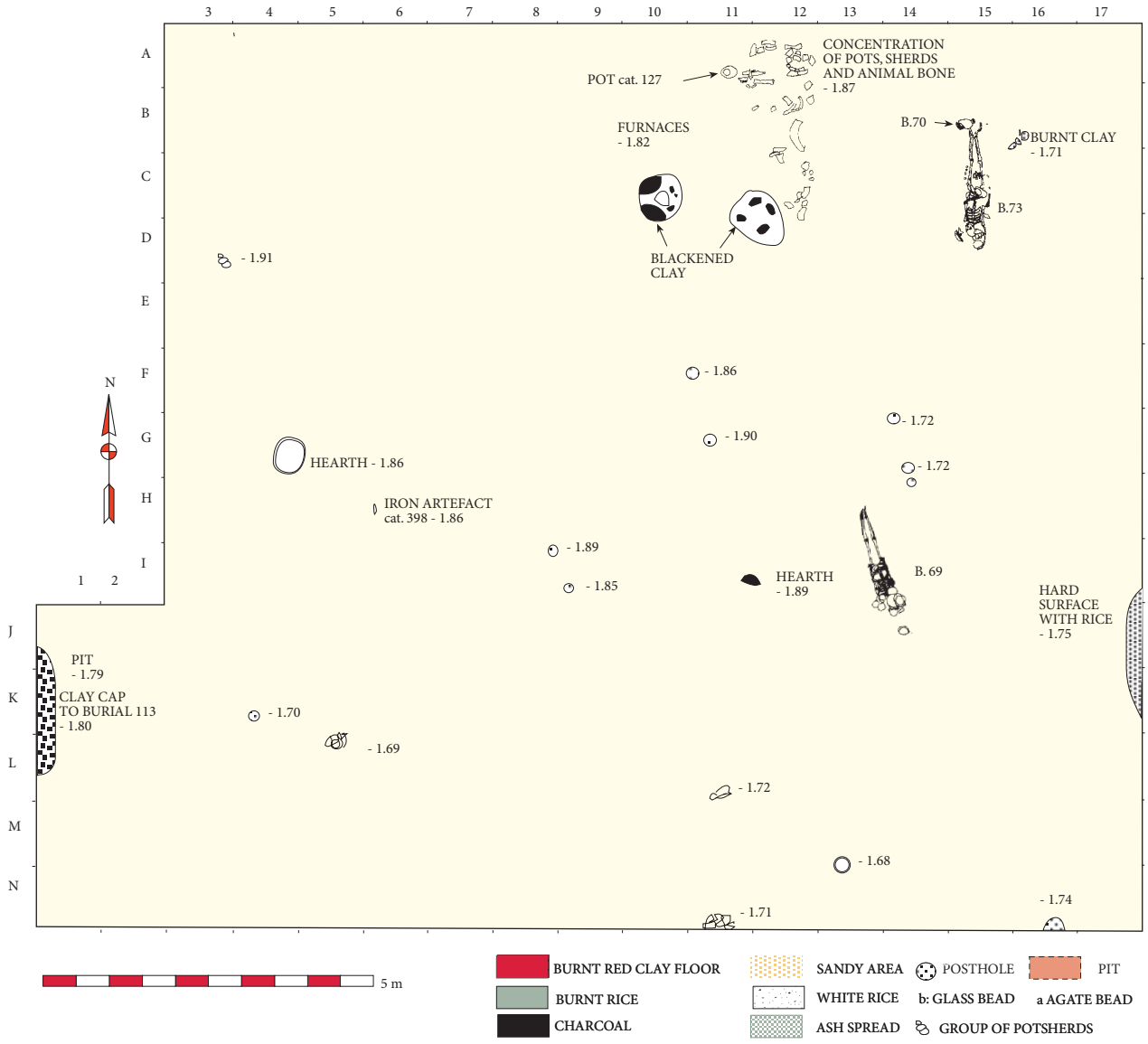


FIG. 7:9 Plan of layer 3:11

There are two futher furnaces at C10 and D11, which were probably associated with the working of iron. At A-B 11-12, there is a marked concentration of large animal bones and potsherds. Mortuary phase 4C burials 69, 70 and 73 are found at this level.

Burial 69 contained the complete skeleton of a man aged 25-30 years at death. He was richly endowed with grave goods, most notably by wearing four bronze belts and two very large ear spools which were presumably set into distended ear lobes. He also wore many bronze bangles, toe and finger rings. An iron blade, together with at least five pottery vessels were present in the vicinity of the cranium. Two bimetallic rings were recovered, one from the upper left femur and the other near the chin. This is one of the wealthiest graves found in terms of grave goods, although only one glass bead was found.

Burial 70 was that of a child aged 4-10 years. Three bimetallic rings were found in the vicinity of these rather disturbed remains which lay at the feet of an adult aged 35-40, burial 73. Again, only one glass bead was found, but there were three pottery vessels beyond the head, many finger and toe rings, an iron knife, and an agate pendant.

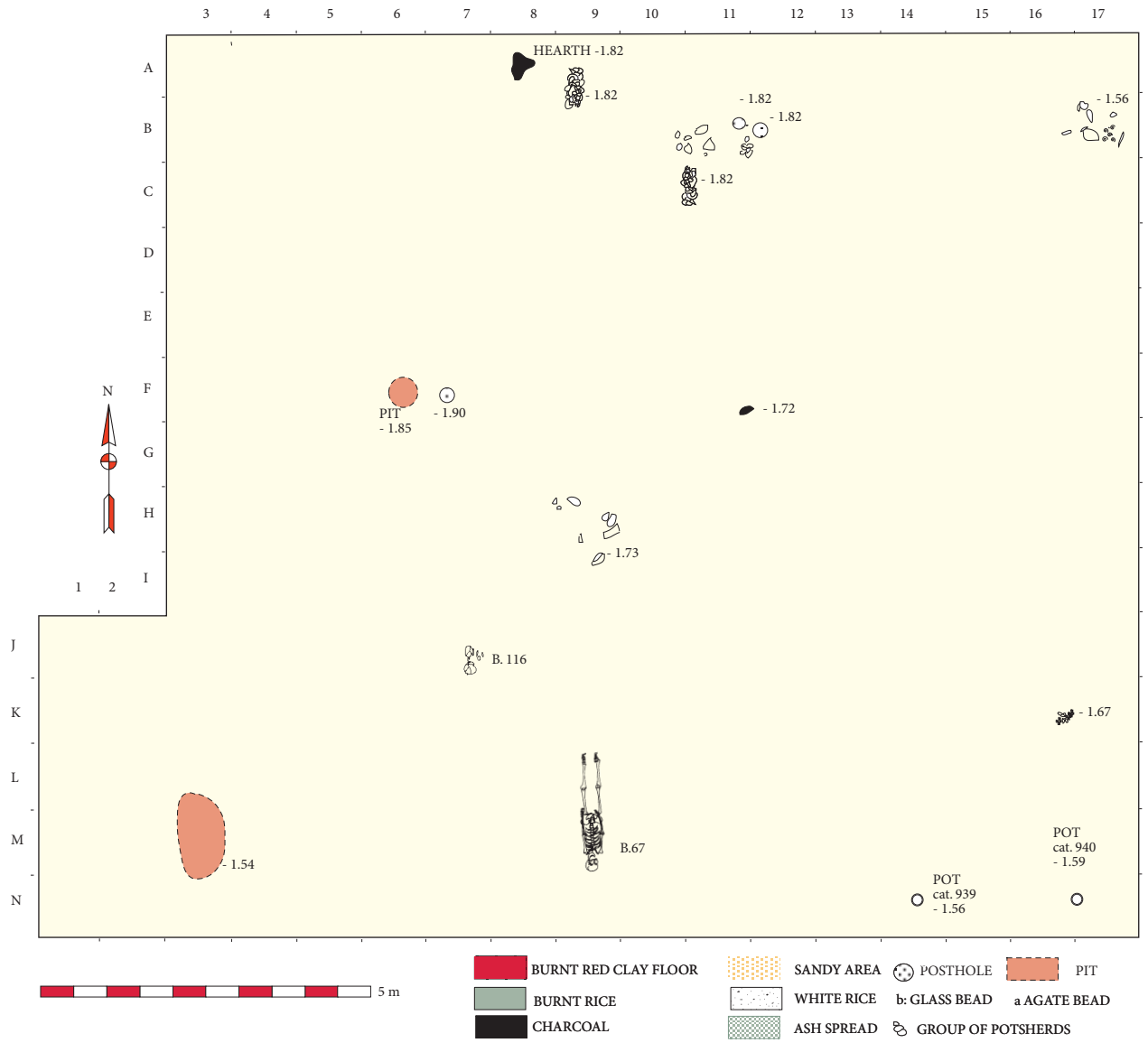


FIG. 7:10 Plan of layer 3:10

There is sparse representation of cultural activity in this level. Two whole pots were found at N15 and 17, and a hearth was present at A8. Two burials were cut down to this layer. Burial 67 was that of an adult aged 20-25 years. Grave goods comprised: two glass beads, bronze rings, a bronze earring and a bivalve shellfish with a hole bored through it. Burial 116 involved a neonate interred with three pottery vessels, glass beads, a bimetallic ring and an iron blade.

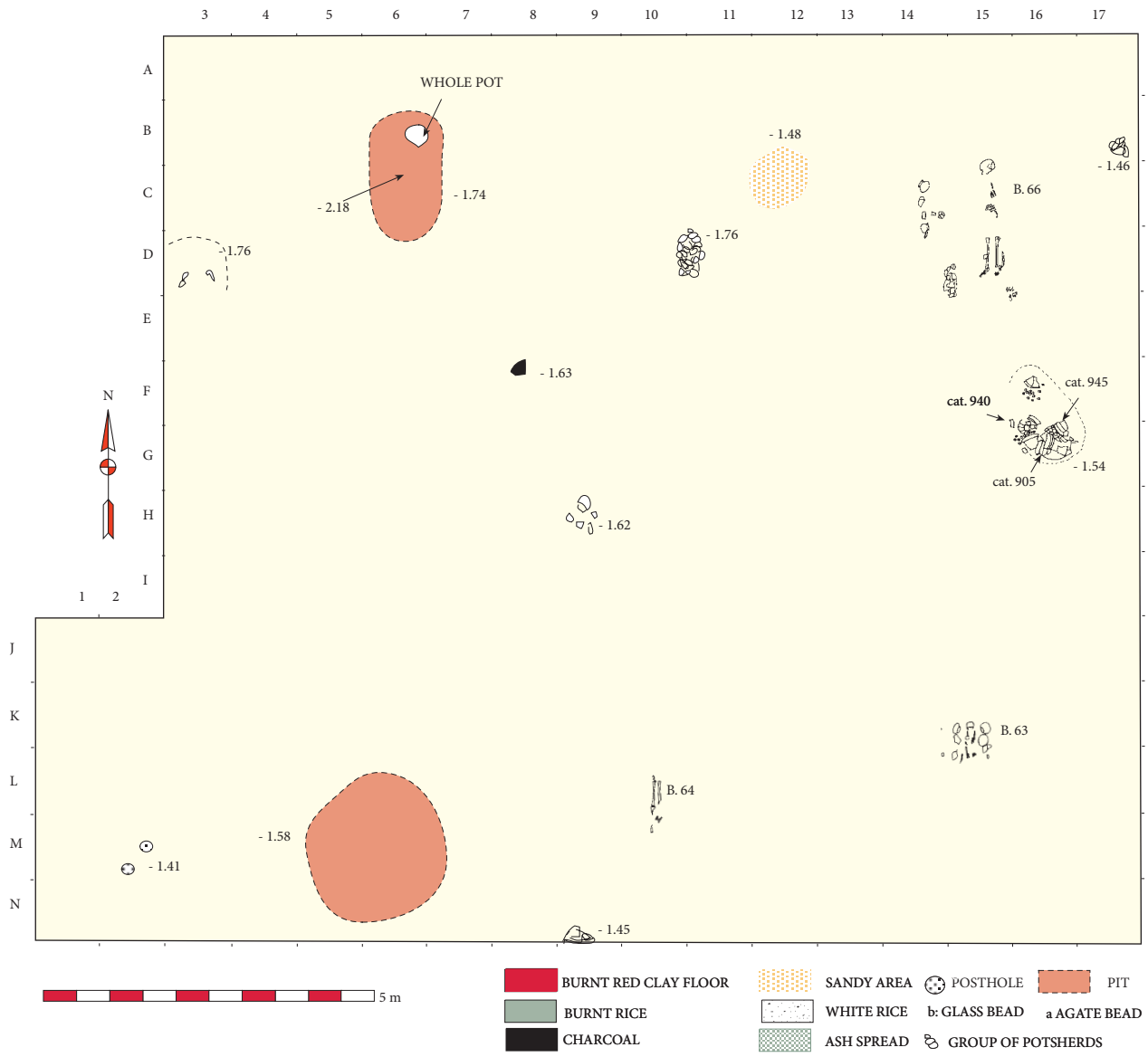


FIG. 7:11 Plan of layer 3:9

In terms of possible domestic activity, this level contains four pits, two of which have pottery vessels within. There are also two burials. Only the lower limb bones of burial 64, an adult probable female, have survived. Burial 66 is only slightly better preserved, although no grave goods were found with this 35-40 year-old male.

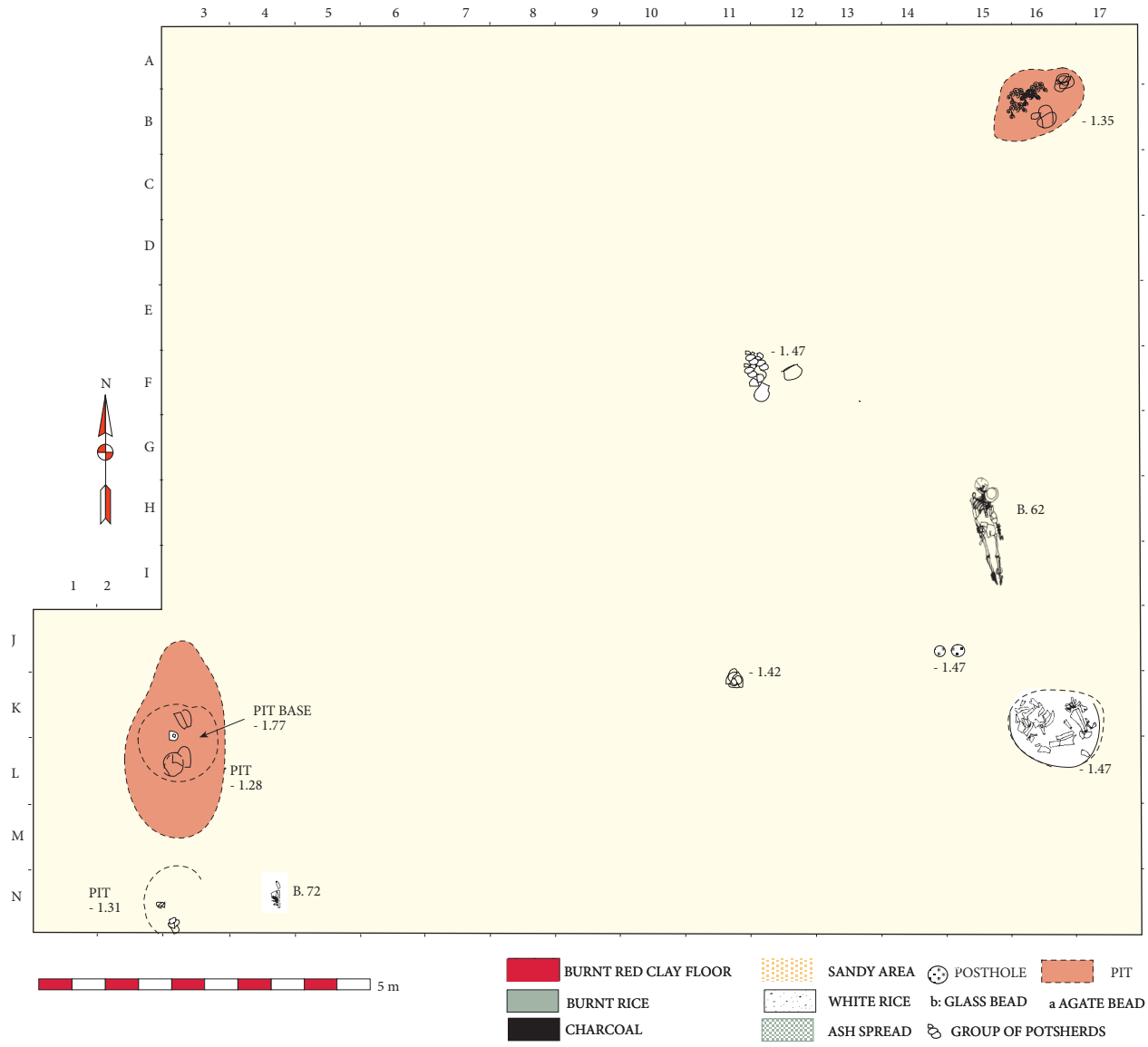


FIG. 7:12 Plan of layer 3:8

There was little evidence for domestic activity in this level. Three pits contained pottery vessels or large assemblages of bovid bone. Burial 62, however, was found intact. The grave of a 35-40 year-old female contained a profusion of grave goods, including many bronze bangles, anklets, finger and earrings, three bimetallic rings, two glass beads, at least three pottery vessels, an agate pendant and an iron knife. Burial 72 by contrast was represented only by a few foot bones of an adult female, and only an iron knife was found in association.

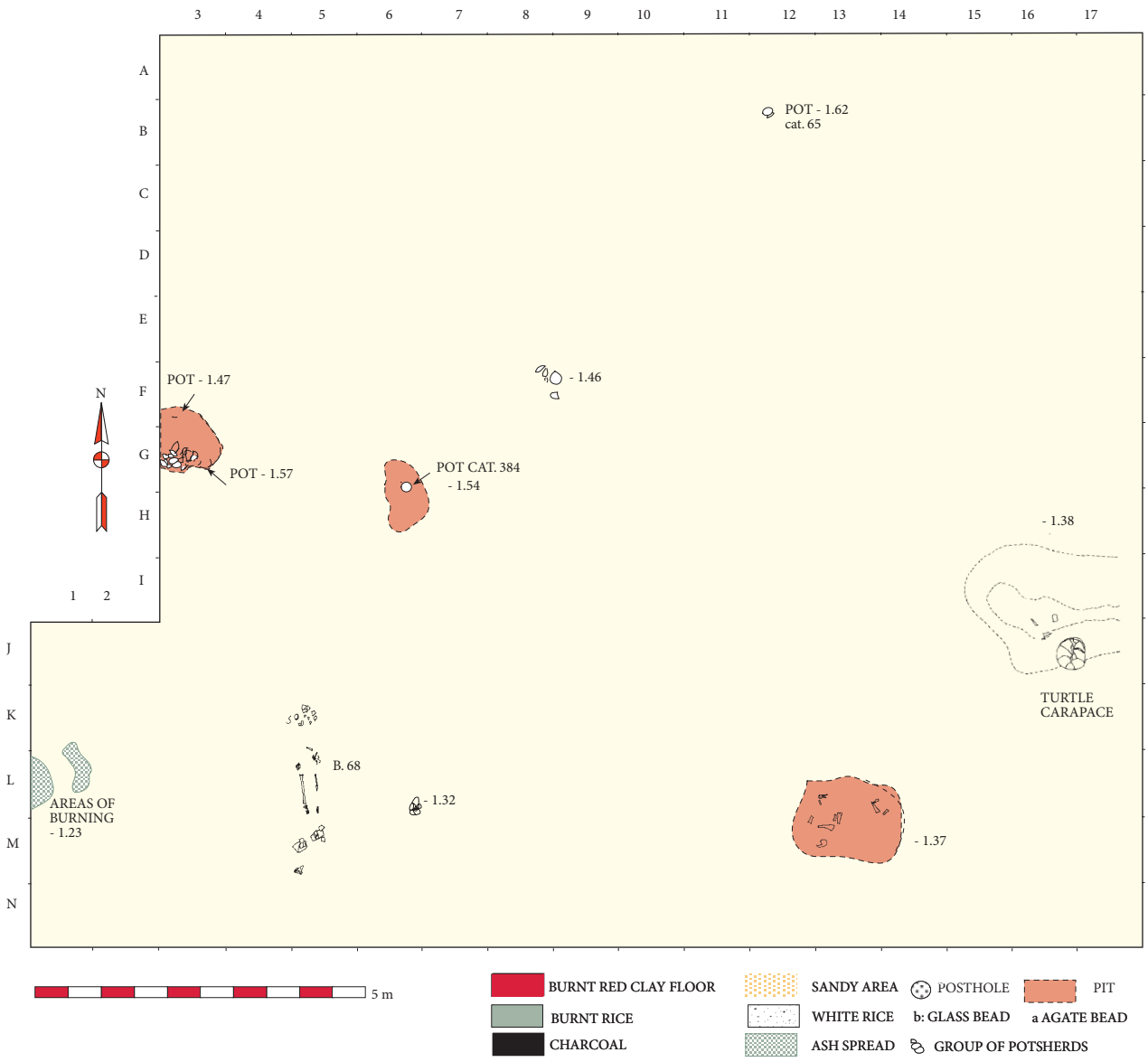


FIG. 7:13 Plan of layer 3:7

This level yielded a series of widely-distributed pits, which contained pottery vessels or, in the case of a shallow pit at J17, a complete and large turtle carapace, compacted burnt rice and much ash and animal bone. A pit at M13 also contained a lot of bovid bones. There was an area of burning at L1, and burial 68, a 25-30 year old identified as probably a male, was buried at L5. This severely-disturbed skeleton was associated with at least 53 gold beads in the area of the neck, a bimetallic ring and fragments of bronze bangles and rings.

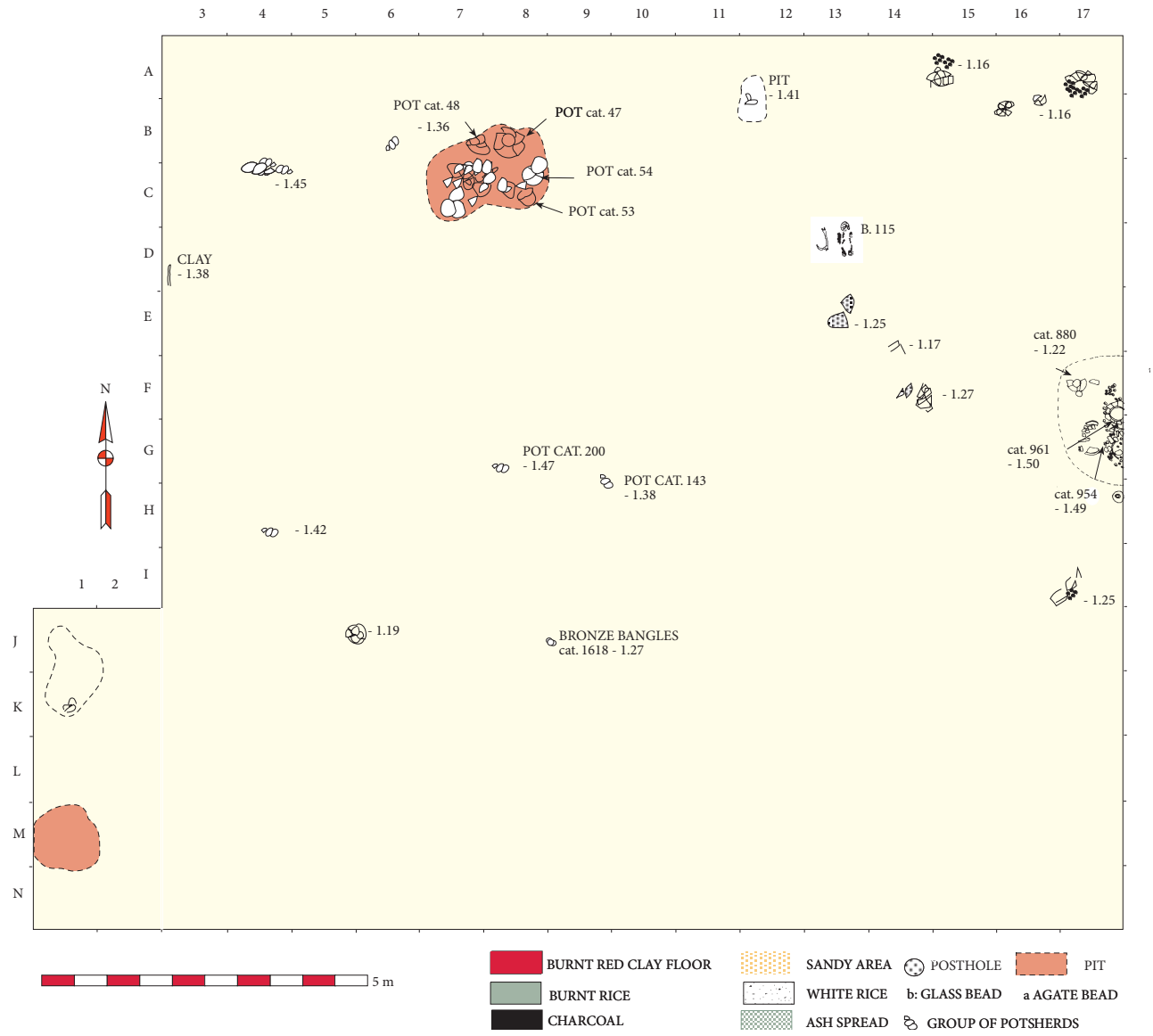


FIG. 7:14 Plan of layer 3:6

This level is characterised by a series of pits. That at F17 contains a number of complete pottery vessels, and complete pots were also found in that at C7. The pit M1, however, contained much carbonised rice. The skeleton of a neonate, burial 15, was found in an extended position with the head to the north at D13. It lay alongside a complete deer antler, and wore much bronze jewellery: armlets, anklets and earrings, and a bimetallic ring.

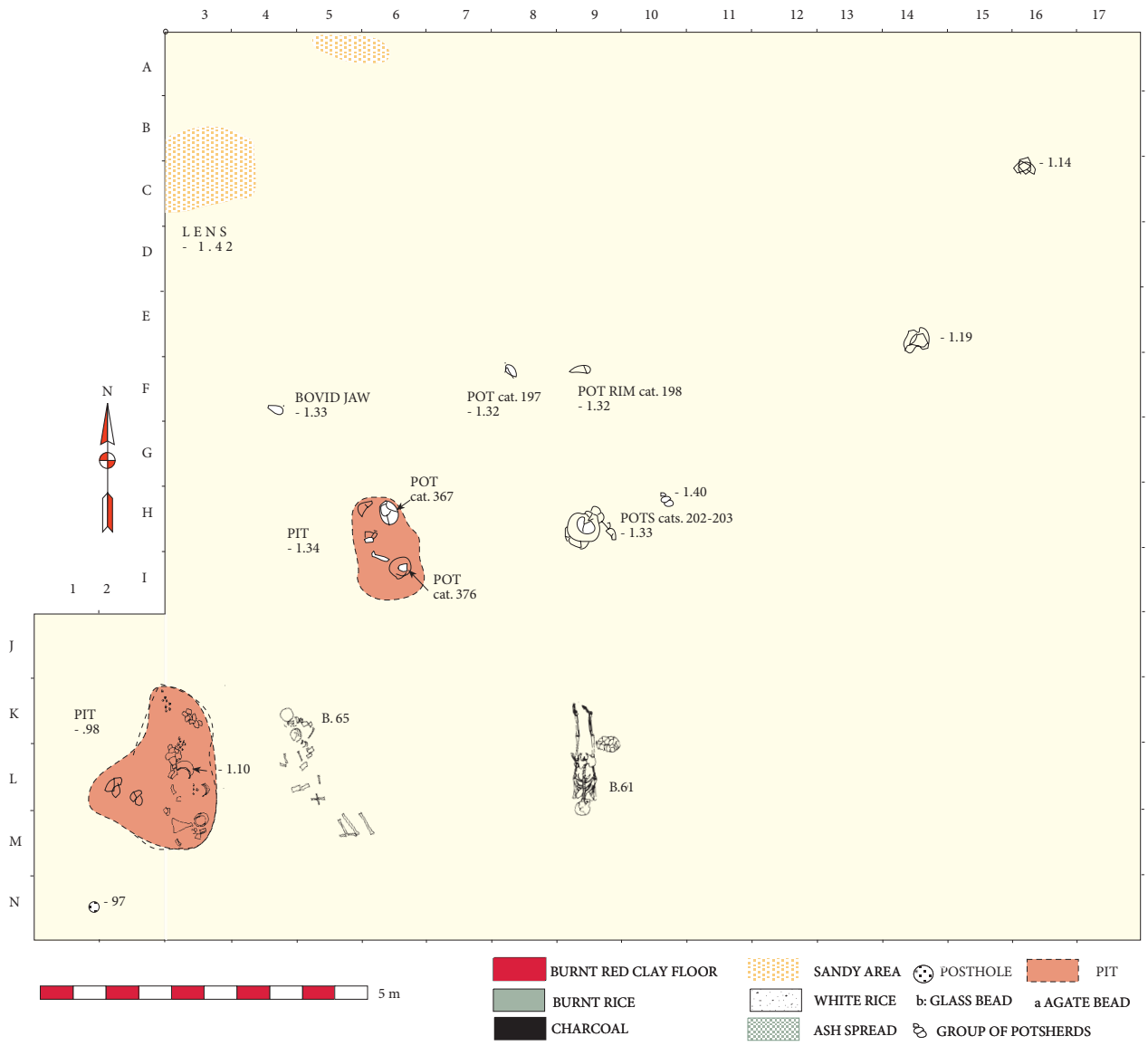


FIG. 7:15 Plan of layer 3:5

This level incorporated two pits containing whole pottery vessels, as well as three complete pots placed singly. One of these, at H9, might well have been an infant jar burial but no human remains were found. There are, however, two inhumation graves. Burial 61 incorporates a man aged under 20. He was interred in the rare prone position, wearing bronze finger and earrings and a bangle. The most interesting aspect of this burial was the recovery of a tanged iron arrowhead lodged in his spine. The orientation of this projectile indicates that it entered the body from in front and below, and to judge from its location, it was probably lethal. Burial 65, that of an adult male, was disarticulated. A pottery vessel, part of an iron knife blade and a bronze bangle were found in the vicinity.

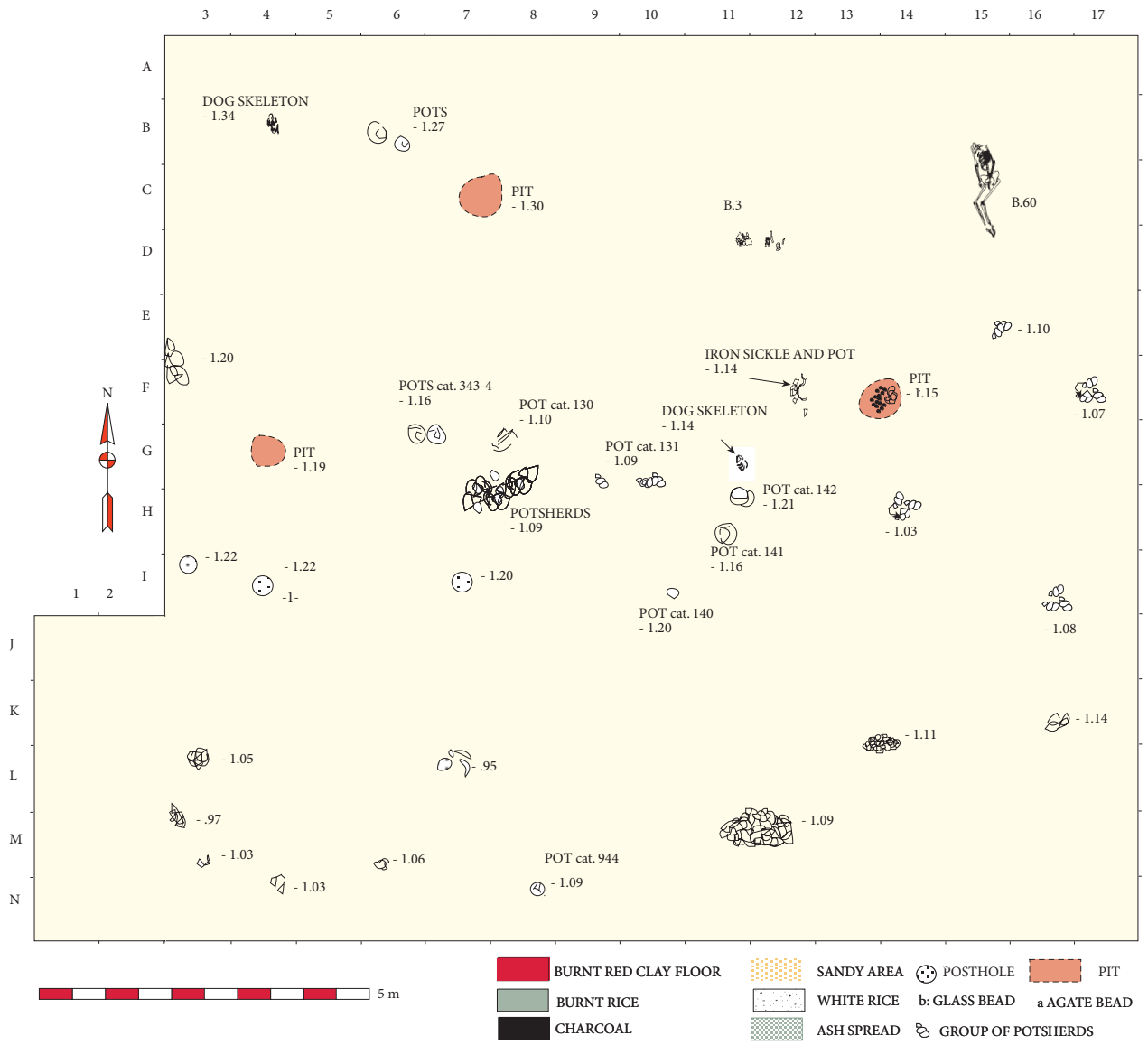


FIG. 7:16 Plan of layer 3:4

This level is characterised by the presence of many complete pottery vessels or concentrations of potsherds, as well as two dog's skeletons, one at B4 and the other at G11. There are also two burials. Burial 60 is a 20-25 year-old male in an unusual position, wherein the upper body was slumped downward, as if it had been buried over a pit. The legs were bent upwards, and there were no grave goods. Burial 3, that of an infant, was very fragmentary, and only bronze bangles survived as grave goods.

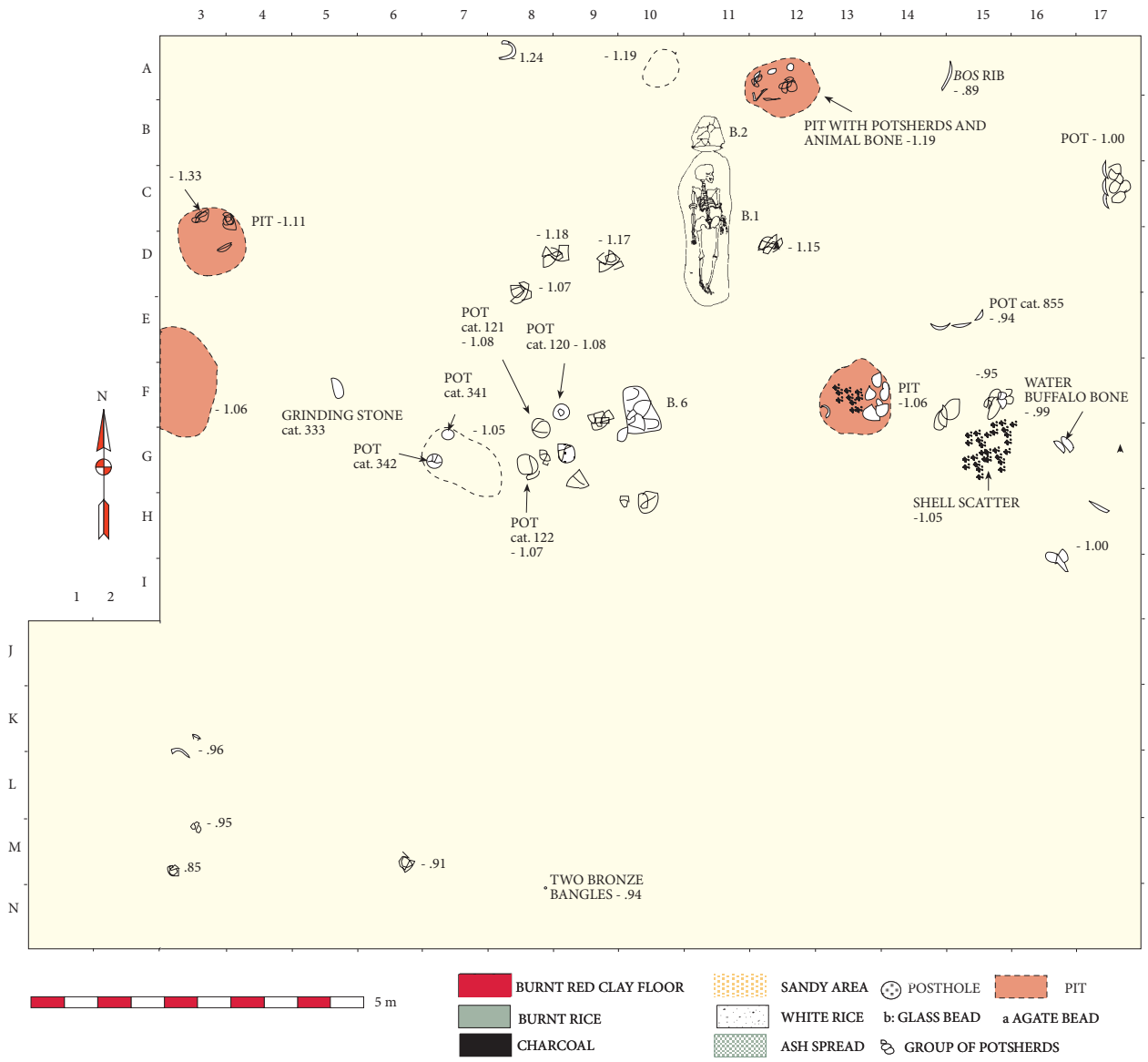


FIG. 7:17 Plan of layer 3:3

Many pits containing complete pottery vessels and animal bones were found in this level. A scatter of potsherds and partially complete vessels were found at H9, and these were probably formerly associated with the disturbed burials found in the vicinity. These comprised burials 6, 7 and 8. Burial 6 was a neonate found within a mortuary jar, and possibly associated with one or more smaller vessels.

Burials 1 and 2 lay to the northeast of this group and were found complete. Burial 1, a 35-40 year-old male, was found with many bronze earrings, bangles, finger rings, iron rings and one glass bead. A mortuary jar lay beyond the cranium (burial 2), which contained the remains of a neonate with two pots, a bronze knife and several bronze rings.

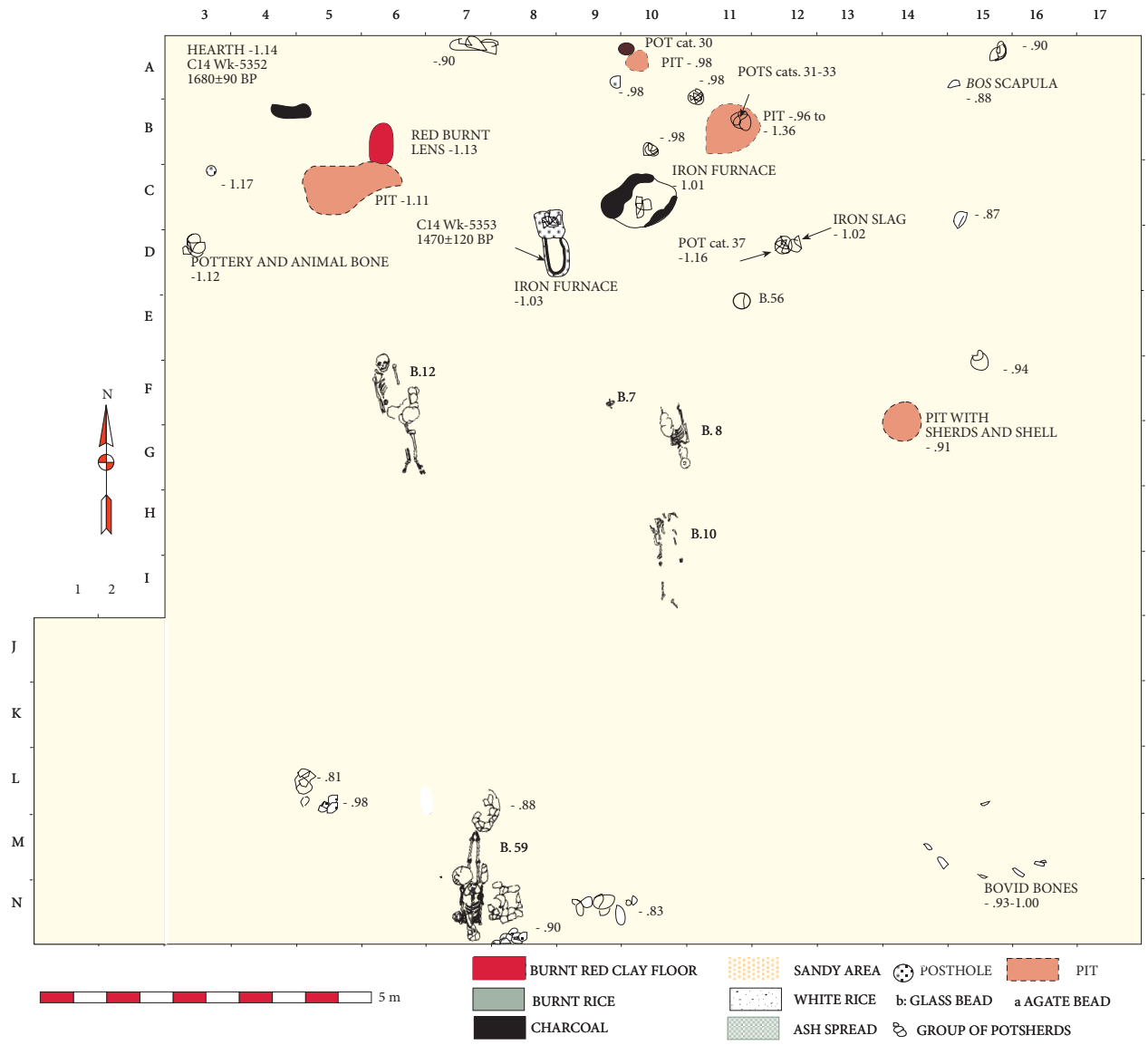


FIG. 7:18 Plan of layer 3:2

There are two radiocarbon determinations for this level, both from areas of burning in the northwestern sector. They are 1470±120 and 1680±90 BP. There is much evidence for burning in this northern part of the excavation, including two probable iron-working furnaces found with iron slag. Both are small, and involve a wall of red clay round a central core of burnt clay. At M16-17 there is a further type of domestic activity in the form of a concentration of large bovid bones.

Burials were less nucleated than in the later mortuary clusters, although the same orientation and ritual elements remained. Burial 7 was little more than part of an infant's arm and bronze bangles. Burial 8 was the disturbed remains of an adult aged 25-30 years with two pottery vessels, a glass bead and an iron knife and sickle. Burial 10 was that of a woman aged over 40 at death. Her bronze jewellery included finger and earrings and bangles. She also wore an agate bead, and was accompanied by an iron sickle and and iron knife.

Burial 12 was also an older female, aged over 40 at death. Her grave goods were similar, including bronze ornaments, an iron sickle and two pottery vessels. Burial 59 lies at the southern edge of the excavated area. This 25-30 year-old adult was relatively complete, and was accompanied by three pottery vessels, bronze finger rings and bangles, an iron ring, a silver earring and an iron sickle and iron knife.

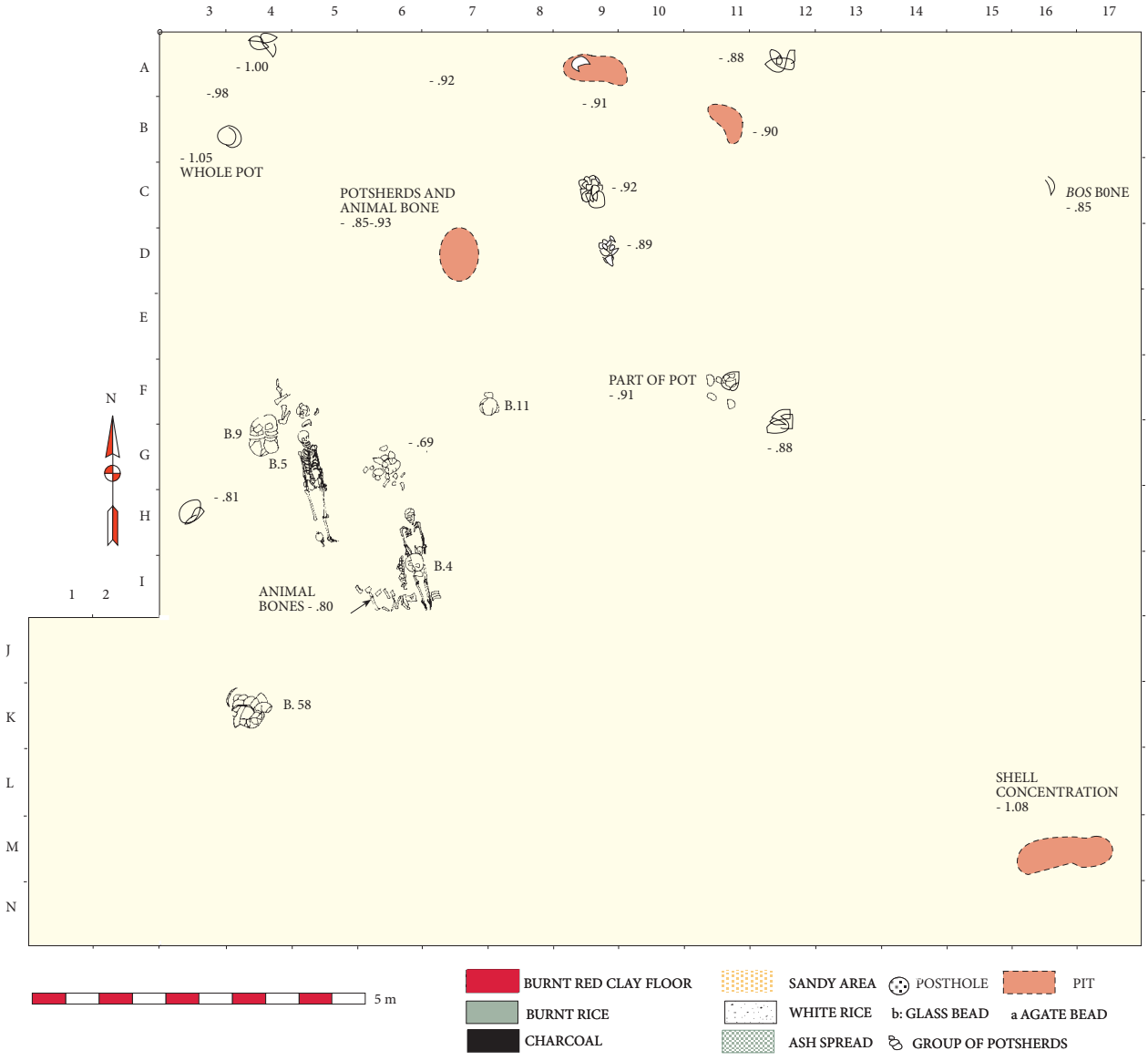


FIG. 7:19 Plan of layer 3:1

The uppermost context of layer 3 included accumulations of potsherds or partially complete pottery vessels, concentrations of shellfish and a dense deposit of pottery vessels and animal bones at D4-6. There was also a series of burials. Burial 58 involved a neonate in a jar associated with an iron tool. At only 59 cm below datum, this was among the highest burials encountered. Burial 9 was a second lidded jar, also containing a neonate on this occasion accompanied by a necklace of agate beads, bronze ear ornaments and bangles, an iron knife and an iron sickle. This infant was interred just west of the cranium of burial 5, a 20-25 year-old probable male. He was found with an agate pendant and bead necklace, an iron sickle and a second iron implement, possibly a spear. A concentration of animal bones lay beyond his head. Burial 4, on the same orientation and located to the southeast, was that of a 15-18 year-old. Grave goods included a pottery vessel, agate bead and a pendant, bronze bangles and a ring, and an iron sickle and knife. Again, animal bones concentated near the skeleton, on this occasion beside the right lower leg. A third neonate jar burial, no. 11, was found in the general area. There were no associated grave goods beyond the mortuary vessel.

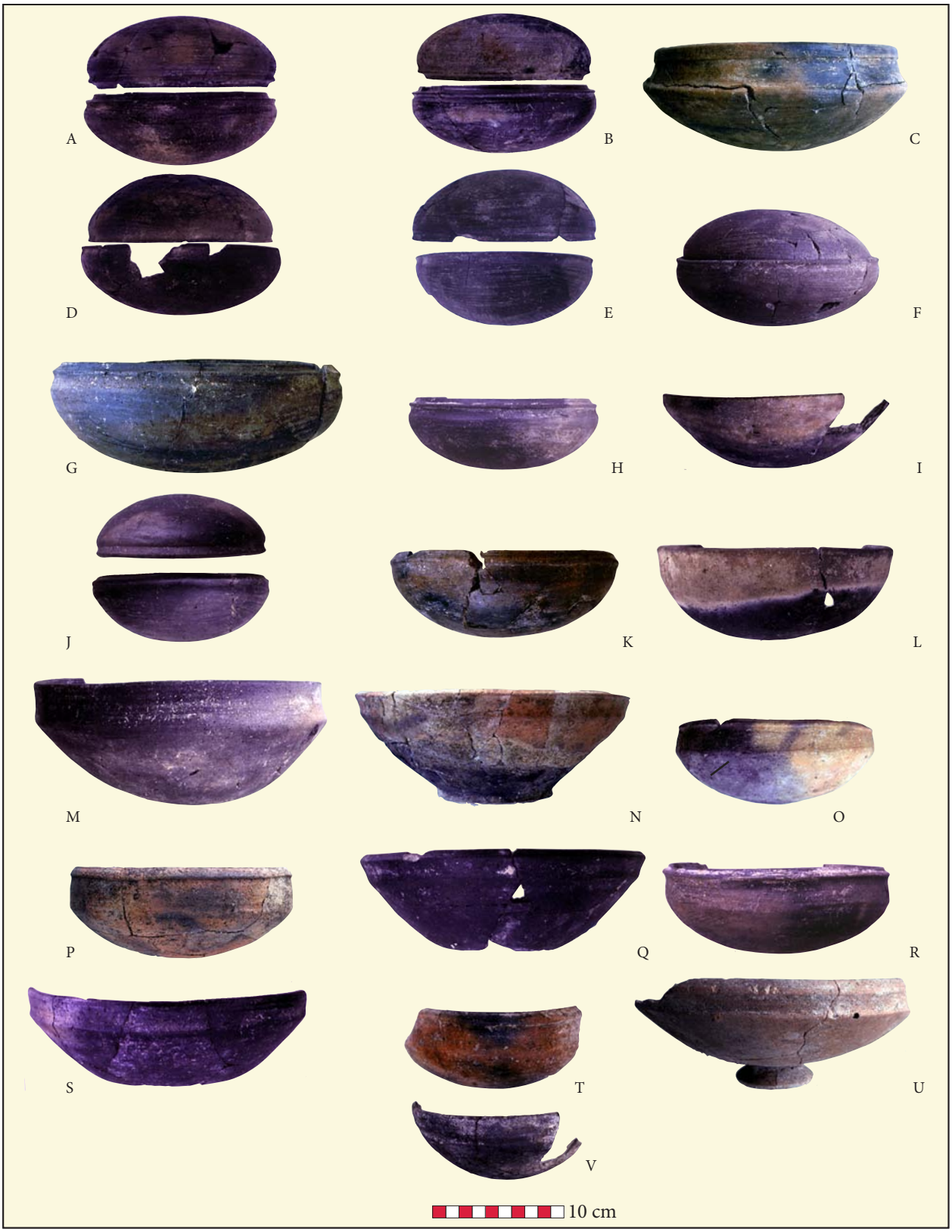


FIG. 7:20 Pottery vessels from layer 3. A. cat. 1005a&b C3 3:13 F.2, B. cat. 1056a&b C1 3.14, C. cat. 1002 C2 3:13 F.1, D. cat. 998 a&b C2 3:12 F.2, E. cat. 999a&b C2 3:12 F.2, F. cat. 953&B C3 3:11 F.3, G. cat. 250a B2 3:11 F.1, H. cat. 1055A C1 3:14, I. cat. 957 C2 3:9 F.1, J. cat. 939 a&b C3 3:9-10, K. cat 221 B2 3:8 F1, L. cat. 65 B2 3:7, M. cat. 1340 C1/X1 3:5 F.1, N. cat. 880 B3 3:6, O. cat. 70 A2 3:4 F.1, P. cat. 944 C2 3:4 F.2, Q. cat. 1036b A3/B3 3:1 F.3, R. cat. 1011 C2 3:1 F.1, S. cat. 1036a A3/B3 S:1 F.3, T. cat. 1000 C2 3:1 F.1, U. cat. 1004 C2 3:1 F.1, V. cat. 793 A1/B1 3:5 F.1



FIG. 7:21 Pottery vessels from layers 2 and 3. A. cat. 1027 A3/B3 3:1 F.3, B. cat. 1580 B2/B3 3:6, C. cat. 1901 A1 2:6 F.1, D. cat. 1429 X1 3:12 F. 2, E. cat. 144 3:11, F. cat. 376 B1 3:5 F.1, G. cat. 16 A1 2:5 F.1, H. cat. 1003 C2 3:13 F.1



FIG. 7:22 Pottery vessels from layers 2 and 3. A. cat. 905 B3 3:9 F.1, B. cat. 122a B2 3:3 F.3

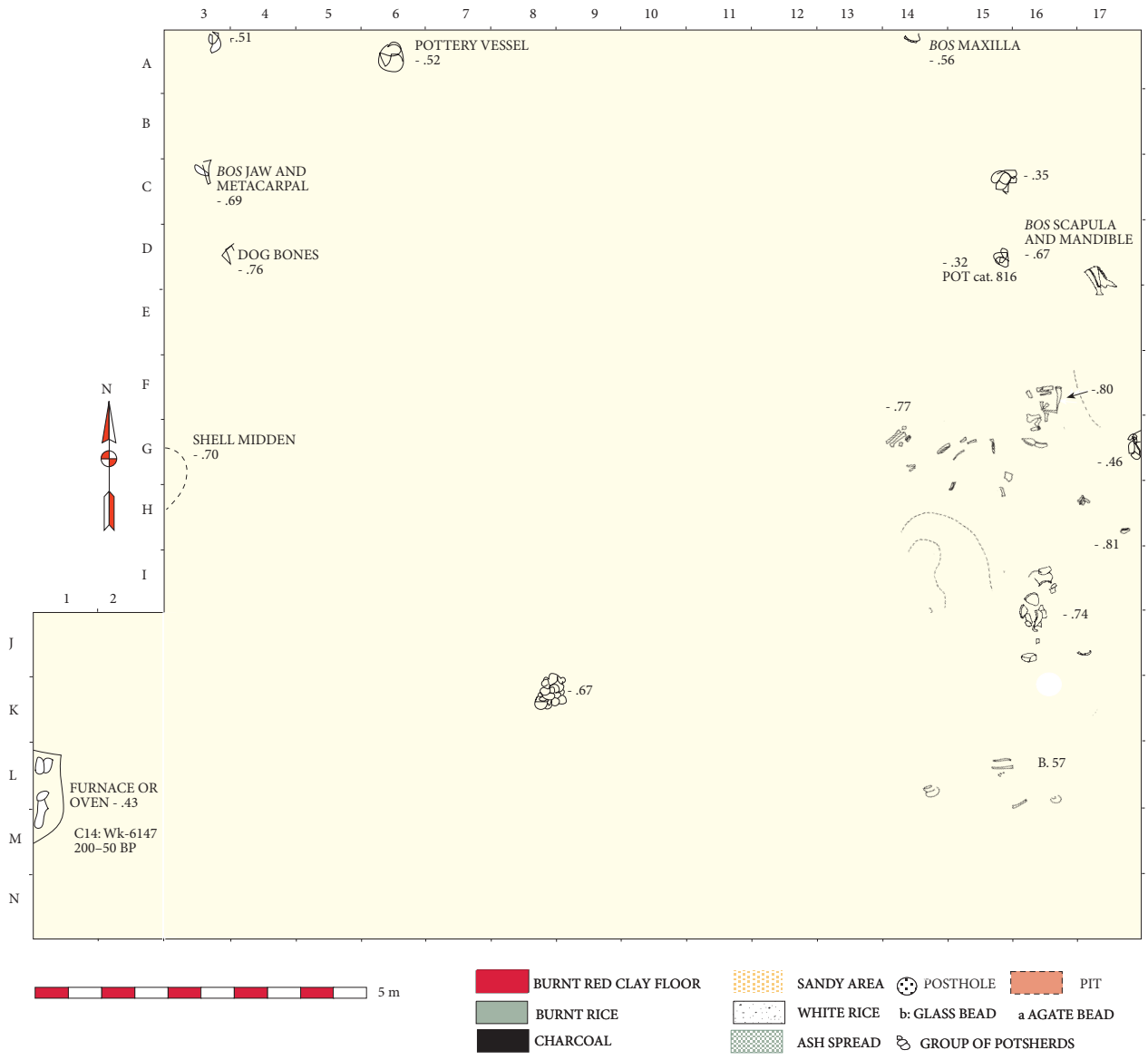


FIG. 7:23 Plan of upper layer 2

Upper layer 2 incorporates many potsherds and large animal bones. A furnace or oven at L1 has been radiocarbon dated to 200±50 BP, indicating a very recent origin. The scattered remains of burial 57 were found at L15. On laboratory examination, it was found that there are two individuals represented, an adult aged 25-30 years of age, and a child aged 12-15 years. An iron knife, bimetallic ring and a bronze bell were found in the vicinity.

Layer 1 comprises the uppermost deposits, comprising garden soil resulting from recent horticulture on the mound.

VIII. THE BURIALS OF MORTUARY PHASES 1 AND 2

C.F.W. HIGHAM AND R. THOSARAT

The sample of burials from Noen U-Loke is one of the largest to include relatively well-preserved human remains from an Iron Age site in Southeast Asia. They have been divided into five successive mortuary phases on the basis of their stratigraphic sequence. In the following review, the burials from each phase will be described, beginning with males, then females, adults of unknown sex, children and infants.

MORTUARY PHASE 1

Burial 125 is the only representative of this phase. The grave cut was recognised at a depth of 4.40 m below datum, and a complete pottery vessel reminiscent of those from Bronze Age contexts at Ban Lum Khao was recovered with some human foot bones. The rest of this early burial lies beyond the excavated area. A pit containing whole pottery vessels two metres to the east may represent a second early burial.

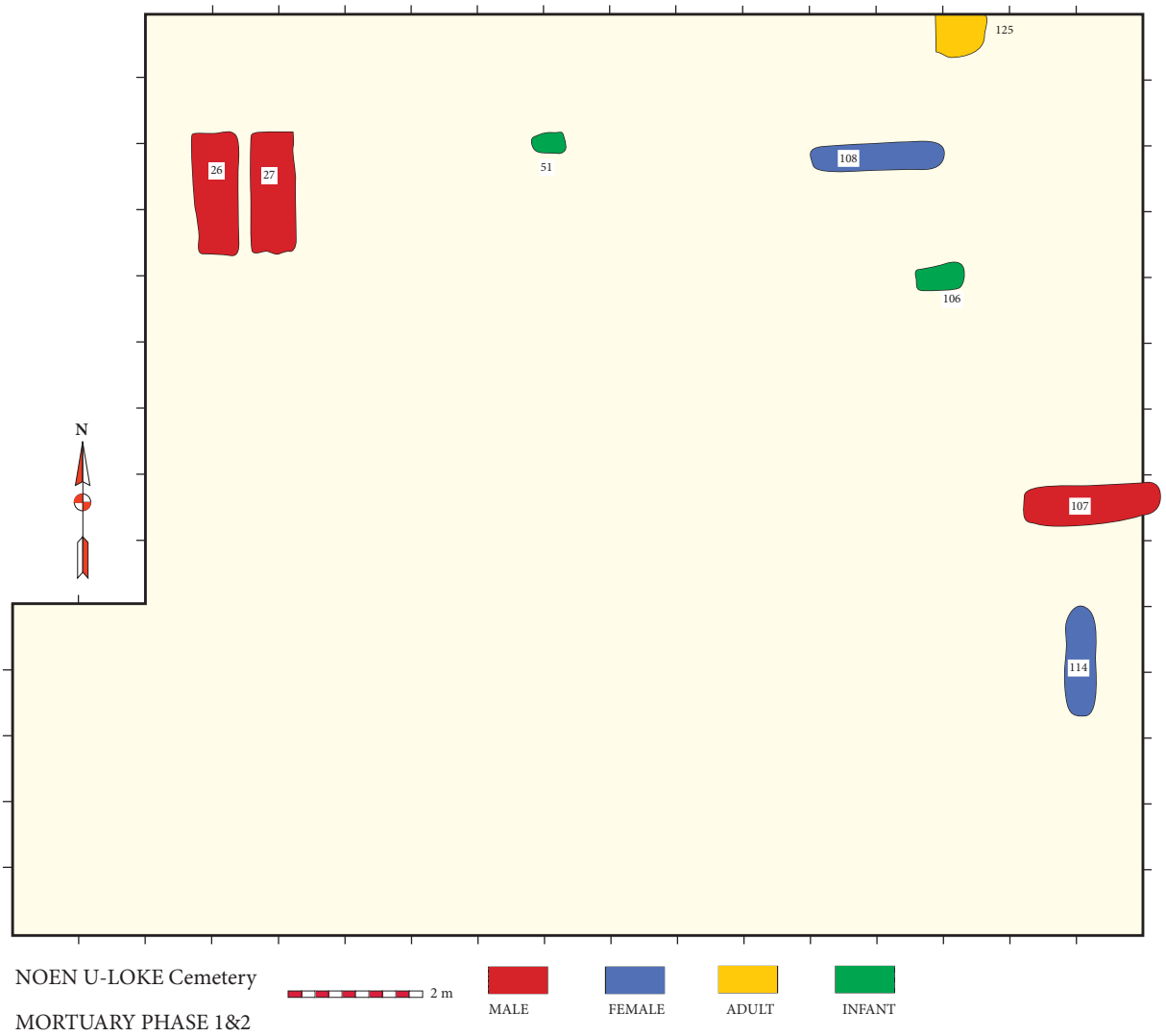


FIG. 8:1 The distribution of graves during mortuary phases 1 and 2



FIG. 8:2 Burial 125. The grave cut can clearly be seen in section, and the pottery vessel lies just beyond the human foot bones. A large deposit of yellow material lies over the grave cut



FIG. 8:3 Burials 26 and 27 (foreground). The graves were cut through layer 5, which is the light coloured material lying between the two interments

MORTUARY PHASE 2

The second phase of burials incorporates a series of scattered inhumation interments. Three are orientated with the head to the north or south, and three lie on an east to west orientation. Burial 51 comprised only a stray maxilla in a pit found in layer 6:7.

Burial 26

This burial of a mid adult male was first identified as a grave silhouette cut from layer 4 through layer 5. The cut was observed at a depth of 3.65 m, and the top of the cranium was found at the same time. The skeleton lay at an angle of 10° west of north. It was accompanied by four pottery vessels, two beyond the cranium, one beside the left hand and the fourth beside the left ankle. That beside the hand contained the skeleton of a fish belonging to the genus *Channa*. The articulating foot bones of the

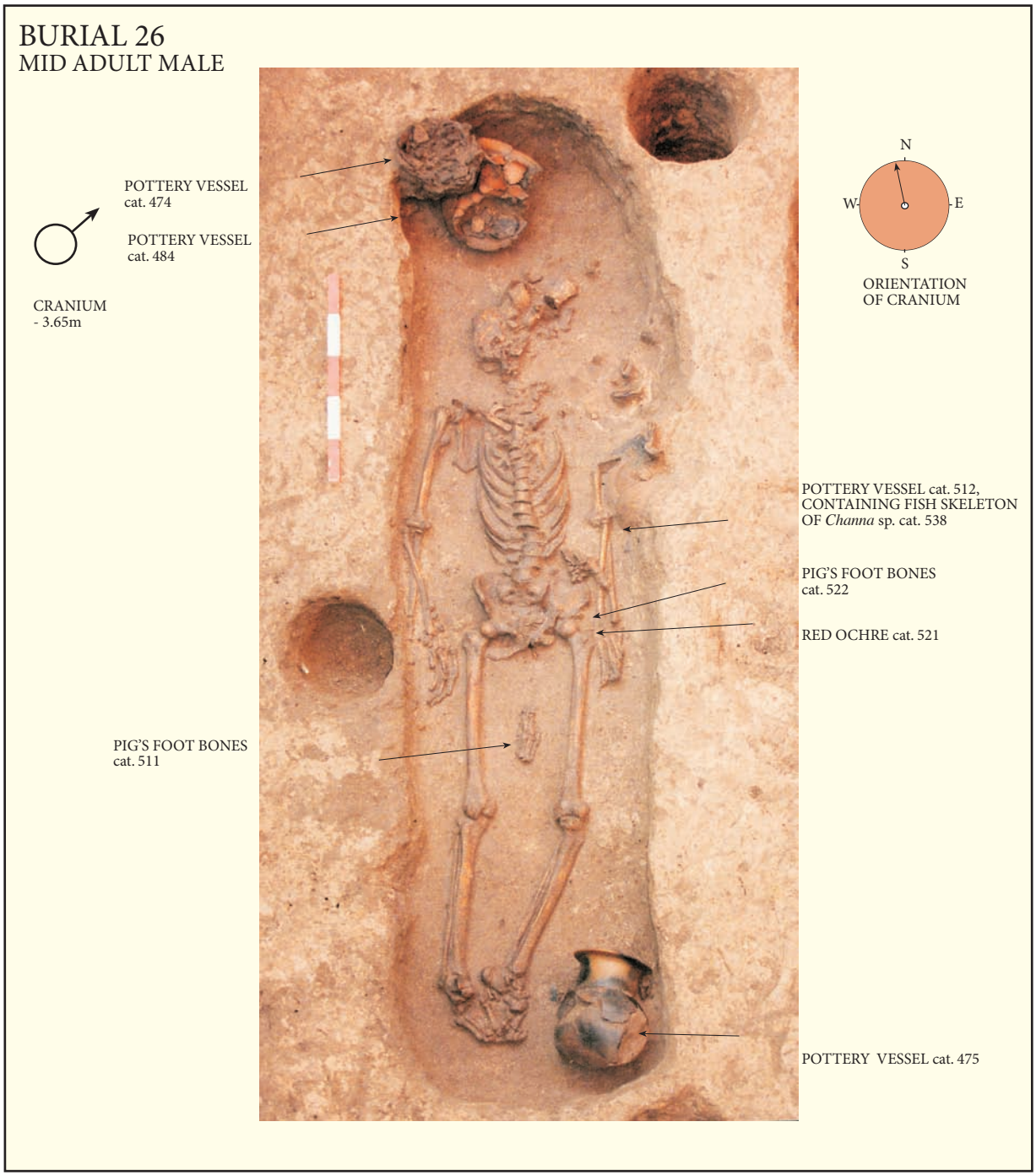


FIG. 8:4 Burial 26



FIG. 8:5 The pig's tusks from burial 26. Note the holes bored for suspension. Scale 2 cm

fore limb of a pig had been placed between the thighs, and another set of foot bones lay next to the left arm. This burial lacked any iron or *in situ* bronze grave goods, but a unique shaped pair of large pig's canines were found in the area of the neck, pierced for suspension. The grave fill incorporated a spindle whorl, but this may not have been in primary association with the interment.

Burial 27

This burial is the richest in the mortuary phase 2 assemblage. It lies parallel with burial 26, but the body was orientated with the head due south. The grave cut was clearly apparent on the surface of layer 5 at a depth of 3.66 m, again indicating that the burial dates to the lower levels of layer 4. The top of the cranium was reached at a depth of 4.12 m. One of the most interesting points about this burial is the combination of bronze and iron artefacts. This man wore three bronze torcs round the neck, and a broad bangle on each wrist. A bangle decorated with spikes was found beside two socketed bronze spearheads and two shell discs. All five were placed adjacent to a pottery vessel beyond the feet. In terms of iron, a large socketed spearhead lay to the left of the cranium and parallel with the body. A socketed hoe or axe lay upright beside the left ankle. Four pottery vessels were associated, two beyond the feet, one by the lower right arm and the fourth beside the left knee. Those beyond the feet contained the remains of the fish *Channa striatus, Anabas testudineus* and *Notopterus notopterus*, as well as turtle bones. There were also many pig bones: within a pot beyond the feet, under the pelvis, beyond the feet and within the grave fill.

In addition to bronze jewellery, this man wore shell discs found beside the cranium which had probably been inserted in the ear lobes. Further large shell discs were located beyond the feet. He wore four tiger's canines as a necklace, each pierced and worn as a result of regular



FIG. 8:6. The tiger canines from burial 27. The holes for suspension can be seen, and the wear marks are visible running laterally across each. Scale 1cm



FIG. 8:7 Burial 27, showing the bronze torcs and tiger canine necklace. Scale 5 cm

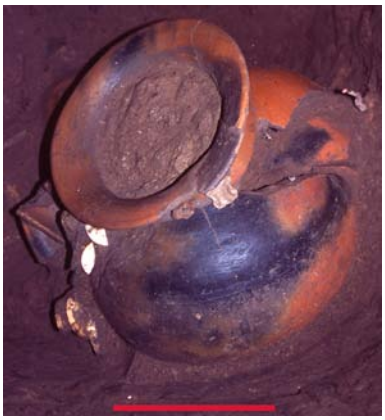


FIG. 8:8 Burial 27, showing pot cat. 487 and the shell discs at the grave foot. Scale 20 cm

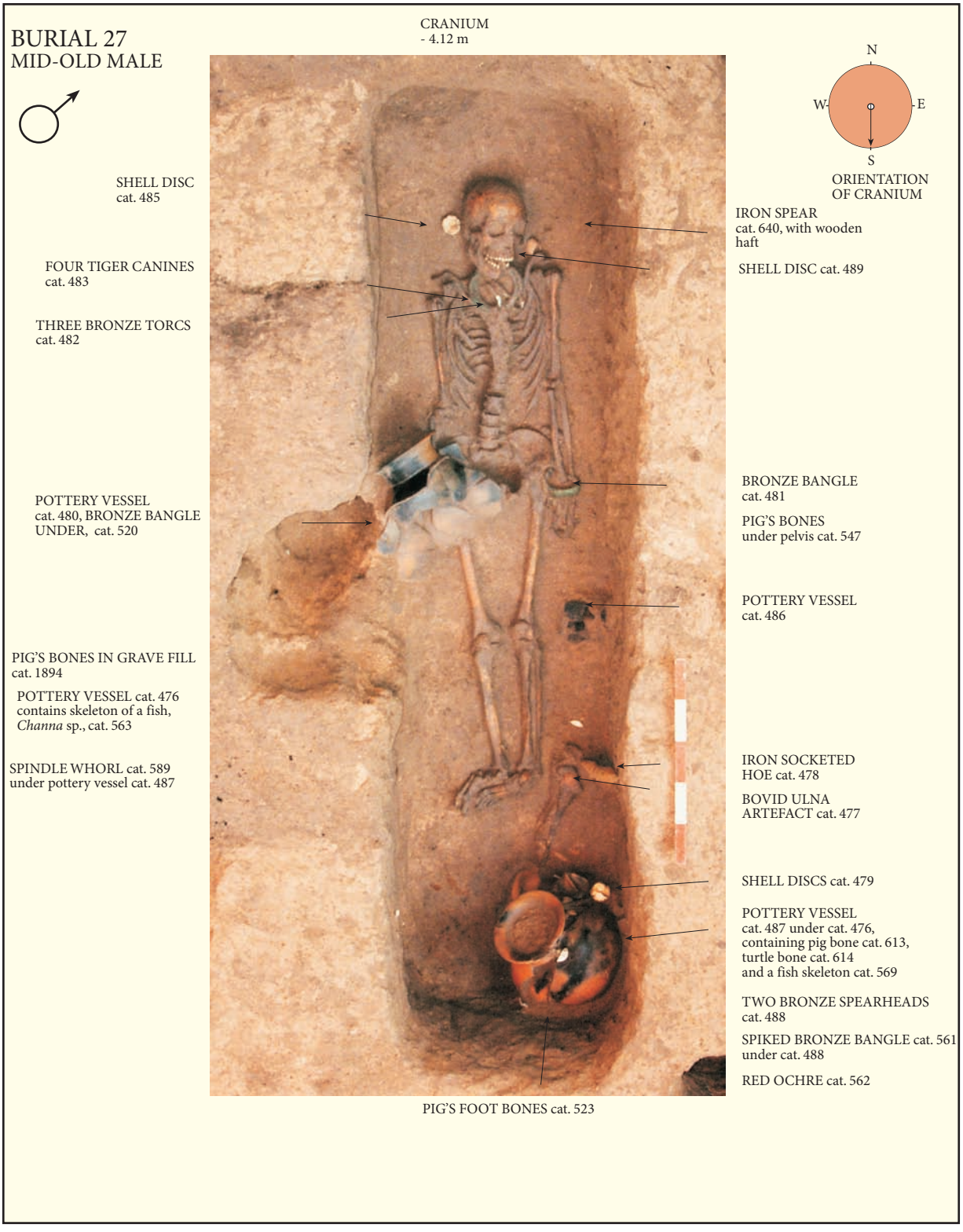


FIG. 8:9 Burial 27

wear over a long period. A patch of red ochre was identified beside the socketed iron spear or short sword, and a spindle whorl was found under a pottery vessel beyond the feet. Finally, a shaped bovid ulna, bored at the distal end and heavily polished, lay beside the left ankle.

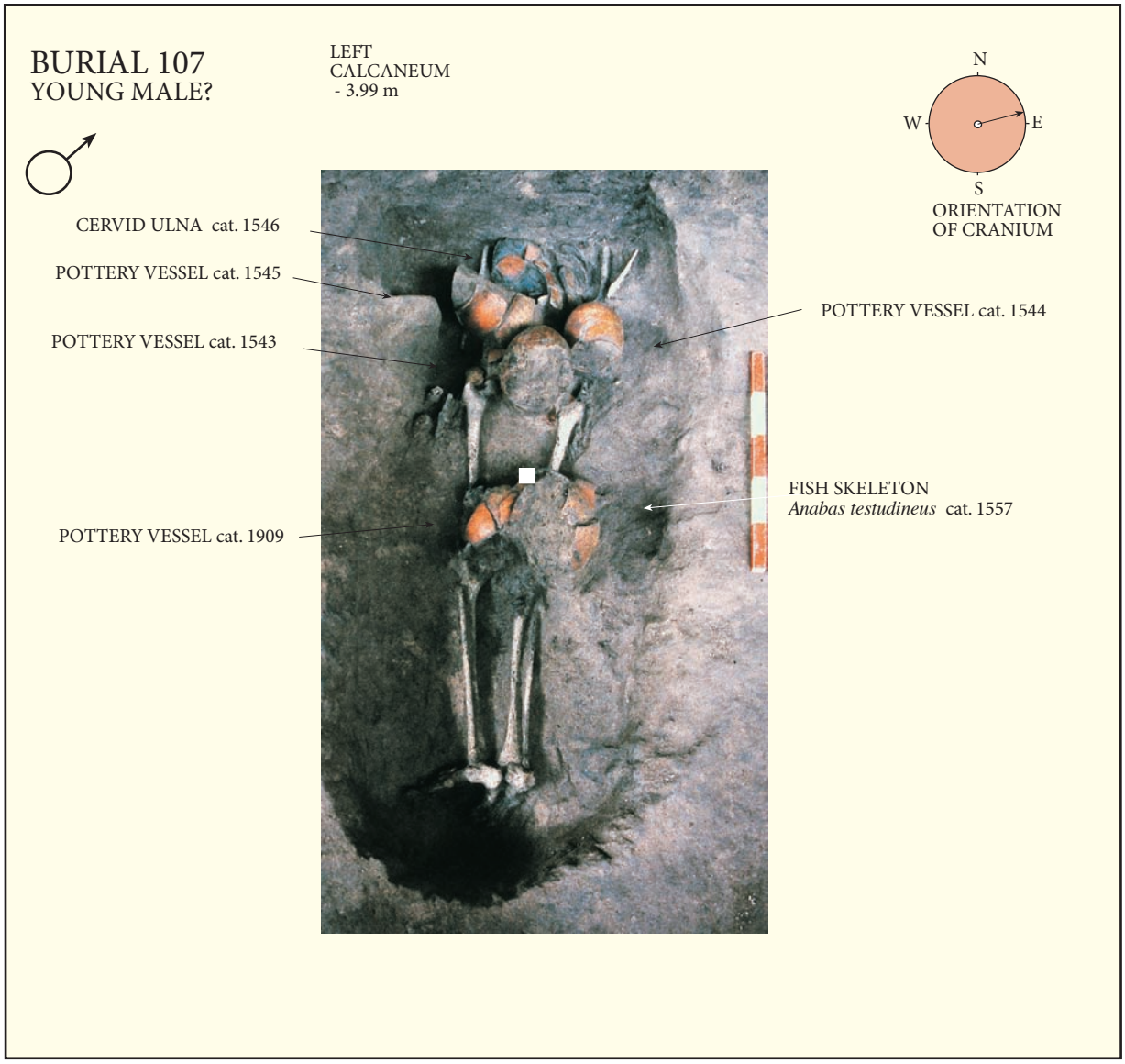


FIG. 8:10 Burial 107

Burial 107

This young male was buried prone, with the head facing 10° north of due east, at a depth of 3.99 m. No grave cut was encountered, the first hint of a burial being the discovery of one of four pottery vessels. These were found over the knees, the abdomen, the right wrist and the left hand. A complete fish (*Anabas*) skeleton had been placed over the right femur. Finally, a cervid ulna was found by the upper left arm.

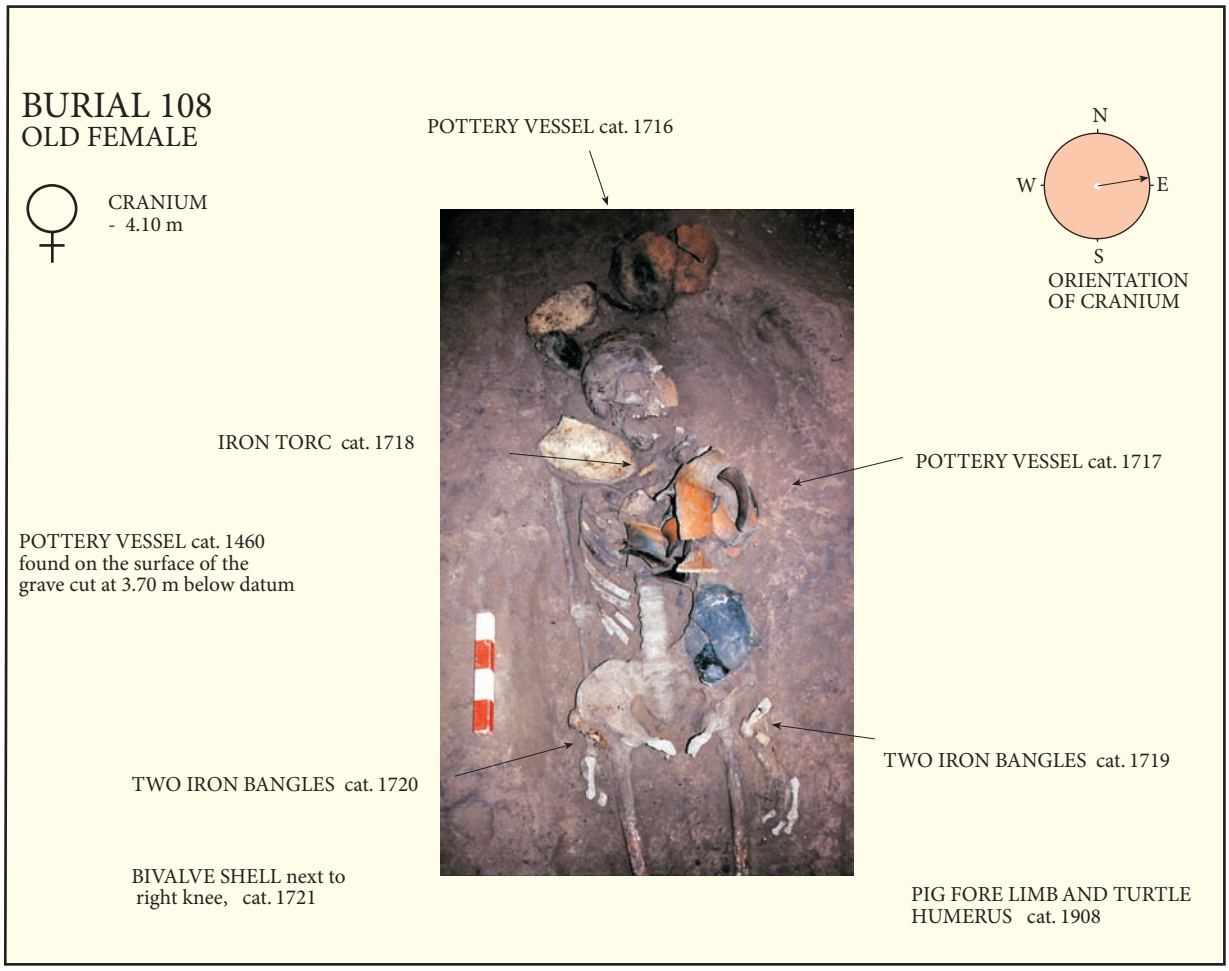


FIG. 8:11 Burial 108

Burial 108

The woman died when over 40 years of age. She was interred with the head pointing 5° north of due east, on her back. The first hint of an impending burial came with the discovery of a pottery vessel, cat. 1460, found at a depth of 3.70 m in uppermost layer 6. The grave cut was then recognized on scraping the surface of 6:2, and the bones appeared at a depth of 4.10 m. Two further pottery vessels were associated, one beyond the head, and the other over the left arm. The most interesting feature of the mortuary offerings, however, was the presence of iron jewellery in the form of an iron torc or neck ring, and four iron bangles, two on each wrist. A bivalve shell was found by the right knee, a finding which matches a recurrent practice at the Bronze Age cemetery of Ban Lum Khao. A pig's fore limb and the humerus of a turtle were found in the general area of the human skeleton.



FIG. 8:12 The close up of the cranium of burial 108 reveals the iron torc or neck ring. Scale 2 cm

Burial 114

The grave of this woman, aged about 35-40 years old, was encountered at a depth of 4.09 m. No higher grave cut



FIG. 8:13 Burial 106, a neonate. The bones lay under the two pottery vessels. Scale 10 cm

was noted. She was interred with the head orientated 15° west of north, and was accompanied by a single pottery vessel placed to the left of the cranium.

Burial 106

The neonate was found at a depth of 3.88 below datum, and no grave cut was noted (Fig. 8:13). Two pottery vessels (cats. 1463-4) lay over the remains of a newly-born infant, together with a bivalve shellfish (cat. 1466) and a fragment of bronze (cat. 1467).

Burial 51 comprised only some loose teeth found in a a pit.

MORTUARY PHASES 1 AND 2: SUMMARY

Of burial 125, the earliest found, we know virtually nothing, except that it might belong to the late Bronze Age. An extension of the area excavated is a first concern for the future. The phase 2 burials have yielded pottery vessels virtually identical in form and decoration with the latest ceramics from Ban Lum Khao. The provision of bivalve shellfish with the dead also echoes Bronze Age practice. Yet the sophistication of the iron industry is self evident in the forging of ornaments with burial 108, and a large socketed spear and socketed hoe or axe with burial 27. Moreover, the profusion of bronze ornaments found in the later burials at Noen U-Loke are not matched in phase 2

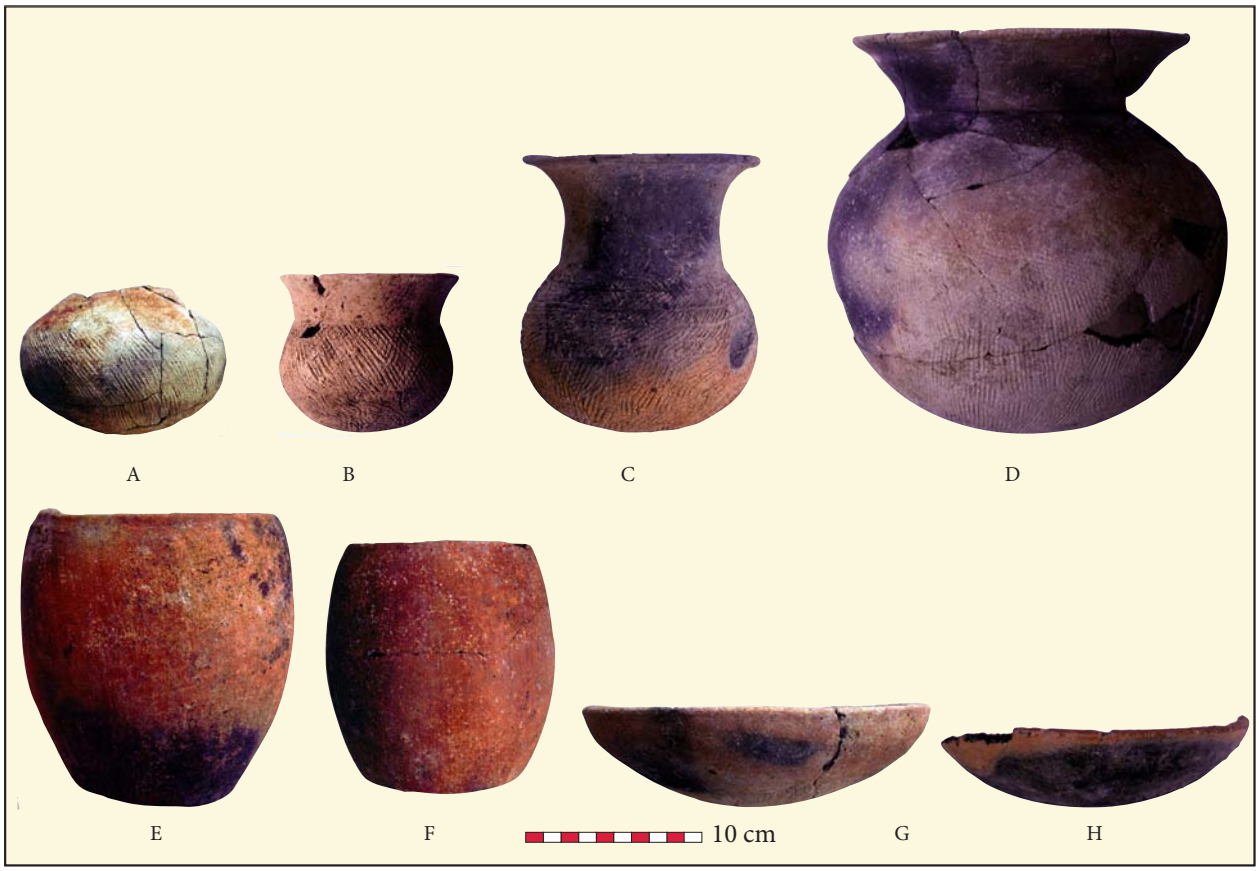


FIG. 8:14 Pottery vessels from mortuary phases 1 and 2. A. burial 125 cat. 1782 (mortuary phase 1), B. burial 114 cat. 1542, C. burial 106 cat. 1463, D. burial 108 cat. 1716, E. burial 107 cat. 1543, F. burial 107 cat. 1544, G. burial 106, cat. 1464, H. burial 108, cat. 1460



FIG. 8:15 Pottery vessels from mortuary phase 2. A. Burial 26 cat. 475, B. burial 26 cat. 484, C. burial 108 cat. 1717, D. burial 27 cat. 480, E. burial 27 cat. 476, F. burial 27 cat. 487, G. burial 26 cat. 512, H. burial 107 cat. 1545

notwithstanding the technological mastery of the burial 27 torcs and bangles. Compared with the later burials, no glass, agate or carnelian ornaments were encountered in phase 2. These graves were cut through layer 5, presumably from lower contexts in layer 4 above. Four radiocarbon dates bracket these phase 2 graves. Wk-5364 comes from a hearth in layer 6:4, severed by the cutting of burial 27, and therefore earlier than the interment. It is 2280±130 BP. A second 6:4 date is Wk-6148, 2180±45 BP. A layer 6:1 date, Wk-5363, is 2360±60 BP. Wk-5356 comes from a depth of 2.85 m below datum, well above the layer from which these graves were likely to have been initiated, and the result is 2090±50 BP. The relevant dates bracket the phase 2 burials between 200-400 BC and 1-200 BC.

IX. THE BURIALS OF NOEN U-LOKE: MORTUARY PHASE 3 CLUSTER A

C.F.W. HIGHAM AND R. THOSARAT

The group of burials ascribed to phase 3 cluster A lay in a tight group, with the heads orientated to the northeast. It comprises two males, two females, a child and an infant interred in a burial jar. It is possible that more burials belonging to this cluster may lie to the north, but at present, the group has a satisfying biological coherence suggesting that the individuals were related to each other. A second infant jar burial was found isolated 9 m to the west.

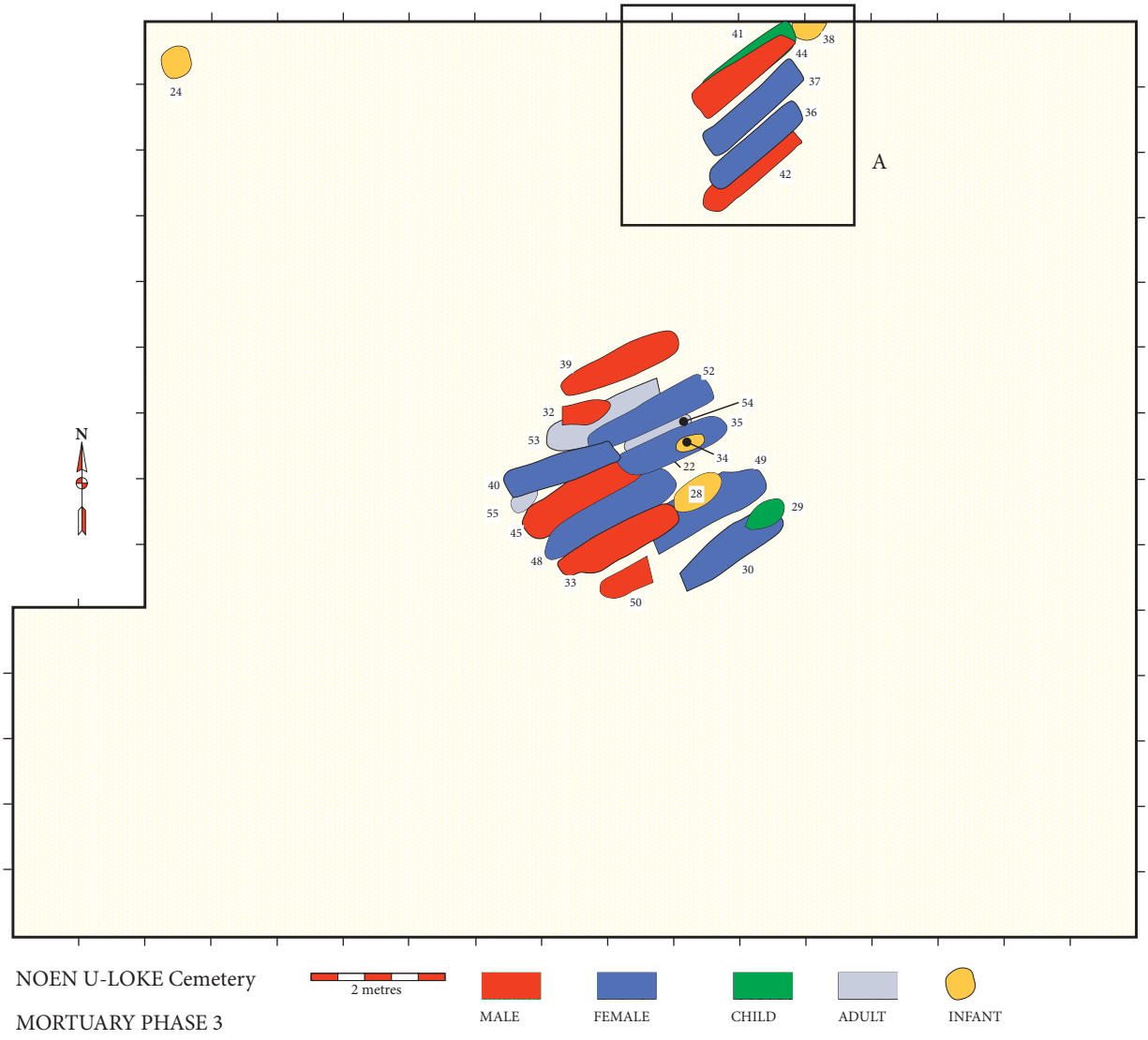


FIG. 9:1 The distribution of mortuary phase 3 burials

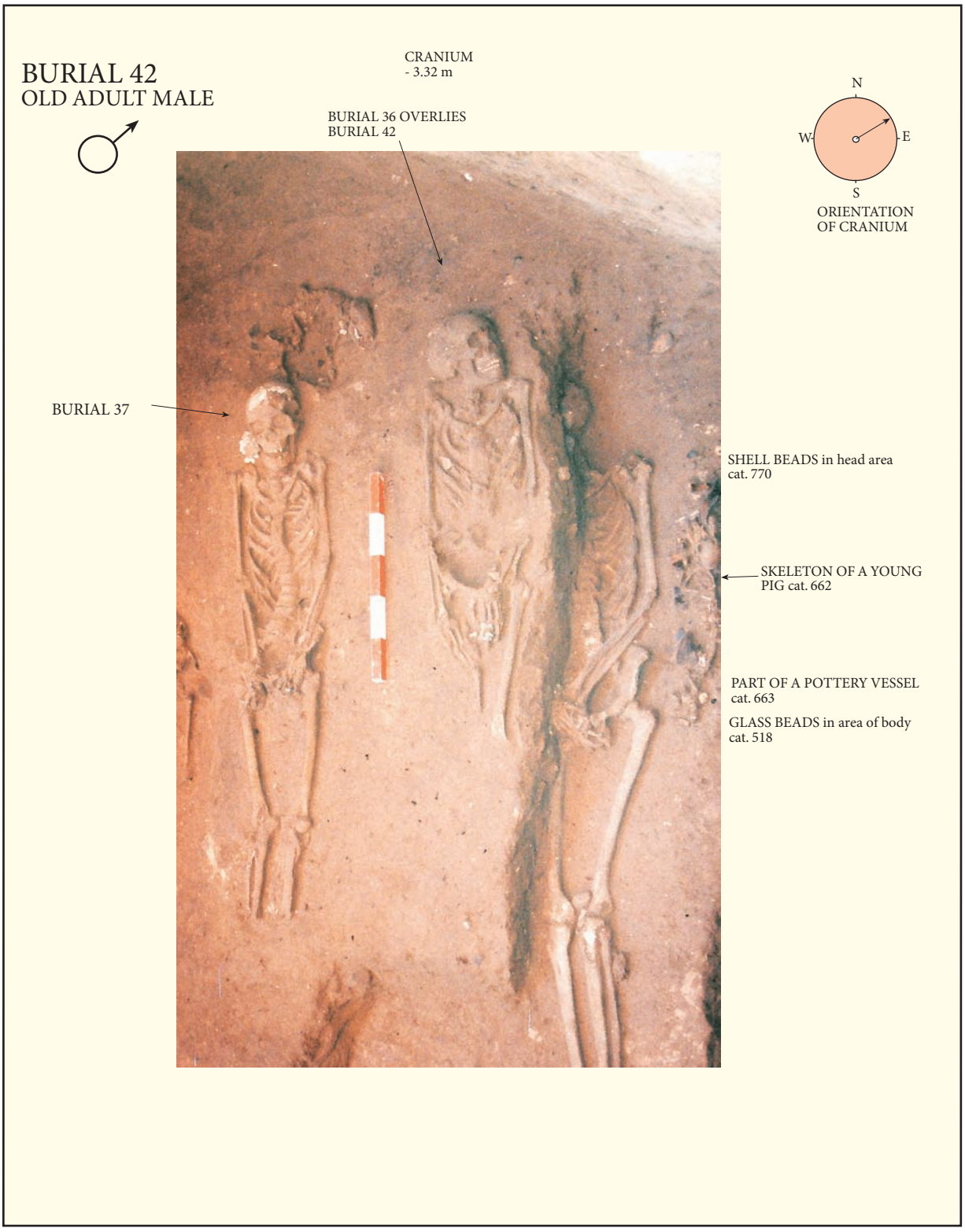


FIG. 9:2 Burial 42

Burial 42

This grave contained a male aged over 40 years at death. He lay partially below burial 36, a female, the cranium being 3.32 m below datum. He was associated with the complete skeleton of a very young pig, which lay to the left of the body. There was also a pottery vessel, and the first glass beads encountered with a burial, 44 being found in the general area of the body, along with 42 shell disc beads in the vicinity of the cranium.

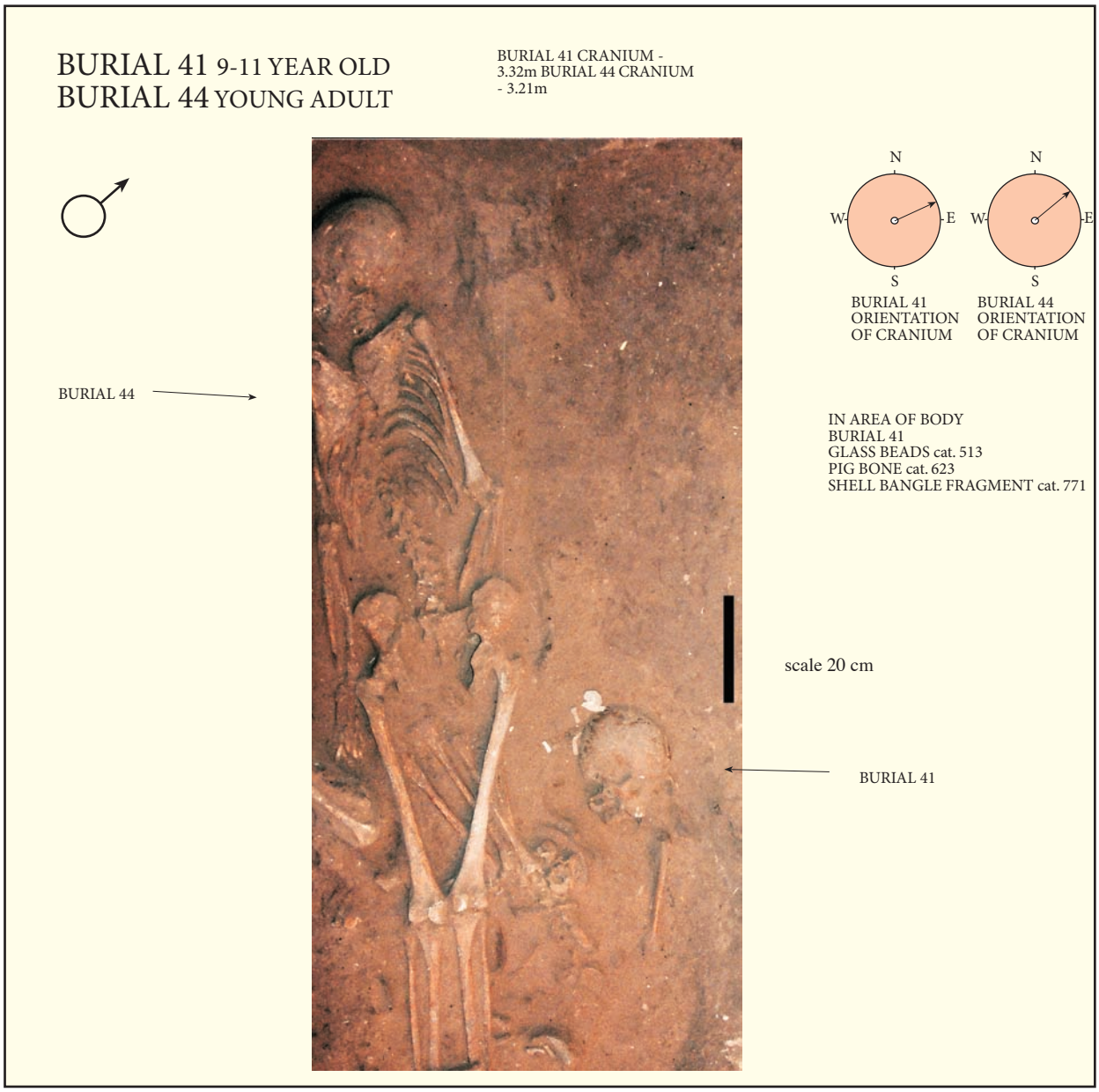


FIG. 9:3 Burials 41 and 44

Burials 44 and 41

This young male was interred lying prone over burial 41, that of a child. No grave goods were encountered. Burial 41 itself was disturbed with the interment of burial 44. The child, aged between 7 and 11 years at death, was found with some scattered glass beads, some pig bone and part of a shell bangle.



FIG. 9:4 Burial 36

Burial 36

The remains of this woman, aged 20-25 years at death, overlie burial 42. The head was orientated 70° east of north. Only three bronze finger rings were associated.

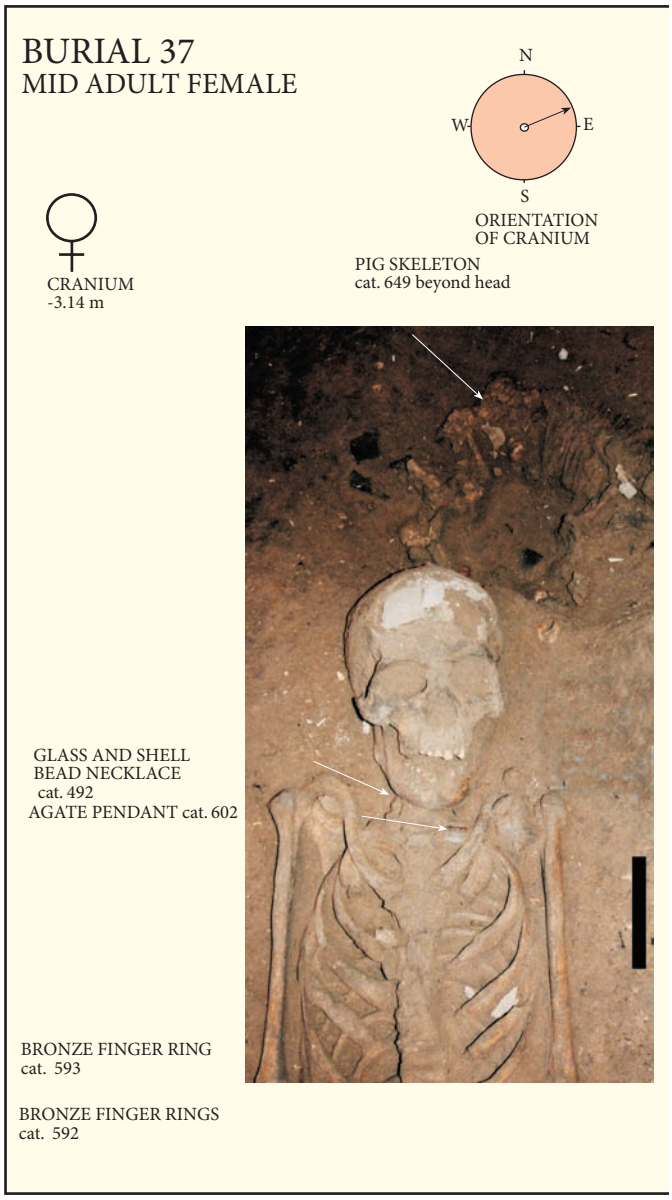


FIG. 9:5 Burial 37. Scale 10 cm

Burial 37

This older female, who died when aged over 40 years, was found alongside and to the north of burial 36. She was undisturbed. Her grave offerings included the first agate pendant found in a mortuary context, as well as bronze finger rings, five on the left hand and four on the right. Glass beads (n=217) and four shell beads were found in the area of the neck, and presumably comprised a necklace. The complete skeleton of a young pig was found beyond the head. Only two such finds were made, both in this group of burials.



FIG. 9:6 Burial 37, showing the pig's skeleton beyond the cranium. Scale 5 cm



FIG. 9:8 Burial 38, the mortuary vessel and lid (cats. 748-7)



FIG. 9:7 Burial 38



FIG. 9:9 Burial 24. The mortuary jar above, and cat. 395, the vessel containing a valve of *Hyriopsis*, below

MORTUARY PHASE 3 CLUSTER A: SUMMARY

The burials belonging to this cluster were found at depths of between 2.95 and 3.40 m. The latter belongs to the isolated infant burial 24. The main cluster of inhumations was found between 3.15 and 3.32 m below datum. No grave cuts were encountered, but if the depth of an inhumation grave was at least 50 cm, as is seen in later and earlier examples where a cutting has been identified, then phase 3 burials would have been excavated from at least layers 4:7 and possibly from has high as 4:5-4. The relevant radiocarbon dates from the layers from which the graves probably originate suggest that they were belong within the first two centuries AD.

This group of graves presents some singular features. There are very few pottery vessels. Indeed, only the infant mortuary jars have survived intact. They contain the earliest recorded agate neck pendant and glass beads, but bronze ornaments are rare, being confined to nine finger rings. No iron grave goods were identified. Two complete young pigs' skeletons had been placed with the dead, an unusual feature in the context of the mortuary assemblage as a whole.

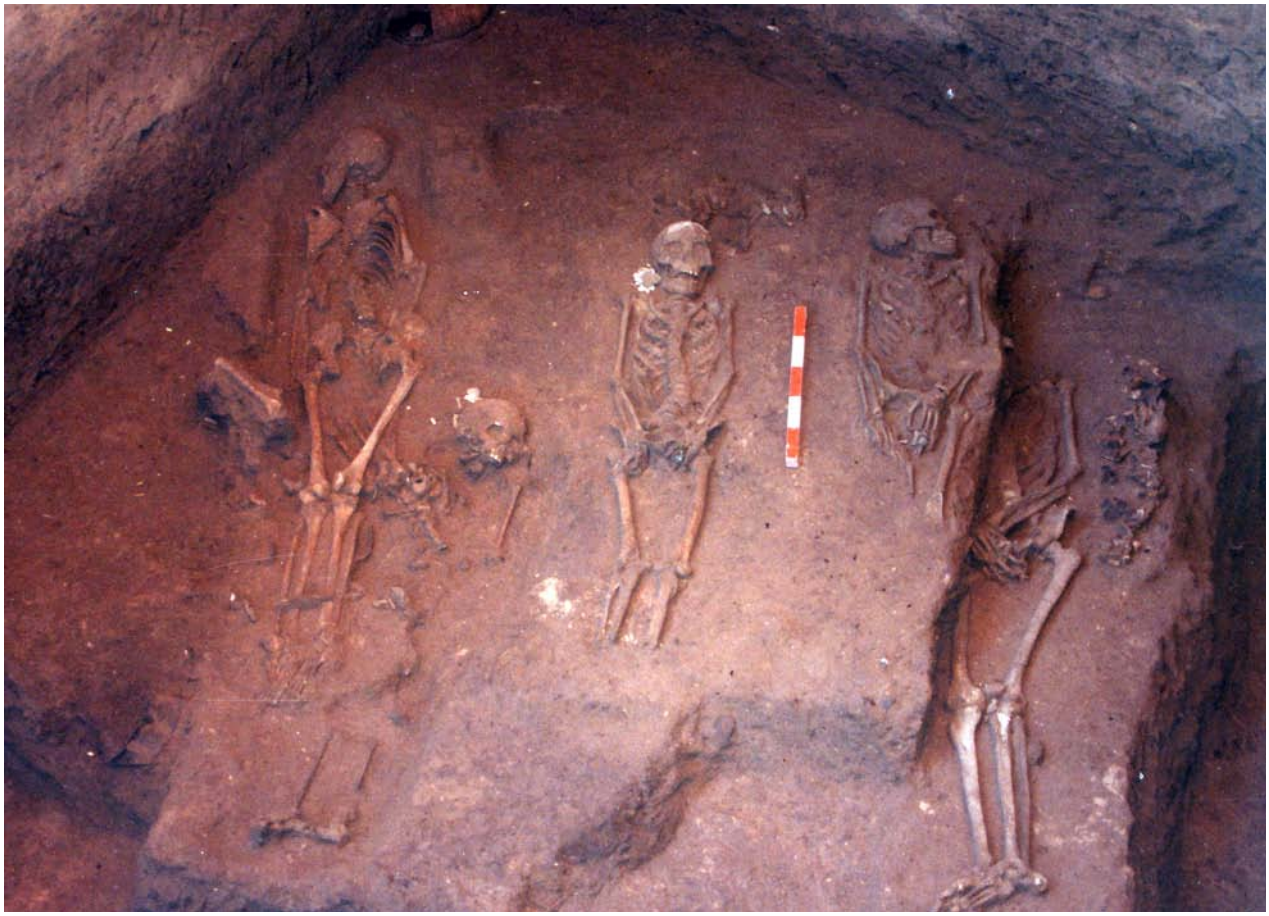


FIG. 9:10 The burials comprising cluster 3A

X. THE BURIALS OF MORTUARY PHASE 3 CLUSTER B

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Cluster B of the third mortuary phase comprises a tightly-nucleated set of graves with a preferred orientation with the head to the northeast. There are five adult males, six adult females, three adults of unknown sex and four infants. The graves were liberally filled with white silificied rice chaff, but no clay linings or cappings were noted. The skeletons lay between 2.42 and 3.03 m below datum, and it is clear that earlier interments were disturbed as new graves were prepared. Due to the liberal use of rice, the bones were usually very poorly preserved.

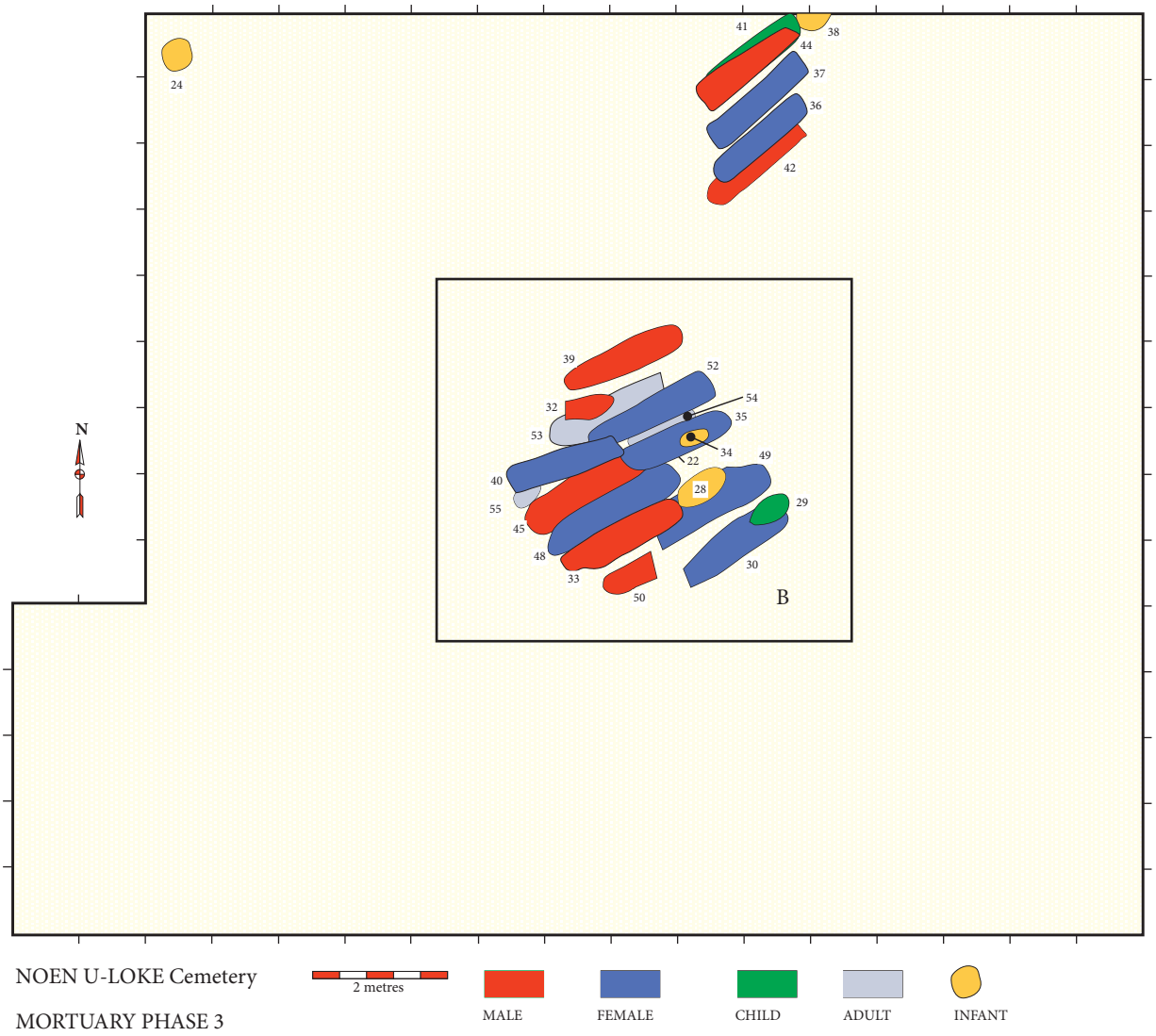


FIG. 10:1 The distribution of graves in mortuary phase 3 cluster B

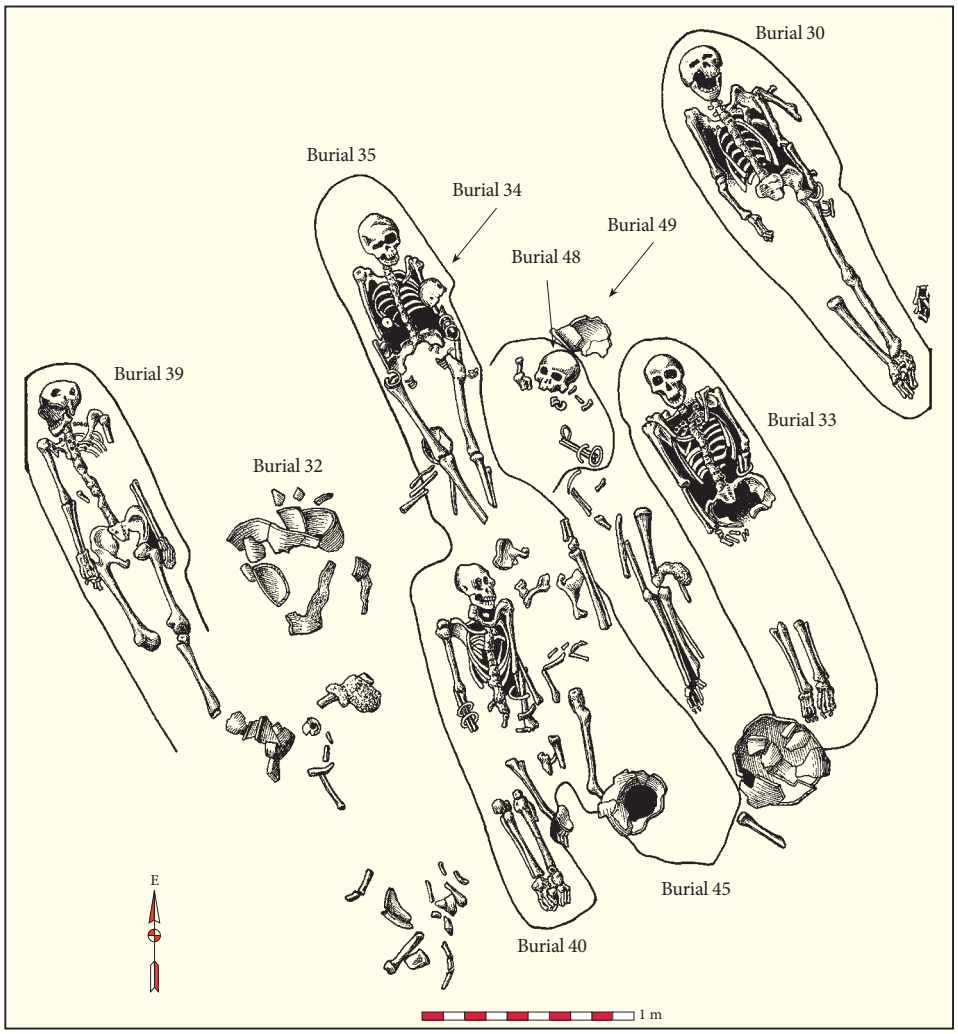




FIG. 10:2 The distribution of the upper layer of graves of mortuary phase 3 cluster B. These graves are relatively intact

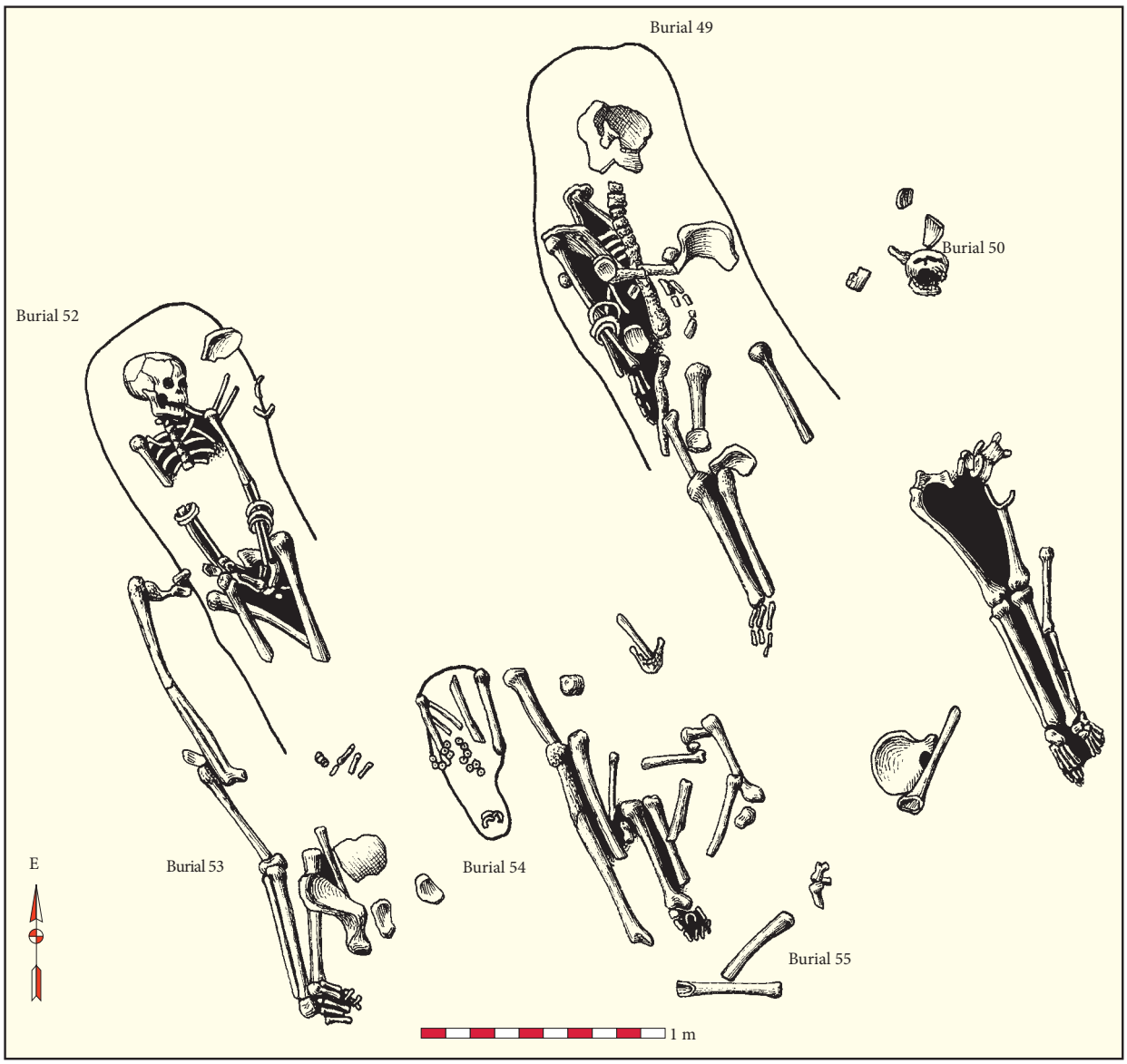


FIG. 10:3 The earlier layer of burials comprising mortuary phase 3 cluster B. The burials were in many cases disturbed with the addition of the burials of the upper layer

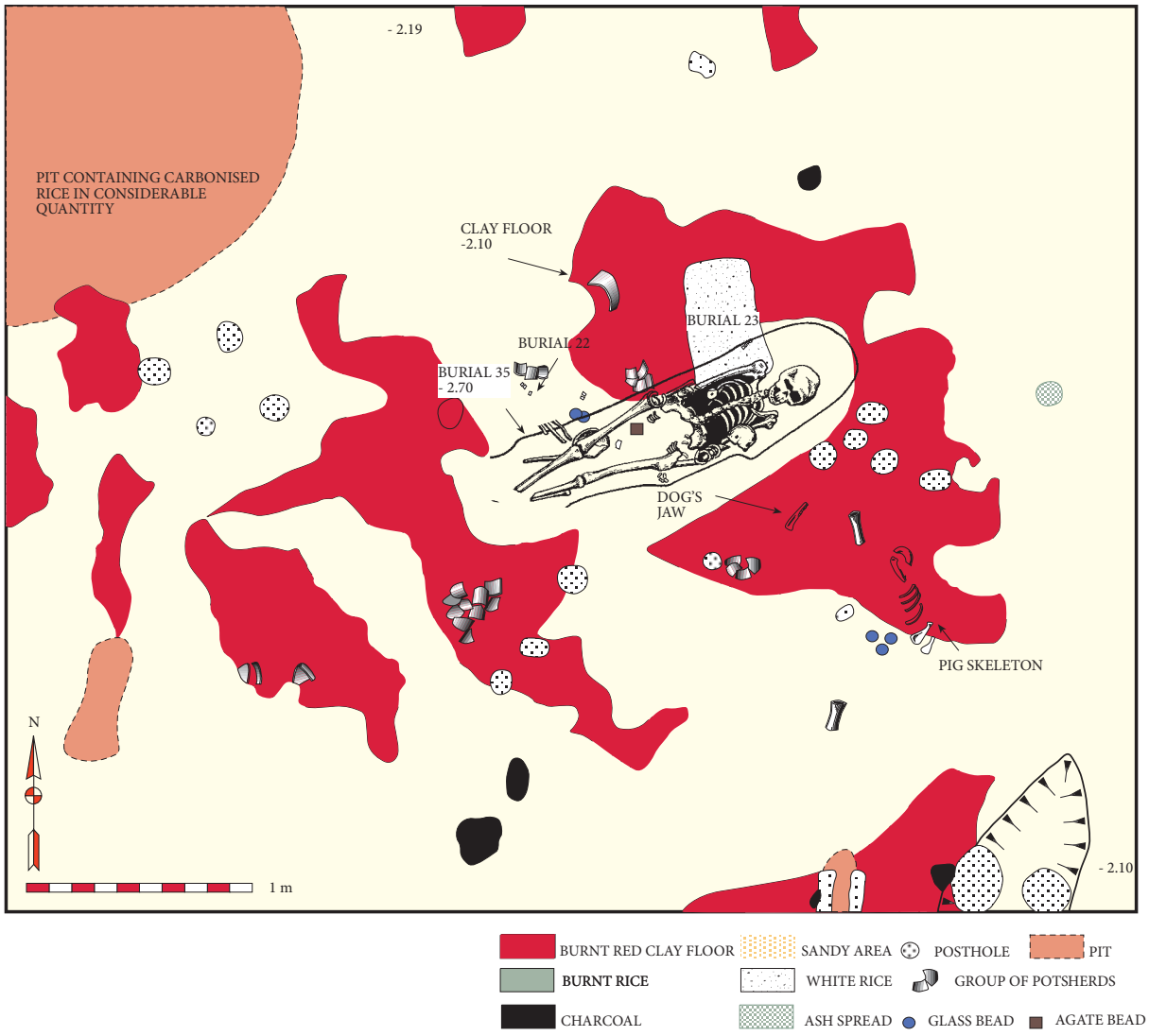


FIG. 10:4 A closeup plan of layer 4:3 in square B2, showing the surviving areas of a burnt clay floor, part of a pit and associated areas of burning. Burial 34 has been superimposed on this plan. This burial was found at a depth of 2.70 m below datum, while the floor lay at a depth of 2.10 below datum. While other burials in cluster 3B were sealed by the floor, this burial seems to have been cut through it, suggesting that the floor was in use during the accumulation of this cluster of graves

Burial 32

Only the cranium and some scattered limb bones of this adult male survived at a depth of 2.52 m below datum. He wore a glass bead necklace and two carnelian beads were found in the vicinity of the skull. A bronze bangle and four spindle whorls were also found in the general area, but these are not in assured relation to the burial.

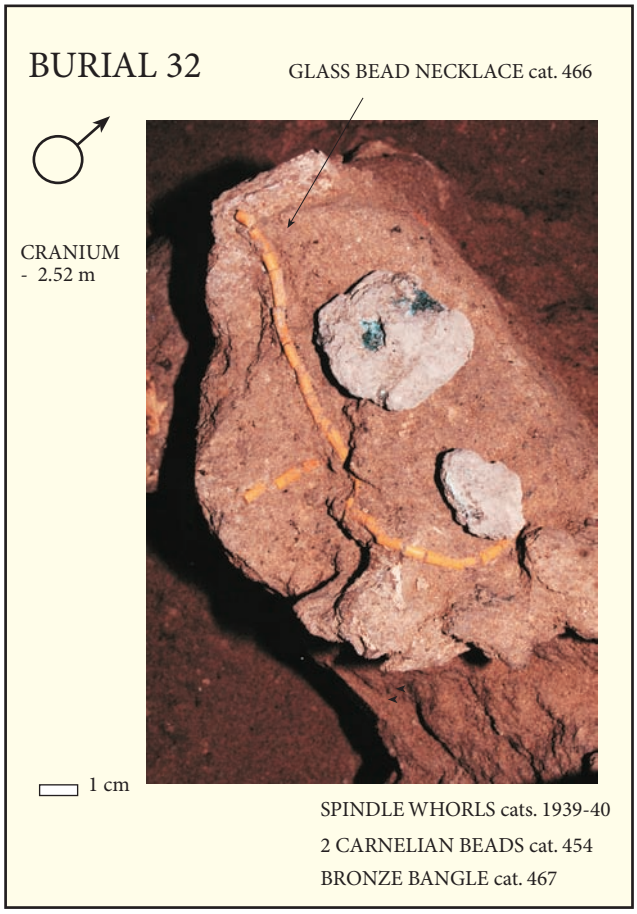


FIG. 10:5 Burial 32

Burial 33

This burial of a 25-30 year-old probable male was identified by its grave cut of white rice at a depth of -2.62 m below datum. The body was orientated with the head pointing 70° to the east of north. He wore a glass bead necklace while an agate pendant was found in the pelvic area. There was a bronze bangle on the left arm, and other fragments of bronze, together with a spindle whorl, in the grave fill.

Burial 39

The skeleton of this young male, aged between 20-25 years at death, was found in a rice bed grave at a depth of 2.65 m below datum. The body was orientated 65° to the east of north. He wore four bronze finger rings on his left hand, a bronze bangle on the right hand and a necklace of glass beads. After the skull was removed and turned, a remarkable bronze spiral ornament was revealed.



FIG. 10:6 Burial 33

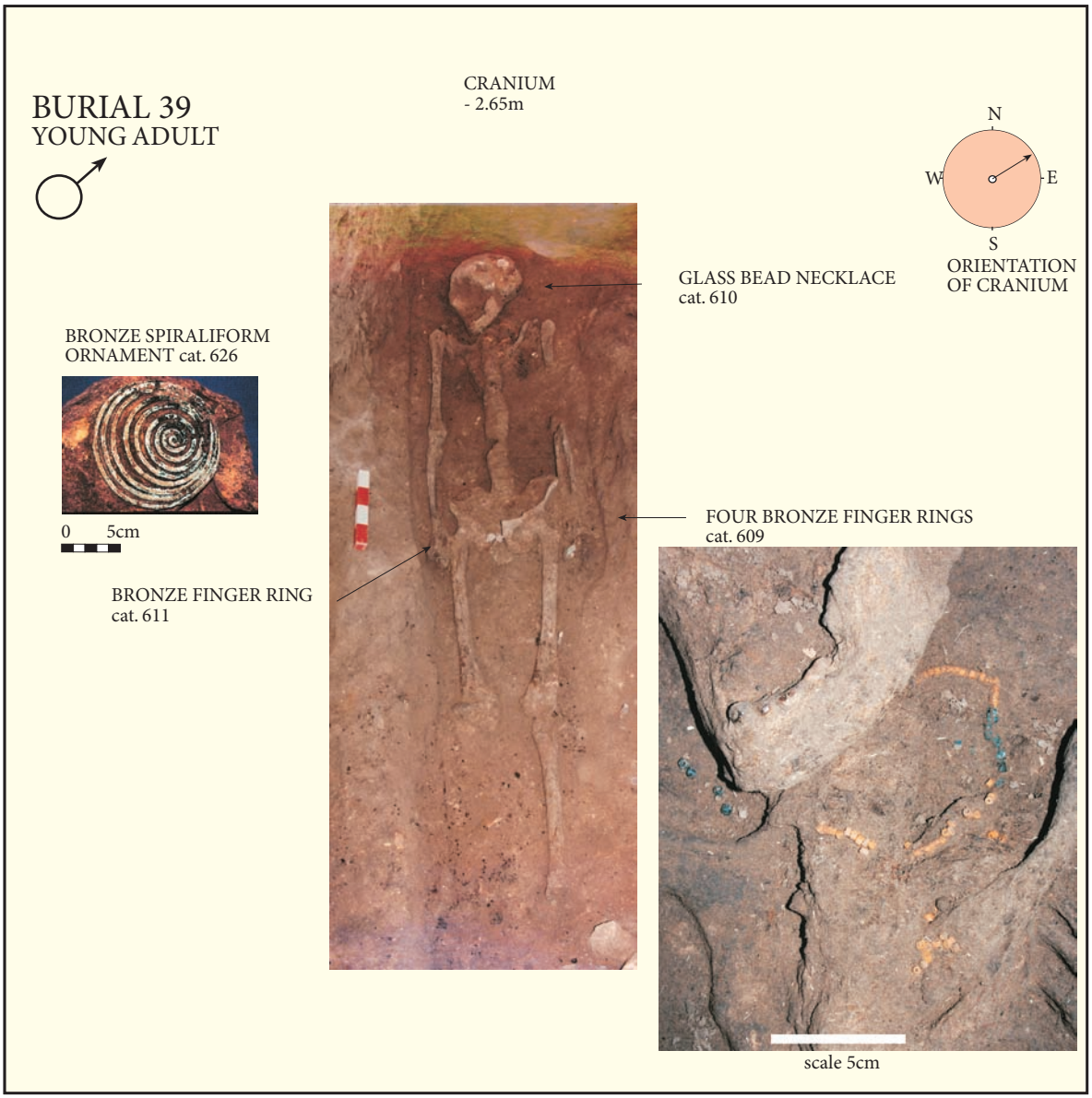


FIG. 10:7 Burial 39

Burial 45

The bones of this probable male, who died when aged betwen 25-30 years of age, were recovered at a depth of -2.70 m below datum. The skeleton was orientated with the head directed 70° east of north, but had been very badly disturbed. The cranium lay under the left femur of burial 35, and the disarticulated limb bones were positioned to the east of burial 40. An agate pendant and 11 glass beads adjacent to the skull are the only goods which could with confidence be ascribed to this burial, although a pottery vessel lay in a position beyond the ankles, and at a depth of - 2.63 below datum.

Burial 50

This burial involved a probable male aged between 20-25 years at death. Again, the skeleton lay in a rice bed, found at a depth of -2.91 m. The skull had been disturbed, the upper limbs are missing and only the body from the pelvis to the toe bones is in place. The man wore a necklace of glass and agate and a carnelian bead, while a bronze ring and five fragments of bronze were found in the area of the body.

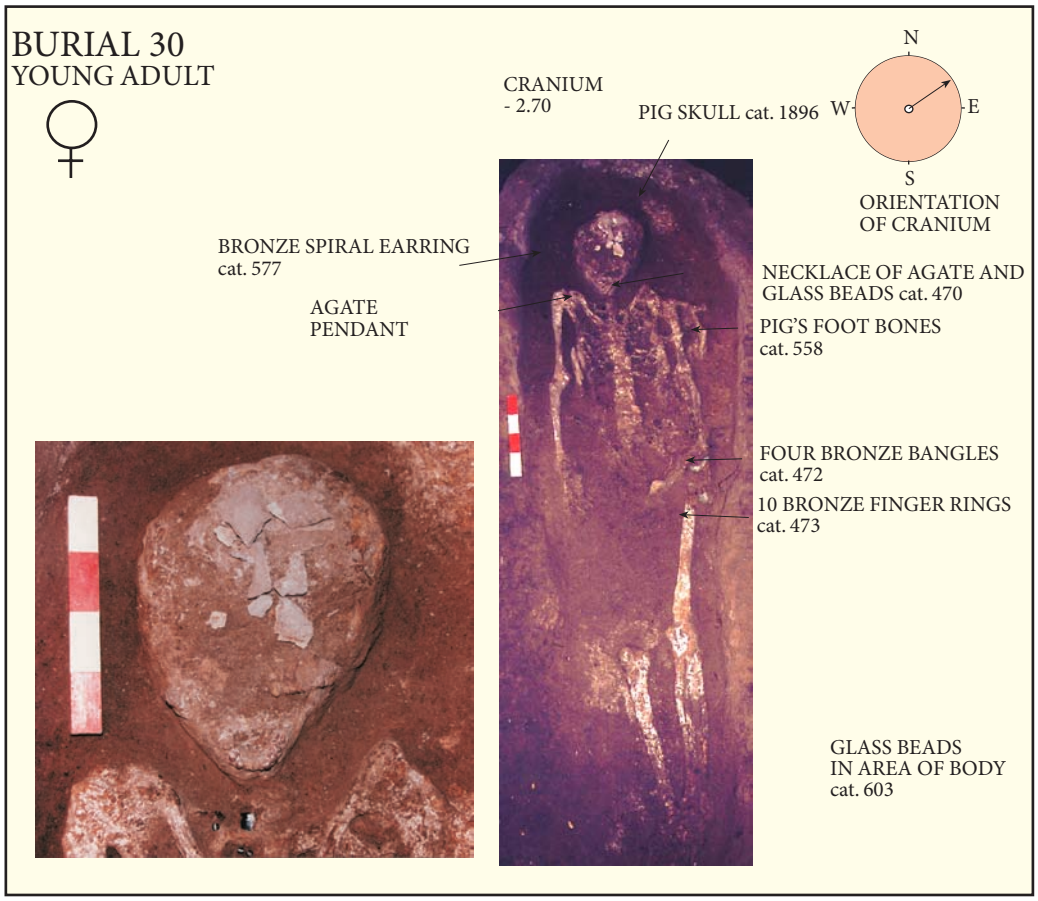


FIG. 10:8 Burial 30

Burial 30

Burial 30 was first encountered as a silhouette of white silicified rice at a depth of 2.61 m below datum. The skeleton was found complete save for the right femur, but the bones were in a very poor condition due to the organic matrix in which they had lain. This young woman, who died when aged under 25 years, wore a necklace of nine agate beads and glass beads, and an agate pendant at the neck. She also had a bronze spiraliform earring, four bronze bangles and ten bronze finger rings, all on the left arm. A young pig's foot bones lay by the left shoulder, and the skull of a very young pig, possibly the same animal, rested beside the head. Further glass beads were found in the area of the body, which was orientated with the head pointing 60° to the east of north.

Burials 34 and 35

This grave of a 35-40 year-old woman was seen as a white silhouette of silicified rice at a depth of 2.59 m below datum. The cranium of burial 34, that of an infant or a child, lay on the left forearm of the adult, the bones of which were 2.70 m below datum. The woman wore a necklace of agate and glass beads, and further, an agate pendant was present at the neck. Bronze ornaments comprised four bangles on the left arm and two on the right, five finger rings on the right and and 11 on the left and a flat spiral bronze on the left ear. There were three spindle whorls, one at the right elbow, a second at the neck and the third over the abdomen.

Burial 40

This 20-25 year-old woman was found, in a rice bed grave, at a depth of 2.71 m below datum. Her body was orientated at an angle of 70° east of north. Her grave was located beyond the ankles of burial 35, and adjacent to burial 45. She wore an agate pendant at the neck, and a single glass bead was found at her feet. She wore three bronze bangles on the right wrist, and three on the left. There were also two spindle whorls over the chest area, and a pig's skeleton lay the left of the left shin.

Burial 48

The skull of this 25-30 year-old female lay on its side, together with some bundled limb bones, just north of burial 49, and alongside burial 33. It was found at a depth of 2.81 m. The grave goods found in association with the bones comprised two carnelian beads, five bronze bangles on the arm and a spindle whorl in the area of the chest.

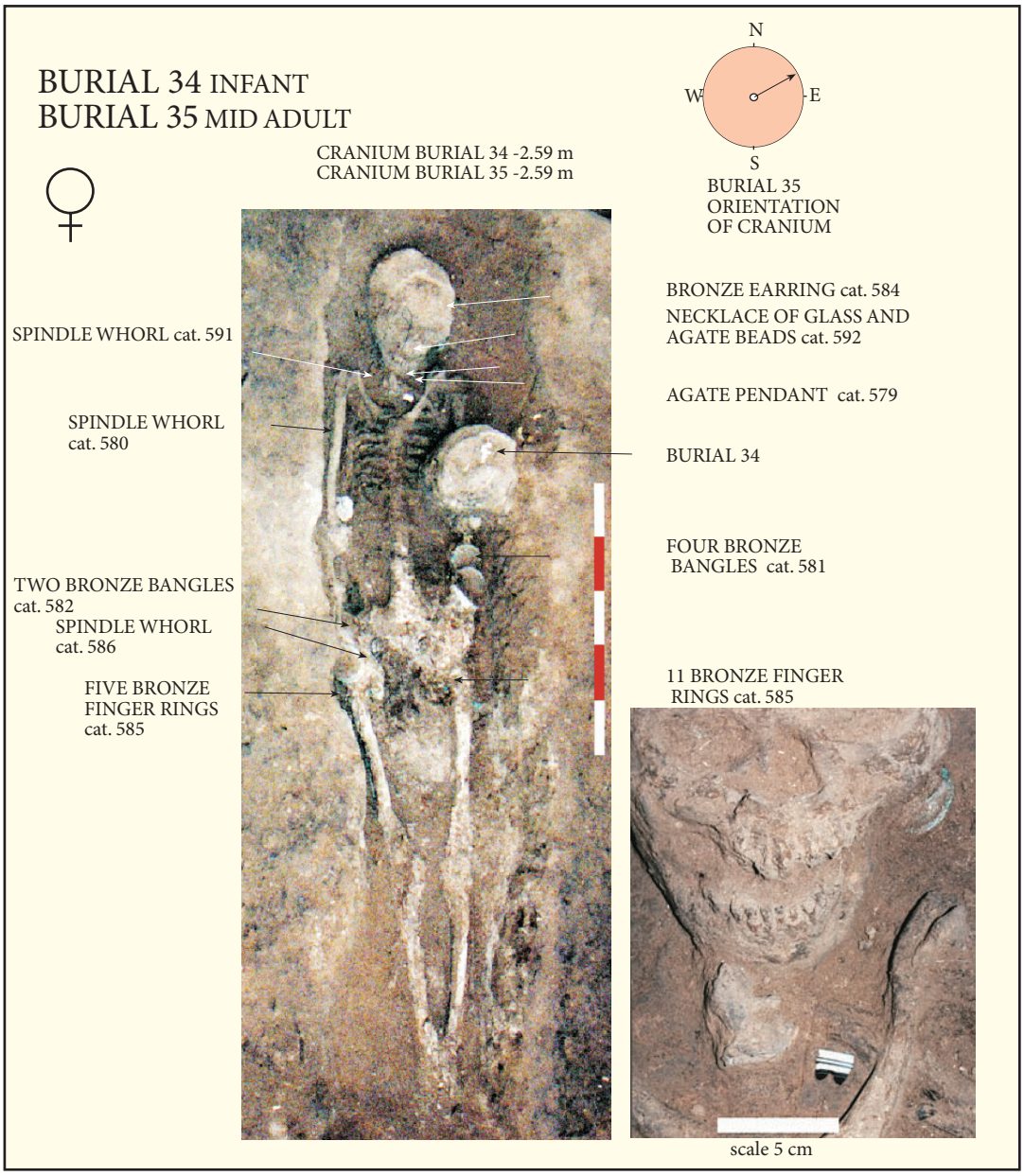


FIG. 10:9 Burials 34 and 35

Burial 49

The remains of a woman aged betwen 35-40 years at death were found in a grave filled with white rice, at a depth of 2.92 m below datum. The bones lay parallel with burial 33, on an angle with the head pointing 65° east of north. The grave goods comprised a necklace of at least two agate and seven glass beads, a carnelian bead, two bronze bangles at the right elbow and the mandible of a very young pig.

Burial 52

The rice-filled grave of this woman, who died when aged over 40 years, was found at a depth of 2.88 m below datum. Her interment disturbed burial 53 just to the west, and burial 54 to the west. She wore a necklace of glass beads with one carnelian bead, and two agate pendants were found in the neck area. There were two bronze bangles on the right wrist, and three on the right. A spindle whorl was found in the area of the body.

Burial 53

This grave contained the remains of an adult, whose body was disturbed with the inhumation of burial 52. The skeleton lay at a depth of 3.03 m below datum, but the cranium was never found. Nevertheless, glass and carnelian beads in the neck area indicate that this adult wore a necklace. In addition, bronzes incorporated six finger rings on the right hand and three on the left, and three toe

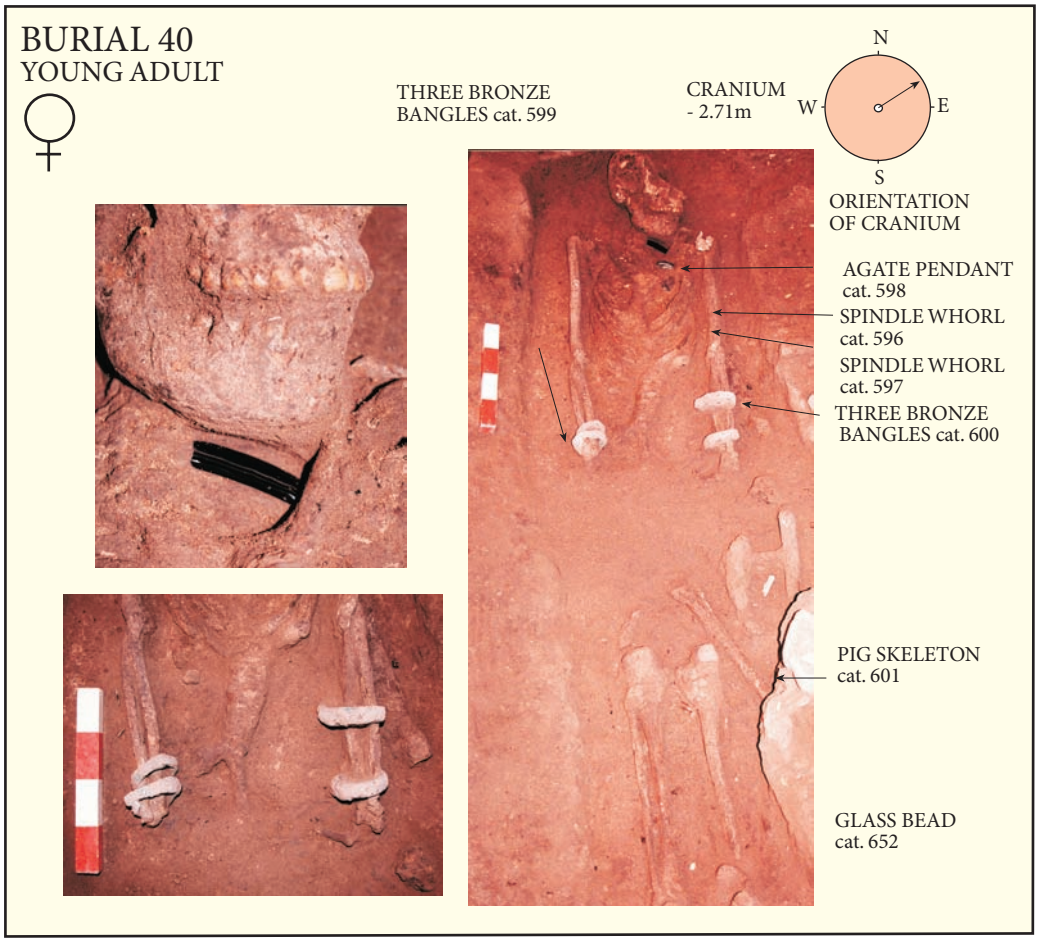


FIG. 10:10 Burial 40

rings on the right foot and four on the left.

Burial 54

Only the tibiae and foot bones of this adult interment survived, at a depth of 2.72 m. On the left foot, this person wore an anklet decorated with 21 bronze bells, and six bronze toe rings. Two glass beads were also found in the vicinity of these bones.

Burial 55

Only the foot bones of this adult were recovered, at a depth of 3.03 m below datum. Two spindle whorls and a glass bead were found in the vicinity of the bones.

Burial 22

Catalogue 358 comprised a concentration of potsherds at a depth of 2.13 m below datum, incorporating the teeth of an infant aged between 3-5 years. Some agate and glass beads were found in the vicinity. This burial might belong to the cluster of adult graves at a lower depth in this area.

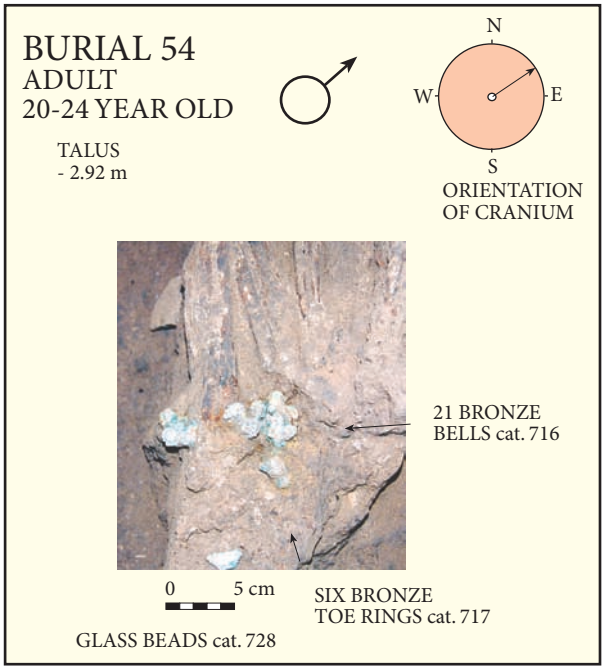


FIG. 10:11 Burial 54

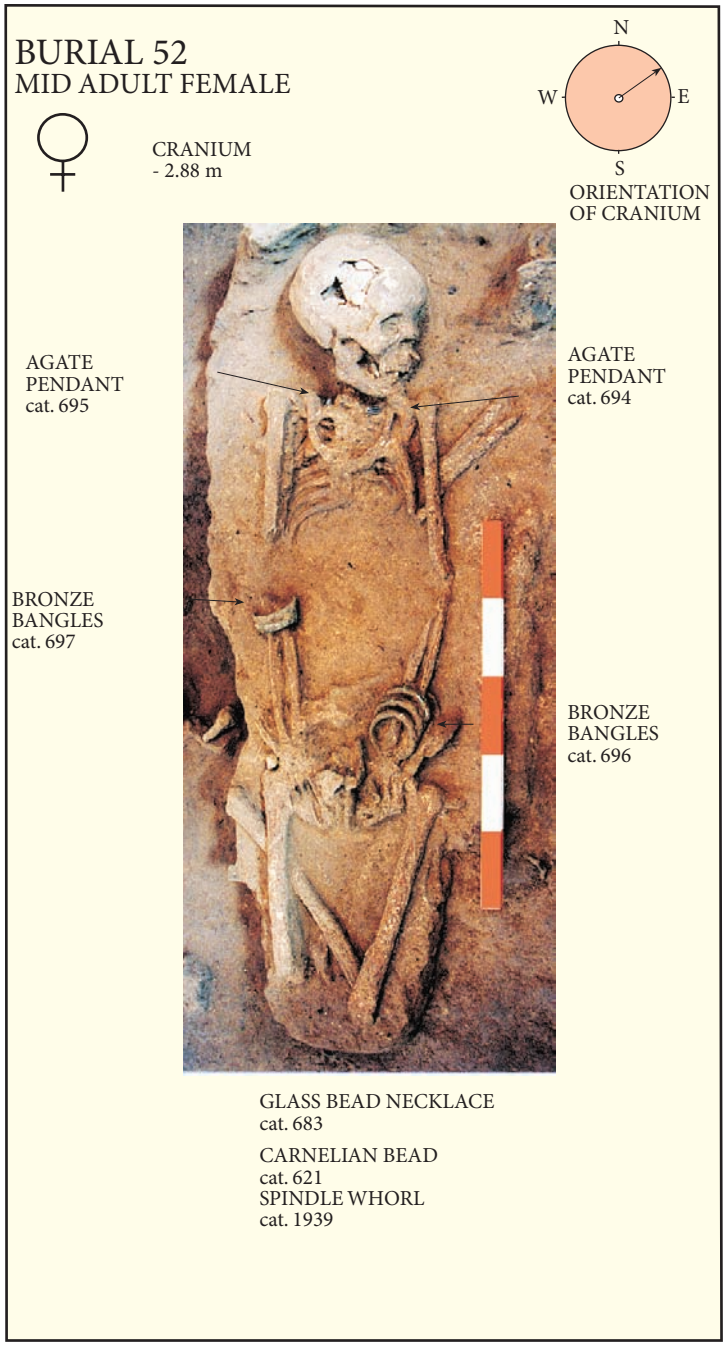


FIG. 10:12 Burial 52

Burial 28

A rice bed grave was found at a depth of 2.42 m below datum. It contained some very fragmentary infant bones, in conjunction with the phalanges of a water buffalo in articulation, part of a pottery vessel, the foot bones of a pig, a spindle whorl and some fragments of bronze. The orientation of the grave matches that of the adults found at a lower level in this cluster.

Burial 29

This seriously disturbed grave contained the remains of a child aged 3-6 years at death. The area of the bones, recovered at a depth of 2.51-2.61 m below datum, included a spindle whorl, orange glass beads, an agate bead and part of a bronze ring.

CLUSTER B: SUMMARY

This cluster maintained the tradition of the orientation seen with mortuary phase 3 cluster A. It also continued in the preference of placing pig remains with the dead, while

pottery vessels were again, rare or absent from burial contexts. Whereas the bones of cluster A burials were found at depths of 3.14-3.32 m, cluster B interments lay between 2.42-3.03 m. It seems likely therefore, that the latter were later. They are also characterised by the inclusion of rice in the graves. There is also stratigraphic and structural evidence which shows that this cluster is earlier than mortuary phase 4 interments. A burnt red floor covers and seals most of the cluster B burials at a depth of 2.13 m below datum. This indicates that the graves were cut from this level or lower. However, burials 30 and 35 were not covered by any of the red floor, and the latter apparently lies within a potential cutting through it. This applies also to the infant burials 22 and 23.

The purpose of this red burnt clay floor remains enigmatic. It might have been a domestic structure. Potsherds, a pig skeleton and calcined dog bones lay on its surface. However, it could equally have been a clay mortuary structure built over this tight cluster of burials, save that three or four late additions to the cluster were cut through it. The excavation of a larger area of this site might indicate whether or not such floors are regularly found over mortuary clusters of this particular stage, before individual clay cappings were provided as with mortuary phase 4.

The grave goods associated with cluster B reveal a lack of interest in pottery vessels, but necklaces made of glass and agate beads are regularly encountered. Virtually every carnelian bead found during the excavations were associated with this cluster. Some bronze bangles and finger or toe rings were present and spindle whorls were regularly found with the dead.

The demographic structure of cluster B reveals an approximate match between males and females, but the rarity of infants or children is particularly notable.

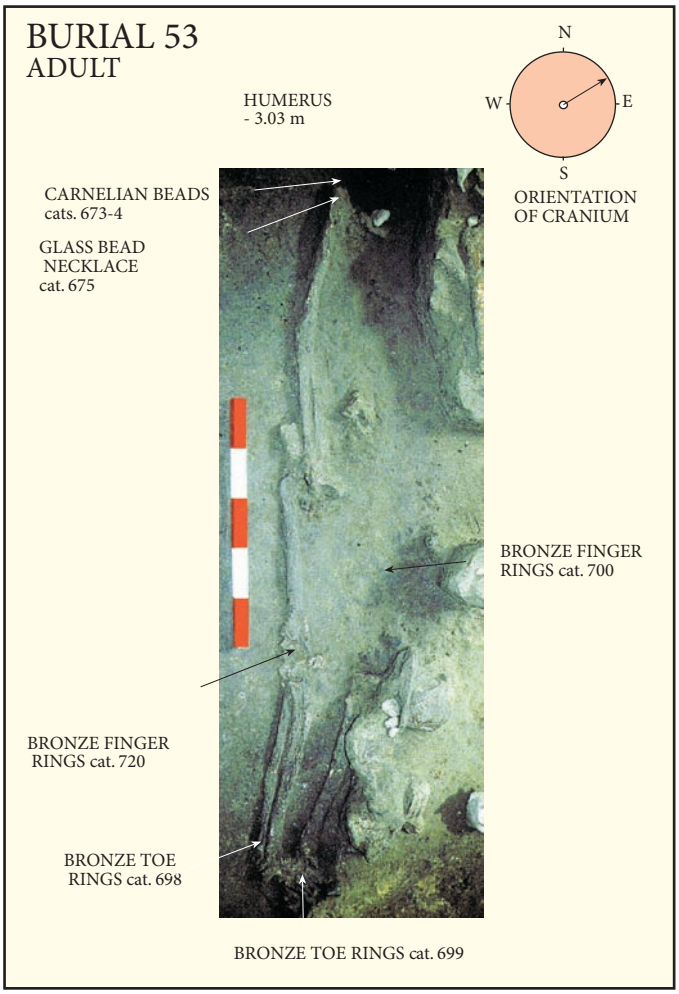


FIG. 10:13 Burial 53

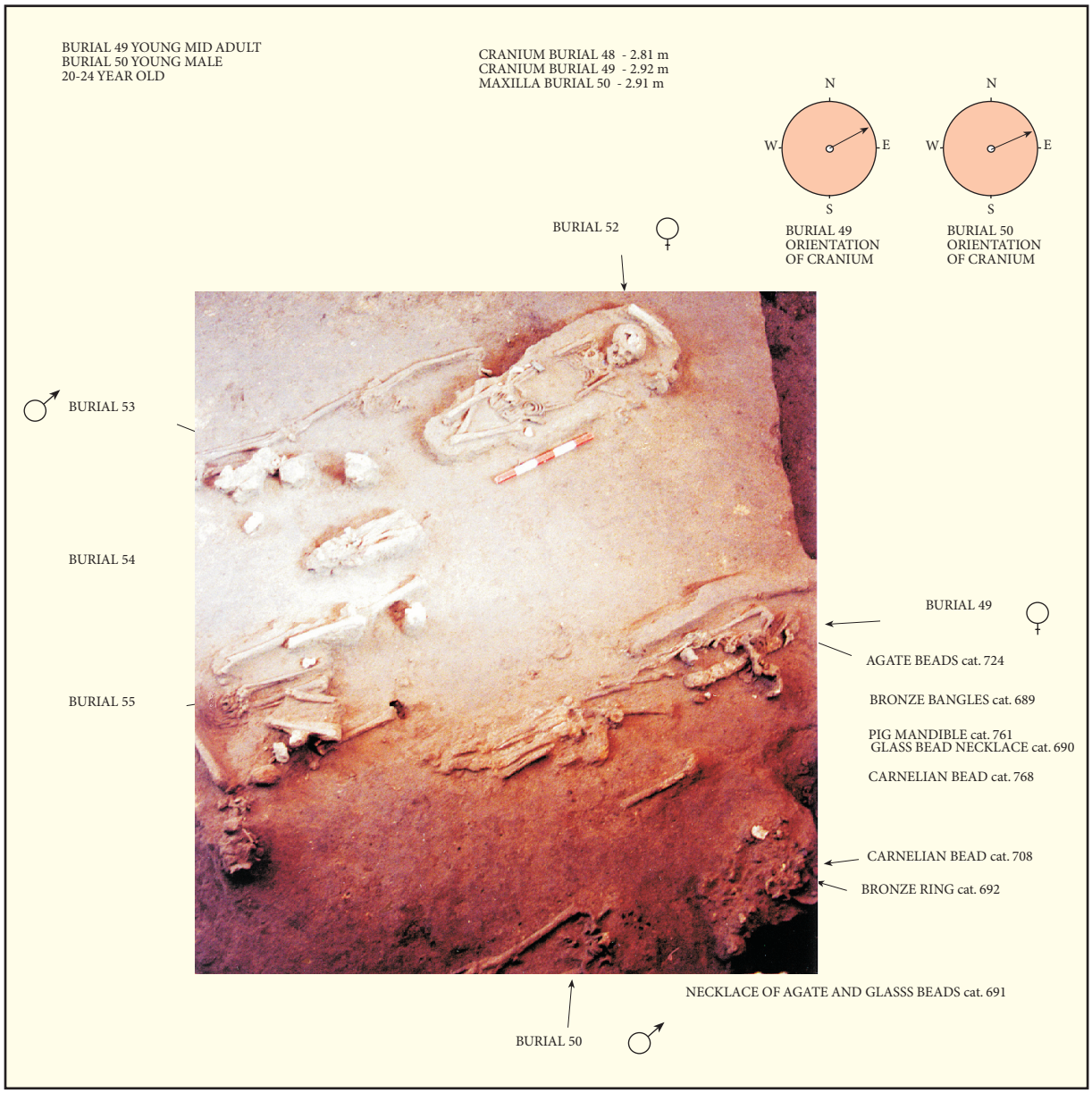


FIG. 10:14 The earlier graves of cluster C, mortuary phase 4

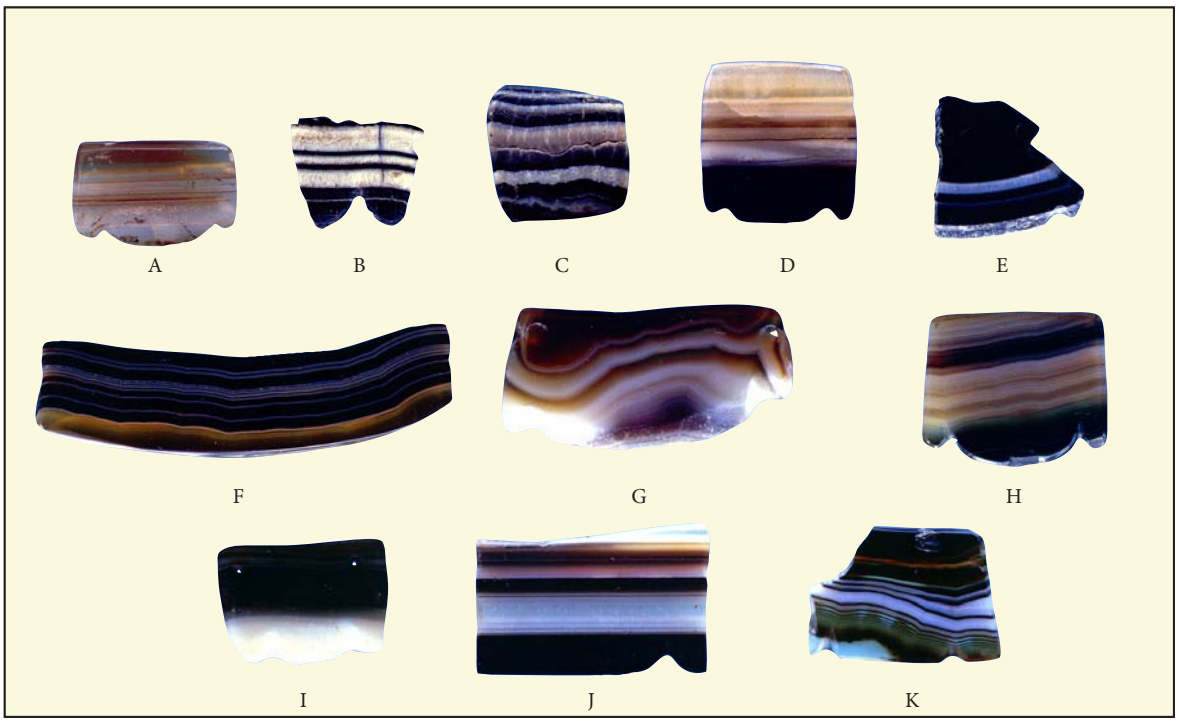


FIG. 10:15 Agate pendants from phase 3B. A. cat. 602 burial 37. B. cat. 579 burial 35. C. cat. 694 burial 52. D. cat. 557 burial 30. E. cat 570 burial 33. F. cat. 598 burial 40. G. cat. 616 burial 45. H. cat. 695 burial 52. I. cat. 337 B2 4:3 feature 12. J. cat. 679 B2 4:11. K. cat. 729 B2 4:12 feature 1. Scale 1:1

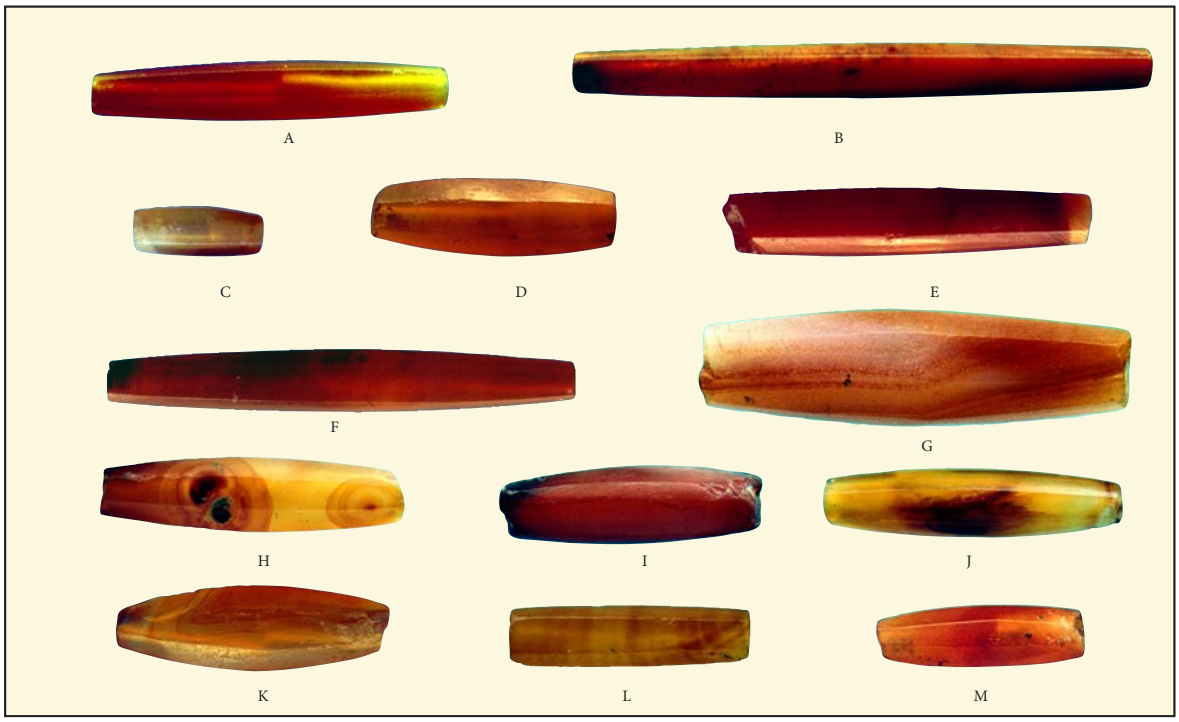


FIG. 10:16 Carnelian beads from mortuary phase 3B burials. A. Burial 32 cat. 508. B. Burial 32 cat. 454. C. cat. 729 4:12 feature 1 D. Burial 48 cat. 1933. E. Burial 50 cat. 708. F. Cat. 436 B2 4:7 feature 1. G. Burial 48 cat. 664. H. Cat. 416 B2 4:6 feature 10. I. Burial 53 cat. 673. J. Burial 53 cat. 674. K. B2 4:8 cat. 620. L. Burial 49 cat. 768, M. Burial 52 cat. 621. Scale 2:1

XI. THE BURIALS OF MORTUARY PHASE 4 CLUSTER A

C.F.W. HIGHAM AND R. THOSARAT

Phase 4 burials were set out spatially in clusters. Cluster A lies to the west of the excavated area, and it is highly likely that more burials remain to be uncovered. The nucleus of these graves is outlined in figure 11:1, while four nearby burials found at approximately the same depth are highlighted with a broken line. These burials lie at depths of up to 2.73 m below datum, but fortunately, it has been possible to identify the top of some graves, since they were capped and lined with clay. These indicate that the burials were excavated from depths of approximately 1.80 m. Burial 80 was found to be 90 cm deep. The graves include the remains of men, women, and infants, but the area was used as a burial ground over a sufficient time span for earlier burials to be disturbed, thus exacerbating the designation of sex on the basis of relatively fragmentary remains.

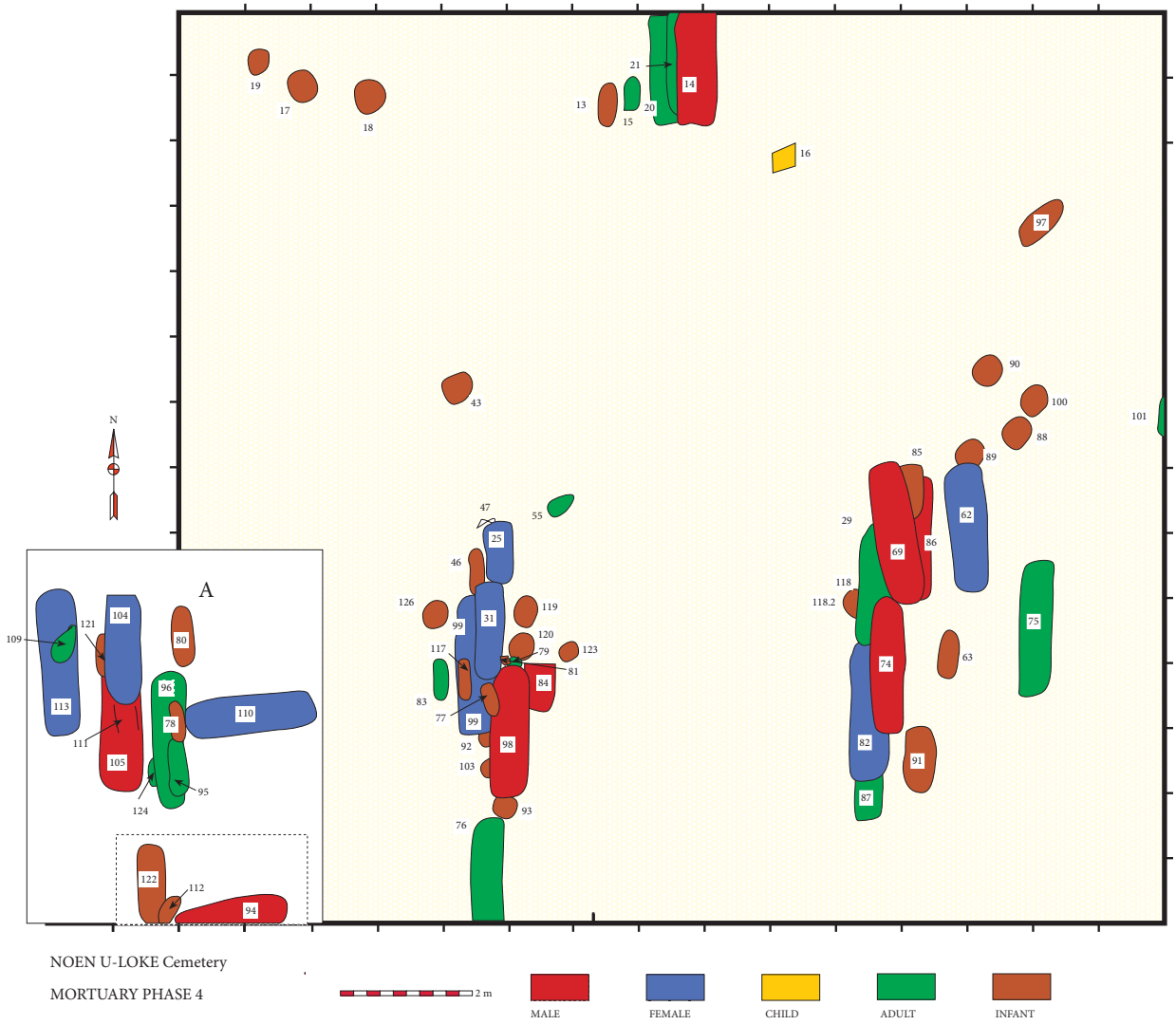


FIG. 11:1 The layout of mortuary phase 4 burials, showing the location of cluster A and burials which might belong to cluster A

Burial 105

This interment of an adult male was first recognised as a clear grave cut capped with clay at a depth 1.80 m in layer 3:13. The body itself lay, with the head orientated 5° east of south, at a depth of 2.57 m. Unfortunately, it had been disturbed in prehistory, but many grave goods were recovered if not always in a known relationship to the body. This grave was also rich in the remains of white, silicified rice. Filling the grave with white burnt rice was a regular feature of phase 4 burials. The general area of the body included parts of a bronze belt, two iron blades, 494 glass beads, fragments of bronze, an iron point and a bimetallic ring. At least eight pottery vessels were associated, four beyond the head area, one by the left arm and three by the ankles. Bronze ornaments were relatively abundant, for in addition to the bronze belt, there were 17 toe rings on the right foot and 25 on the left. It is notable that the rings on the big toes were larger than the others. A silver bangle was found in the area of the left hand, and a spindle whorl lay in the vicinity of the ankles.

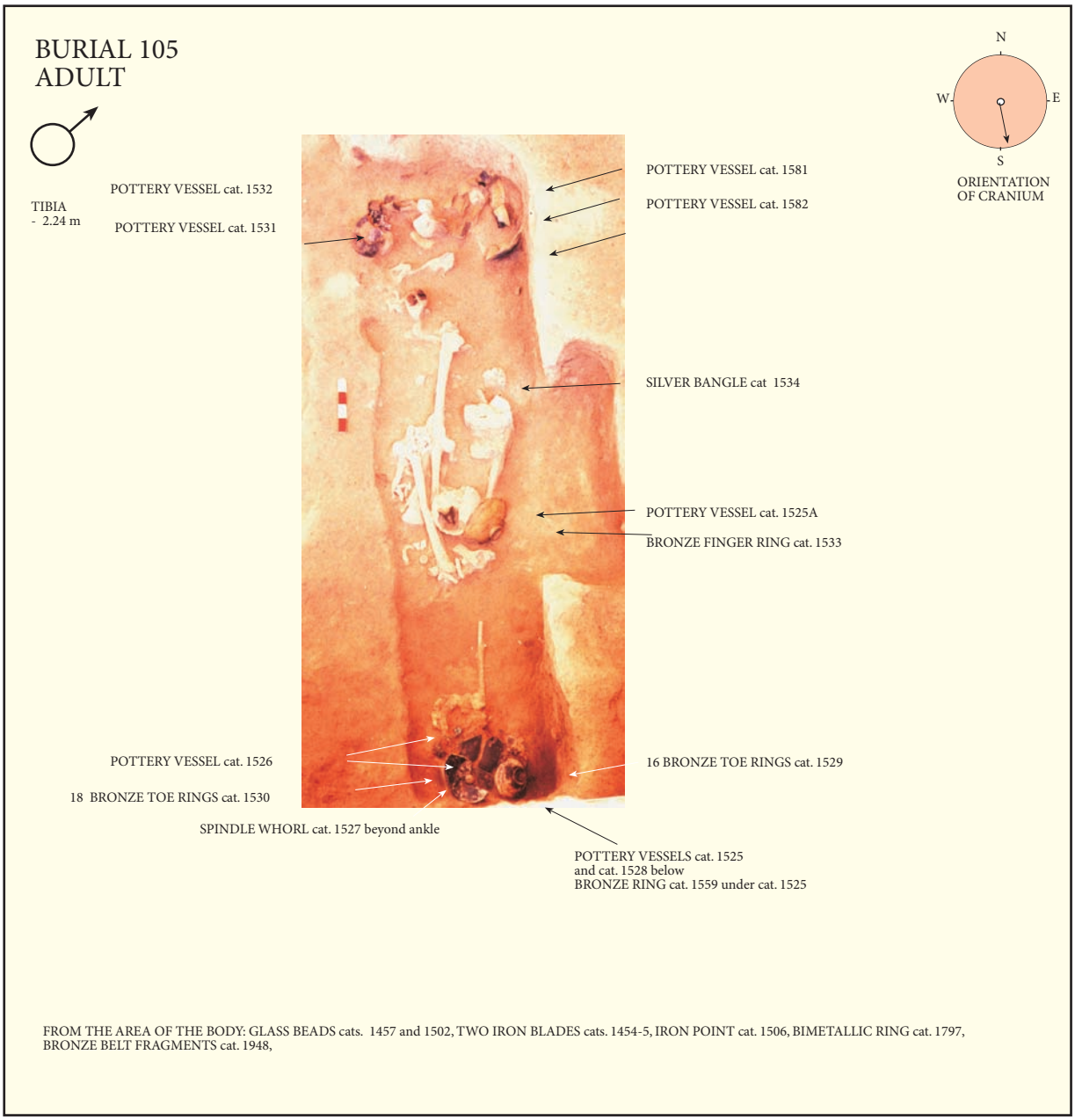


FIG. 11:2 Burial 105

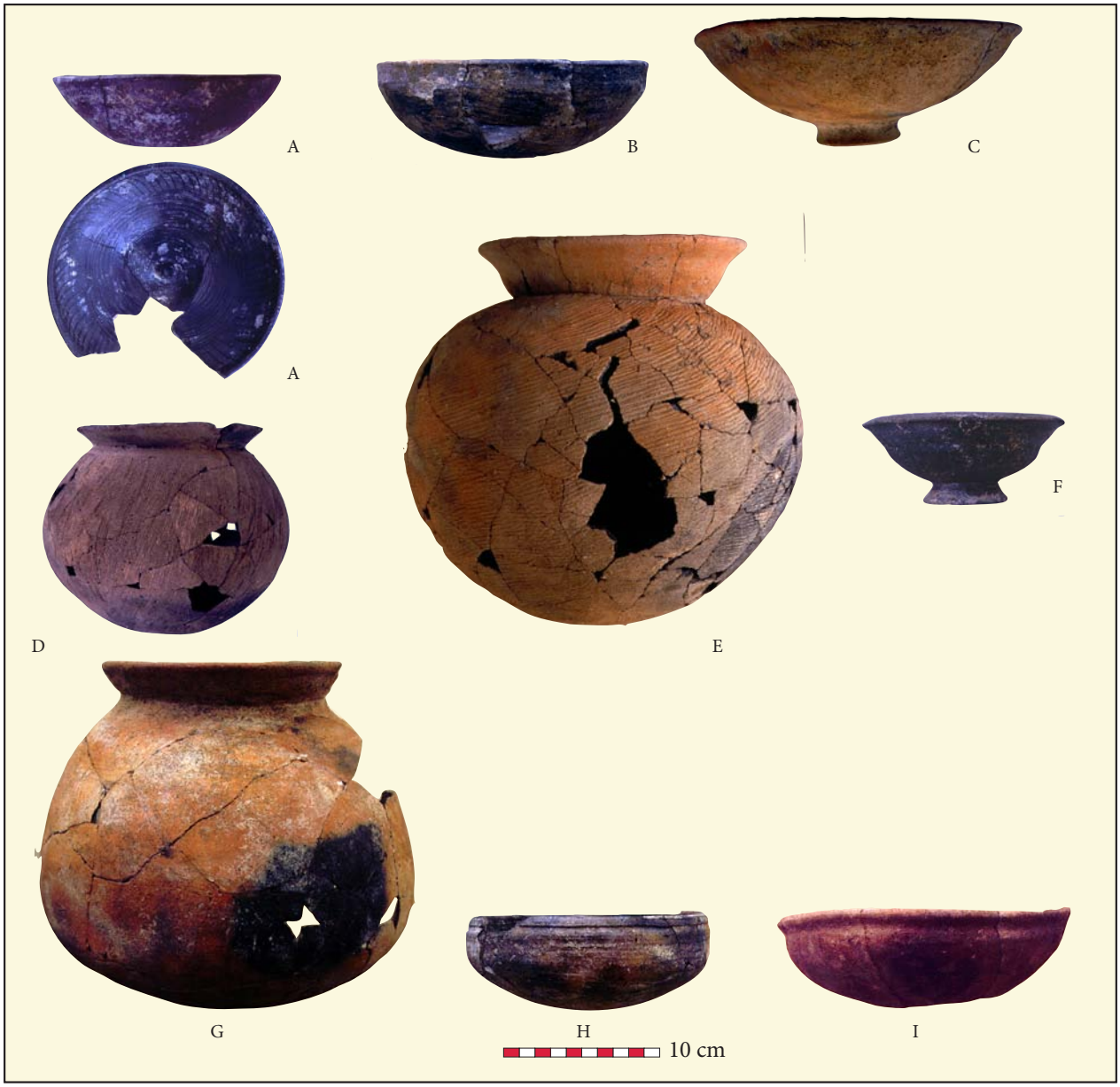


FIG. 11:3 The pottery vessels associated with burials 105 and 104. A. burial 105 cat. 1526, B. burial 105 cat. 1582, C. burial 105 cat. 1581, D. burial 105 cat. 1531, E. burial 105 cat. 1532, F. burial 105 cat. 1525, G. burial 104 cat. 1650A, H. burial 104 cat. 1650B, I. burial 104 cat. 1650C

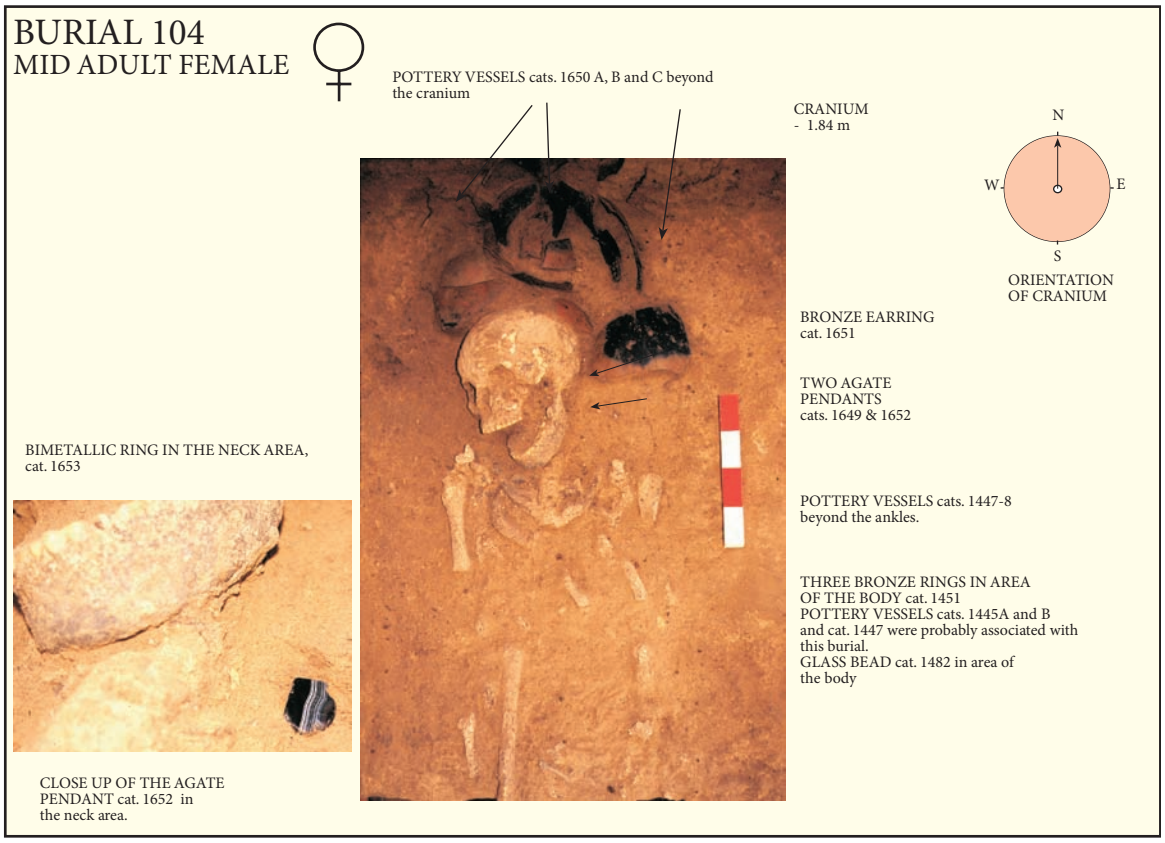


FIG. 11:4 Burial 104

Burial 104

Burial 104 contained the remains of a 25-30 year-old woman. The upper part of her skeleton was found intact, but the lower limbs were in disarray, probably as a result of the later interment of burial 105. Therefore the scattered remains of pottery vessels in the vicinity of the foot bones are not in certain association. Three pottery vessels were found beyond the cranium, and she wore two agate pendants in the area of the neck. Other ornaments included a bimetallic ring, a bronze ear ring on the left ear, and a bronze spiral together with five glass beads in the area of the body.

Burial 113

Burial 113 involved a woman aged about 25-30 years at death. Her grave was lined with clay, including a clay capping, and contained white burnt rice. For this reason, the bones were not well preserved. The lower limbs were only partially present within square X1, and the upper body including the cranium was opened to excavation after the lower limbs had been removed. Consequently, there is no photograph of the entire skeleton. Moreover, there are probably further grave goods to the west and north of the grave which remain unexcavated.

Nevertheless, this woman was interred with a considerable range of grave goods, most notably a necklace comprising 68 gold beads and many agate beads. She also wore two agate pendants at the neck. Four pottery vessels lay beyond the cranium. She also wore many bronze ornaments: two ear spirals, 38 or more bangles, 64 finger rings and nine toe rings. She wore a silver finger ring on her left hand and a silver toe ring on the left foot. Over her upper left arm, there lay an iron knife blade, covered in the remains of fabric. A bimetallic ring lay under her head. Burial 113 thus represents one of the richest interments of this cluster and mortuary phase.

Burial 96

This adult was found almost intact, with the head orientated 50° east of south. The right femur lay 2.61 m below datum. The grave had been filled with white burnt rice. A pottery vessel had been placed over the head, but when removed, it was found that an iron blade lay over the lower part of the face. This person wore at least one bronze torc and a bronze earring on the left ear. Other bronzes included a bangle on the upper right arm, a further ring or bangle under the pelvis, 14 bronze finger rings on the left hand and five others scattered in the vicinity of the hands or recovered from the flotation chamber, part of at least one and probably more belts, two bells and many fragments of ring or bangle. The grave was not undisturbed, and further items were found in the general area of the body, including a second iron blade, and glass beads.

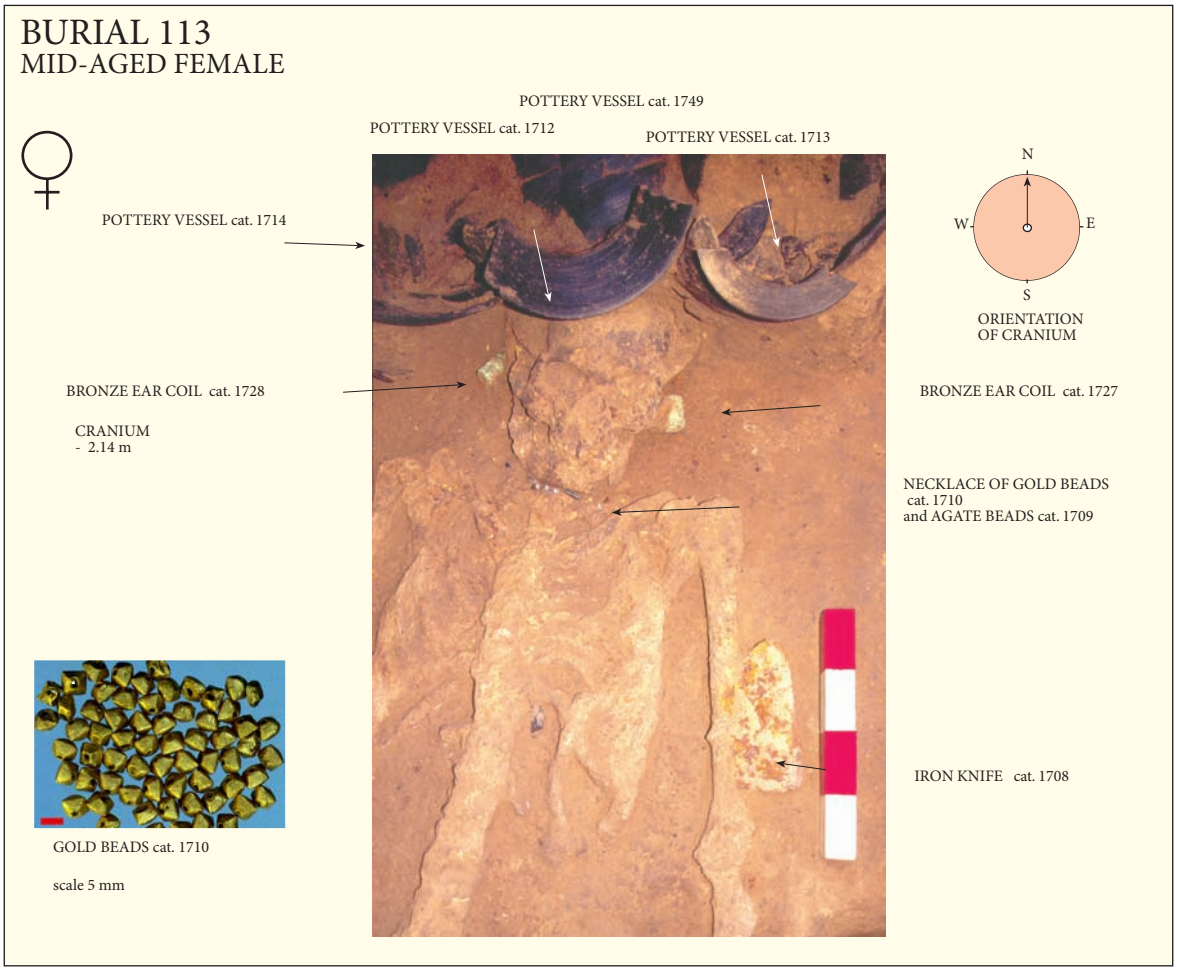


FIG. 11:5 Burial 113: the upper part of the skeleton



FIG. 11:6 Pottery vessels from burial 113. A. cat. 1713, B. cat. 1712, C. cat. 1714, D. cat. 1749

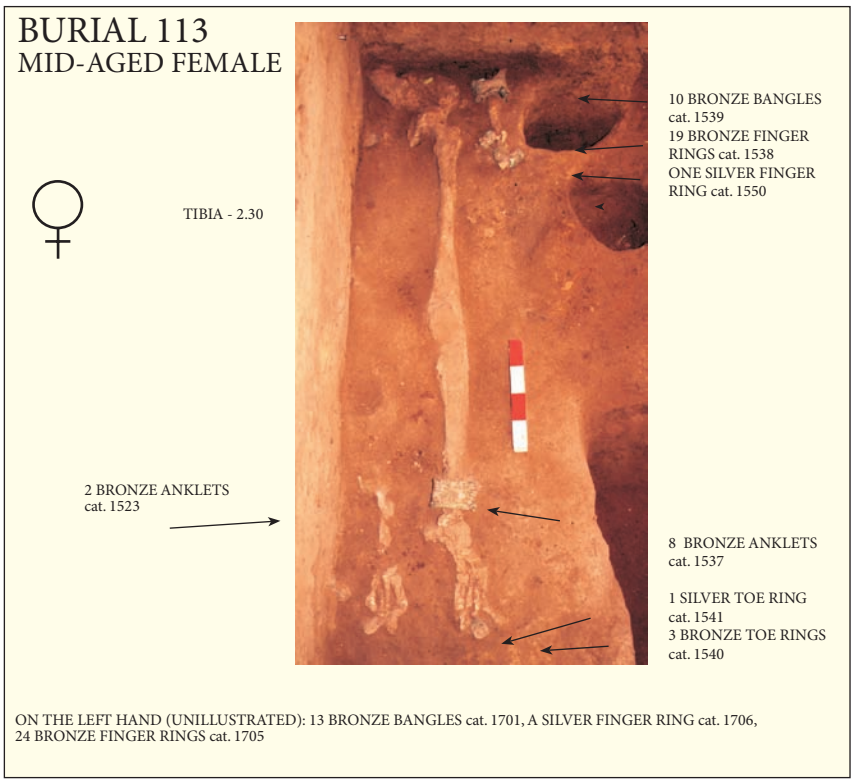


FIG. 11:7 Burial 113: the lower part of the skeleton

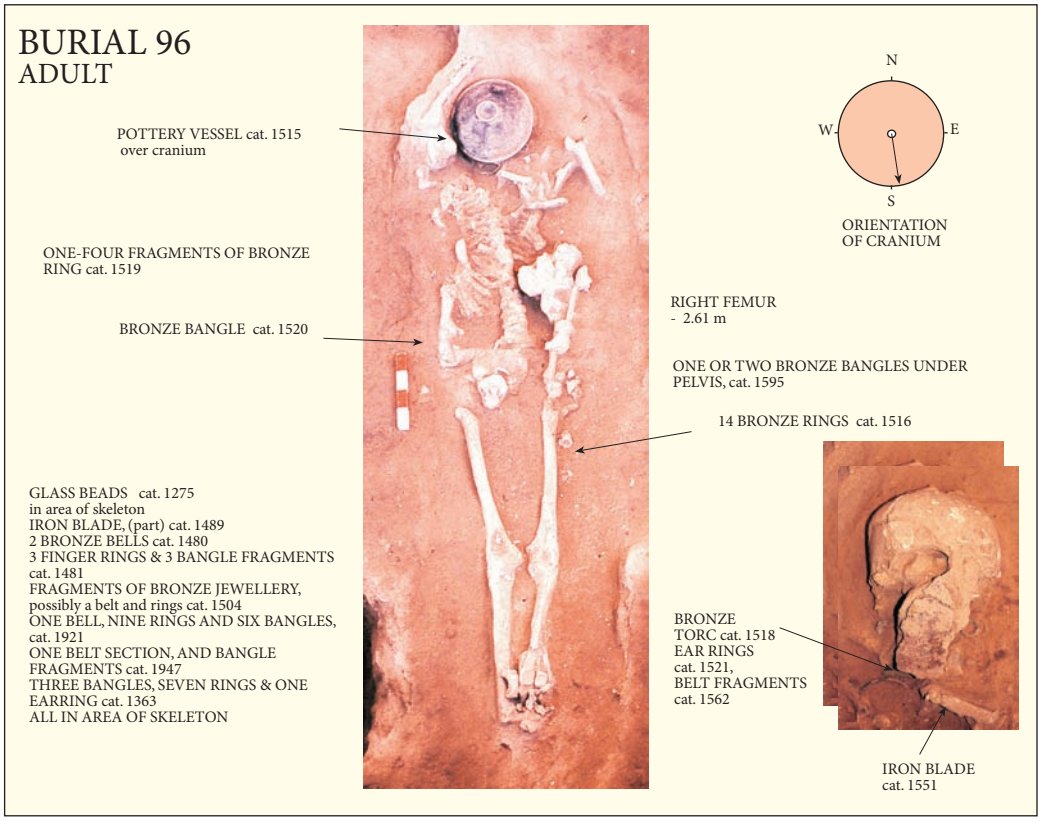


FIG. 11:8 Burial 96

Burial 111

The remains of this probable male, who died when aged between 25-30 years, overlie the grave of burial 105. It is considered likely that this results from the relocation of the remains when the grave for burial 105 was cut. Grave goods include a pottery vessel adjacent to the cranium. The fragments from one or possibly two bronze belts were found which probably belong to this individual. There were also six or seven bronze rings, and a strip of silver. The silver was found under the cranium, and might once have been part of a necklace.

Burial 124

Only the foot bones of this adult interment were found, for the burial had probably been cut into and disturbed by burial 96. The bones were accompanied by 21 bronze bells and a glass bead.

Burial 95

This burial was seriously disturbed, and only the human foot bones have survived. However, a relatively large corpus of mortuary offerings was found as follows: two pottery vessels, a socketed iron tool in the form of an axe or hoe, glass beads, six bronze rings, a bangle fragment and several fragments of bronze.

Burial 109

The grave cut for this interment was noted on the surface of layer 4, but the bones within were heavily disturbed, and no grave goods could be assigned other than a small piece of bronze.

Burial 78

The remains of this adult, aged 30-35 years at death, were found bundled within a grave filled with white burnt rice. An agate bead was found in the vicinity of the cranium, and other grave offerings were restricted to glass beads, a fragment of bronze, and part of a bronze spiral earring.

Burial 80

No human bones were found in this grave, but the disposition of the mortuary offerings indicate that it was the grave of an infant. The grave silhouette was first recognised at a depth of 1.81 m below datum, while the offerings were encountered 90 cm lower, in a bed of white burnt rice. Many bronzes accompanied the infant, which was probably interred with the head pointing to the north. Ten bangles were found on the right wrist

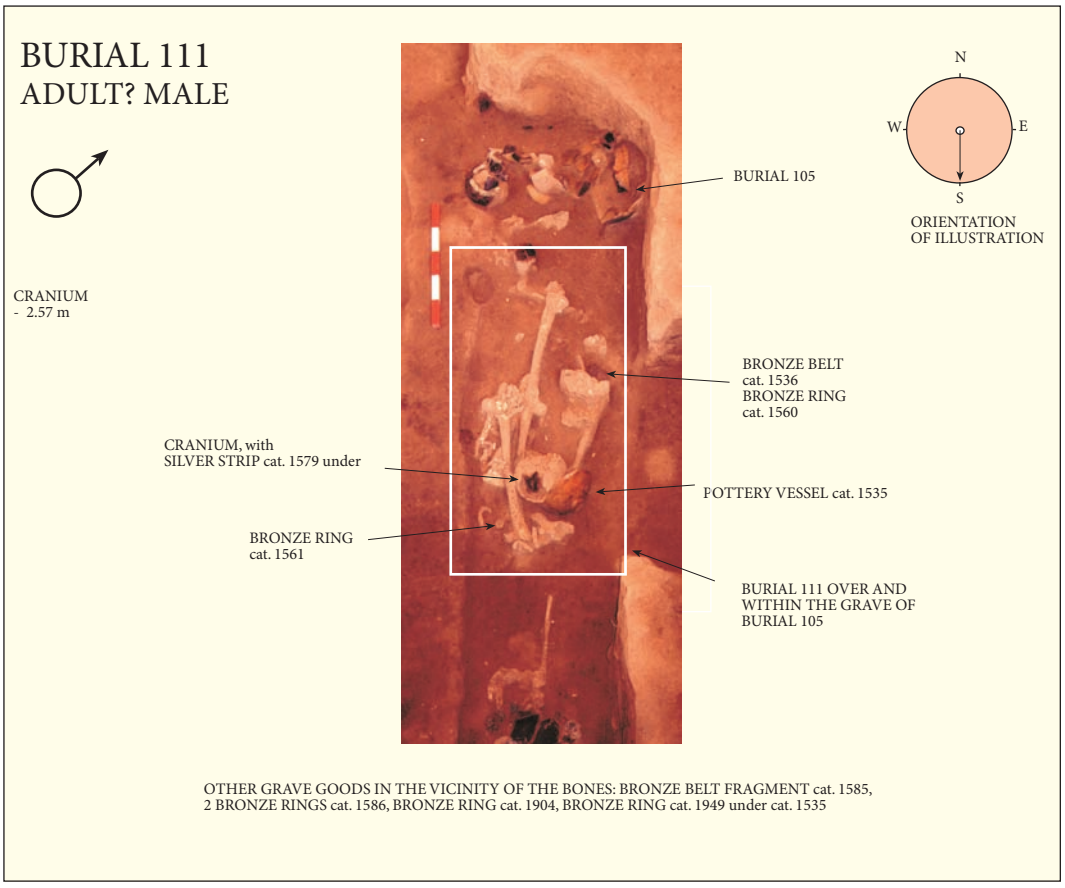


FIG. 11:9 Burial 111

and about seven on the left. The right ankle had 12 anklets, the left three. A necklace with agate and glass beads was found, and a spindle whorl lay by the right hand. Finally, a pottery vessel had been placed beyond the feet.

Burial 112

The bones of an infant were found in a pit in layer 3:8. Aged about three years at death, it was associated with some loose adult human bone.

Burial 121

The cutting for this grave, which contained the very fragmentary bones of a three-month-old infant, was recognised on the surface of layer 3:13 at a depth of 1.80 m, while the human remains lay 2.70 m below datum. Only the bones protected by the proximity of bronzes have survived. These comprised a bronze spiral. Glass beads were also found within the grave.

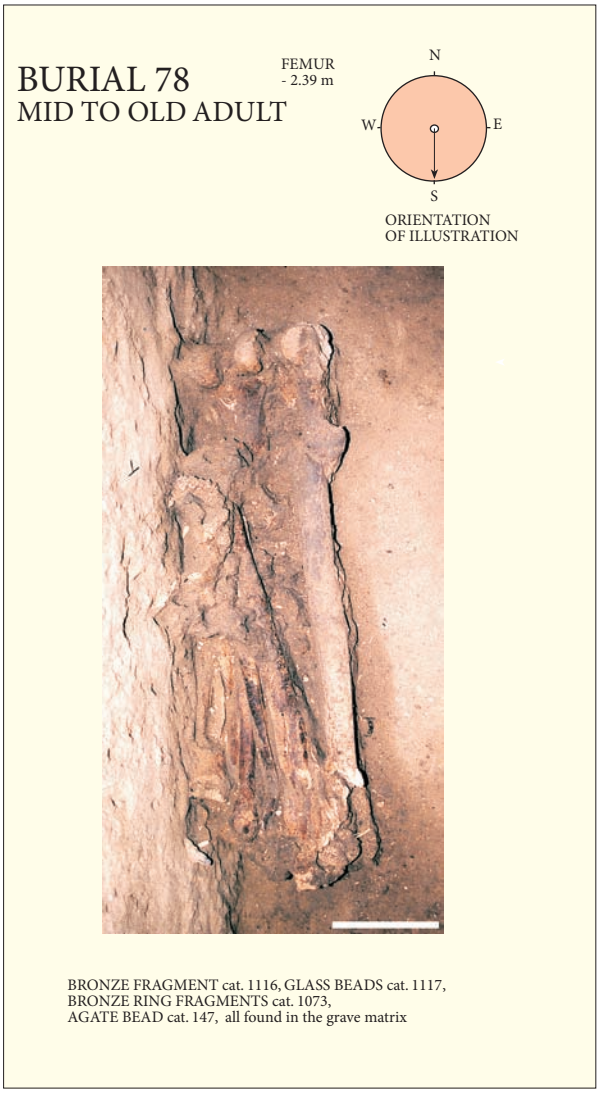


FIG. 11:10 Burial 78. Scale 10 cm

BURIALS PERIPHERAL TO CLUSTER A

Burial 94

This grave contained the remains of a man aged over 40 years at death. Unfortunately, only the cranium and part of the upper body were present within the excavated area. Unusually for this cluster, the body was orientated 80° east of north. Grave goods recovered to date include an orange glass bead, two agate beads in the area of the neck and four bronze rings on the left fingers.

Burial 110

This grave of a woman aged between about 37-42 years at death was found orientated with the head 80° east of north and at a depth of 2.95 m below datum. The grave was complete, but unusually for cluster A, and for all burials of this period, there was no evidence for the inclusion of rice in the burial ritual. Mortuary offerings were rare. She wore a tridacna shell earring, and a small piece of a bronze ring was recovered. A large sherd found adjacent to the head was insufficient to qualify as a whole pottery vessel.

Burial 122

This is the grave of an infant who died when aged between 3-9 months. The body was orientated with the head due north, and was found in a rice bed at a depth of 2.66 m. This burial is particularly notable for the number of pottery vessels placed round the body. Although most were found in a fragmentary condition, at least seven were identifiable. This infant also wore an agate pendant at the neck, and much bronze jewellery. Nineteen bangles were counted on the left arm and at least 16 on the right. There were also three bangles by the right ear and two by the left, as well as an earring. A bronze spiral was found on one toe and a glass bead was located in the area of the body.

MORTUARY PHASE 4 CLUSTER A: SUMMARY

This cluster of graves includes men, women and infants. The preferred orientation was north to south. The two identified females were interred with the head to the north, and the male was buried with his head to the south. The other relatively intact adult was also found with the head to the south. The presence in this last burial of parts of a bronze belt hint that he was probably male, since only positively identified males in other phase 4 clusters wore such belts. There is, therefore, the possibility that men and women in this cluster were interred on opposing orientations. This was found to be the case in the late Bronze Age cemetery of Ban Na Di (Higham and Kijngam 1984).

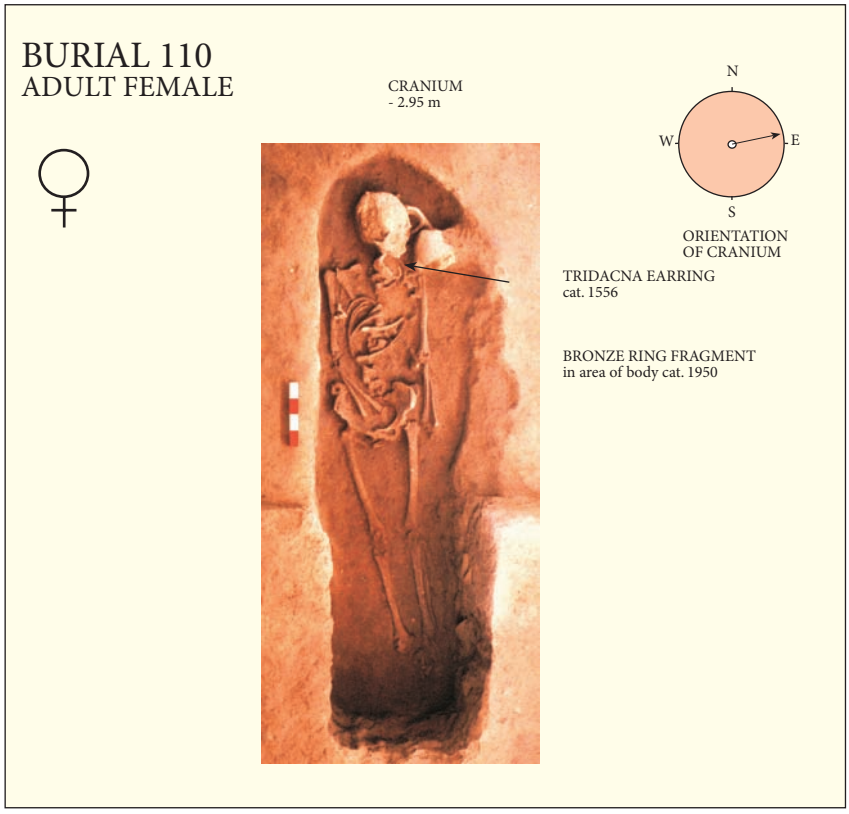


FIG. 11:11 Burial 110

Uncovering the complete cluster would test this possibility.

The graves in this cluster were up to 90 cm deep, and where a cutting was identified, they originated from lower layer 3. The beds of most graves was filled with rice burnt to a white colour, and in some cases, there was evidence for a clay lining, including a cap or cover. The mortuary ritual included the placing of a bowl over the face of the dead. This was not found in any other cluster. It is clear that earlier graves were on occasion disturbed, and the bones were bundled and replaced, often in the grave fill of the subsequent interment. Infants were buried, often with a rich complement of grave goods, in the same manner as adults. No jar burials were encountered.

Intact cluster A burials were accompanied by a wide range and considerable number of grave goods. These included jewellery of gold and silver, agate and glass. Bronzes included earrings, torcs, bangles, anklets, finger and toe rings, bells and belts. Iron was rare, however, and comprised three knives and a socketed hoe or axe. One knife was covered in pseudomorphic fabric, but only two spindle whorls were found, one with an infant and the other with a male.

The dating of this cluster is made possible by a series of radiocarbon determinations for upper layer 4. These provide a *terminus post quem* of AD 100-200. Since upper layer 3 has provided a corrected date of AD 252-446, it is suggested that these burials belong to the second or third centuries AD.

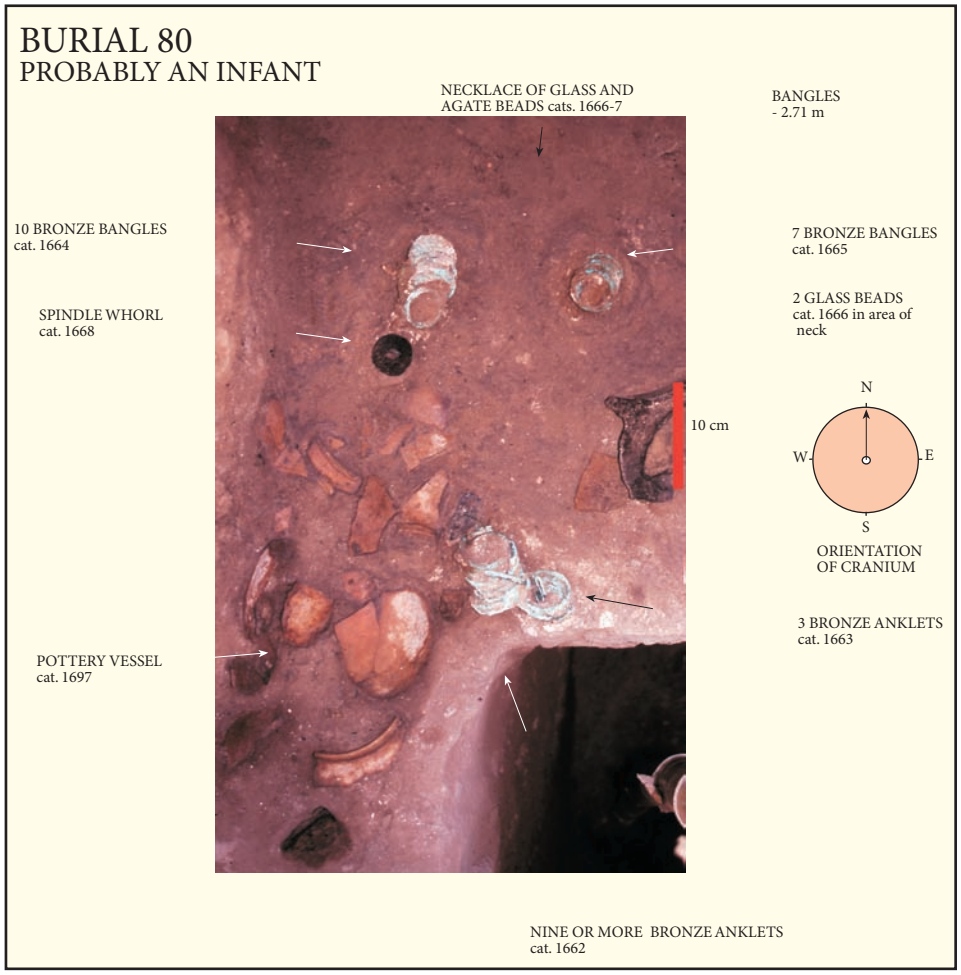


FIG. 11:12 Burial 80

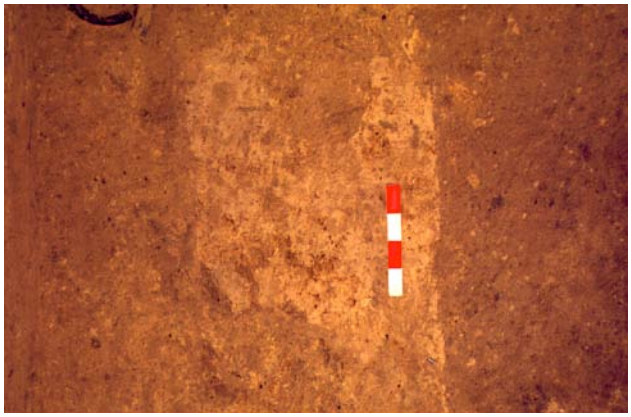


FIG. 11:13 The clay capping to burial 105

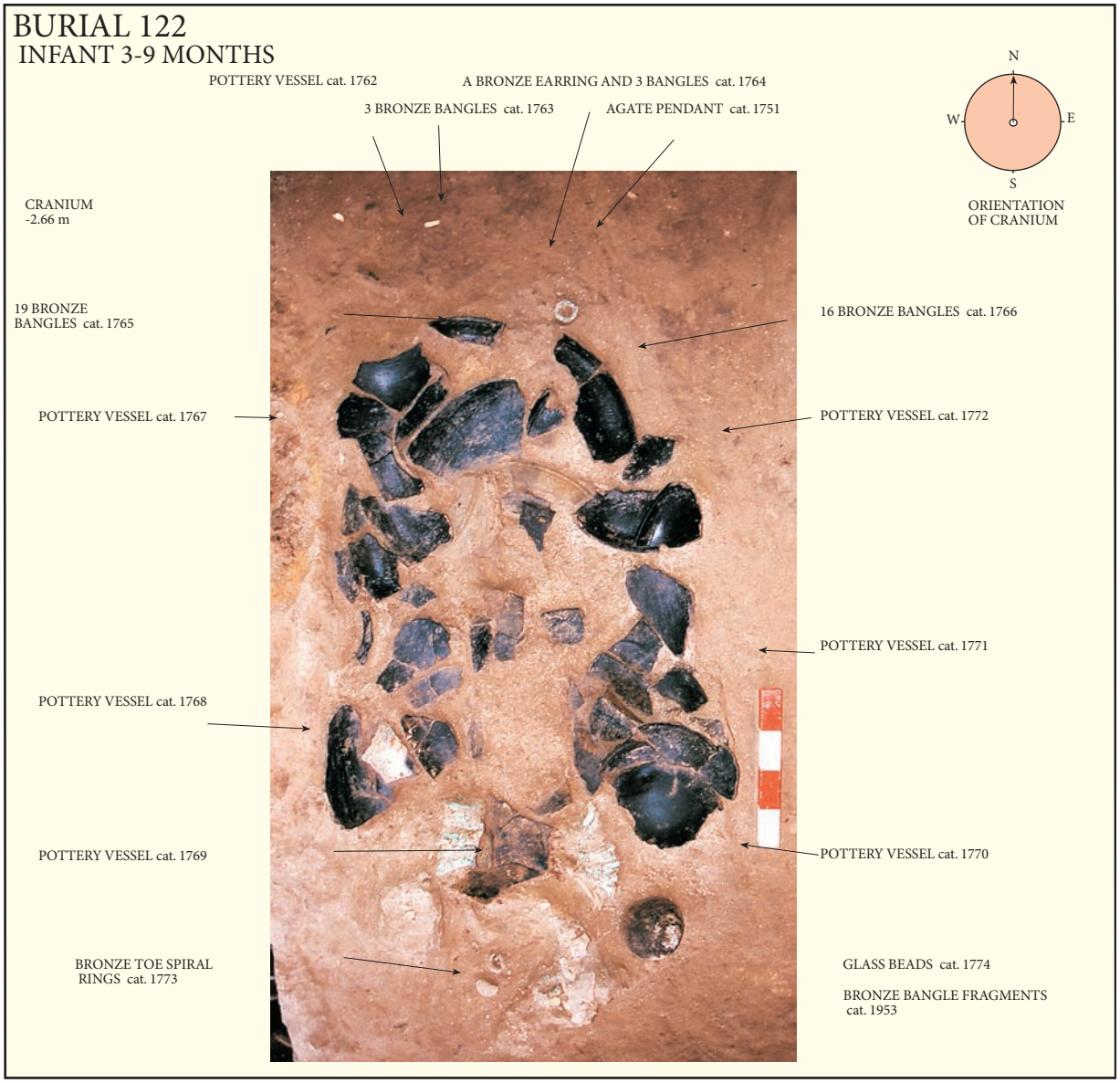


FIG. 11:14 Burial 122

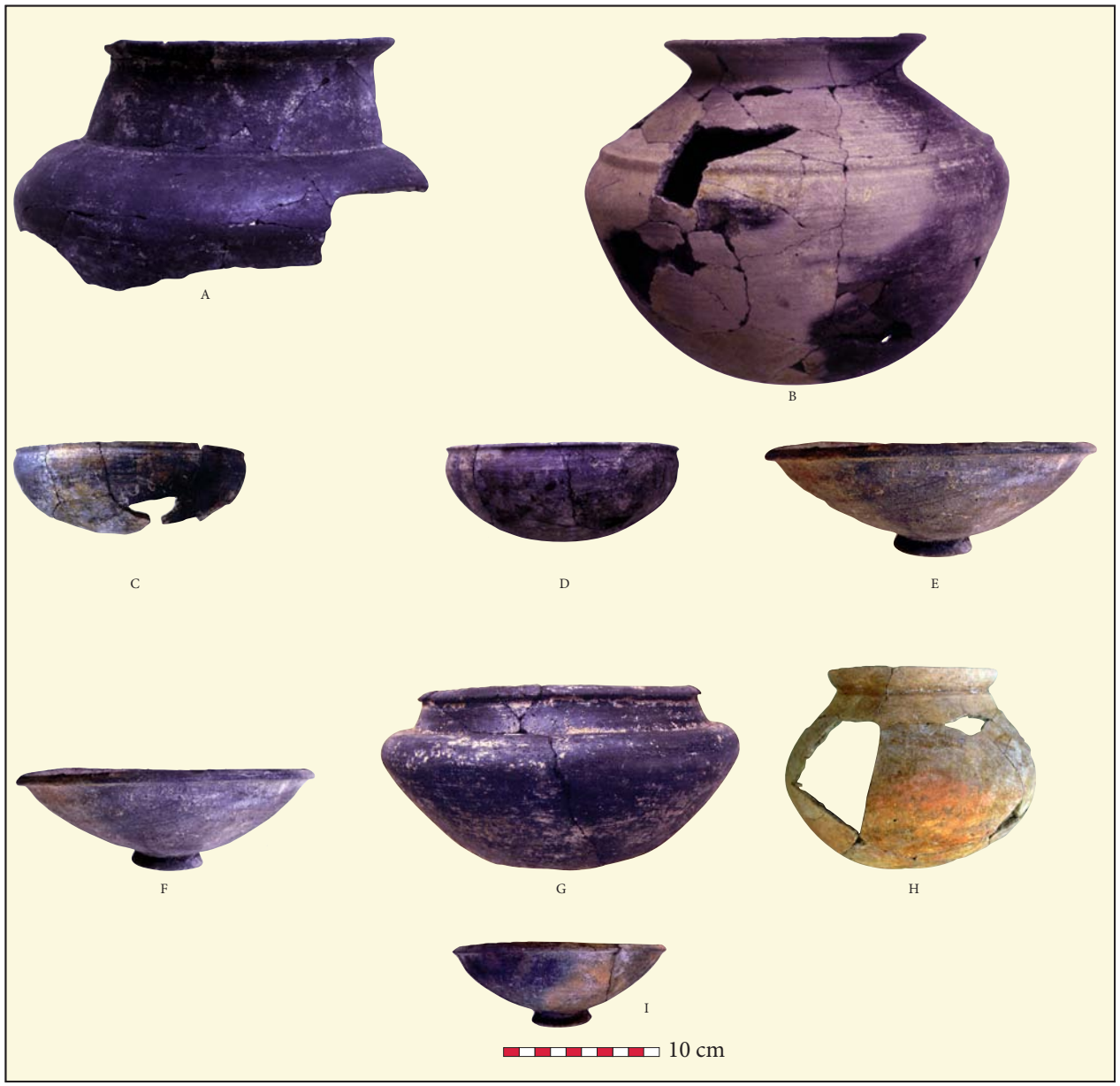


FIG. 11:15 Pottery vessels from mortuary phase 4 cluster A. A. burial 122 cat. 1767, B. burial 122 cat. 1772 , C. burial 122 cat. 1771, D. burial 122 cat 1769, E. burial 96 cat. 1515 F. burial 96 cat 1505, G. burial 95 cat. 1246, H. burial 80 cat 1697, I. burial 111 cat. 1535

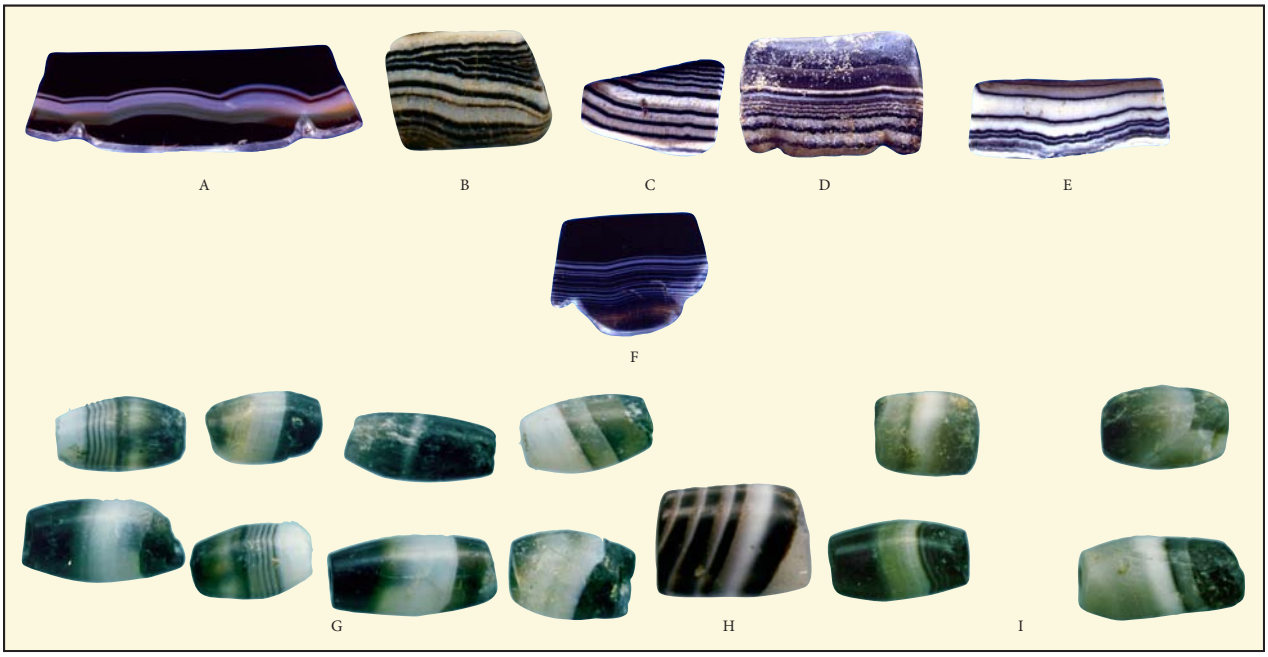


FIG. 11:16 Agate pendants from mortuary phase 4a. A. Burial 122 cat. 1751. B. Burial 104 cat. 1652. C. cat. 1389 X1 layer 3:8 feature 1. D. Burial 113 cat. 1711. E. Burial 104 cat. 1649. F. Burial 113 cat. 1747. G. Burial 113 cat. 1709. H. Burial 78 cat. 1475. I. Burial 80 cat. 1667. Scale A-F, 1:1, G-I, 2:1

XII. THE BURIALS OF MORTUARY PHASE 4 CLUSTER B

C.F.W. HIGHAM AND R. THOSARAT

There are 20 burials in cluster B of mortuary phase 4. One is an adult female and there are two adult males. The balance comprises 14 infants and children, while three individuals are of unknown age or sex. The burials lie four metres to the east of cluster A, and the preferred orientation was again on a north to south axis.

Burial 98

This grave, that of an adult male, lies adjacent to the only female in the cluster, and both are virtually surrounded by the burials of infants and children. It lies in a bed of white, burnt rice, at a depth of 2.52 m. A pottery vessel lay over the cranium, and two spindle whorls were present, both on or near the left shoulder. Bronze ornaments incorporated nine bronze bangles, of which seven were on the left wrist. There were seven finger rings on the right hand, and three spirals on the left. Six earrings were found to the right of the head, and a small fragment

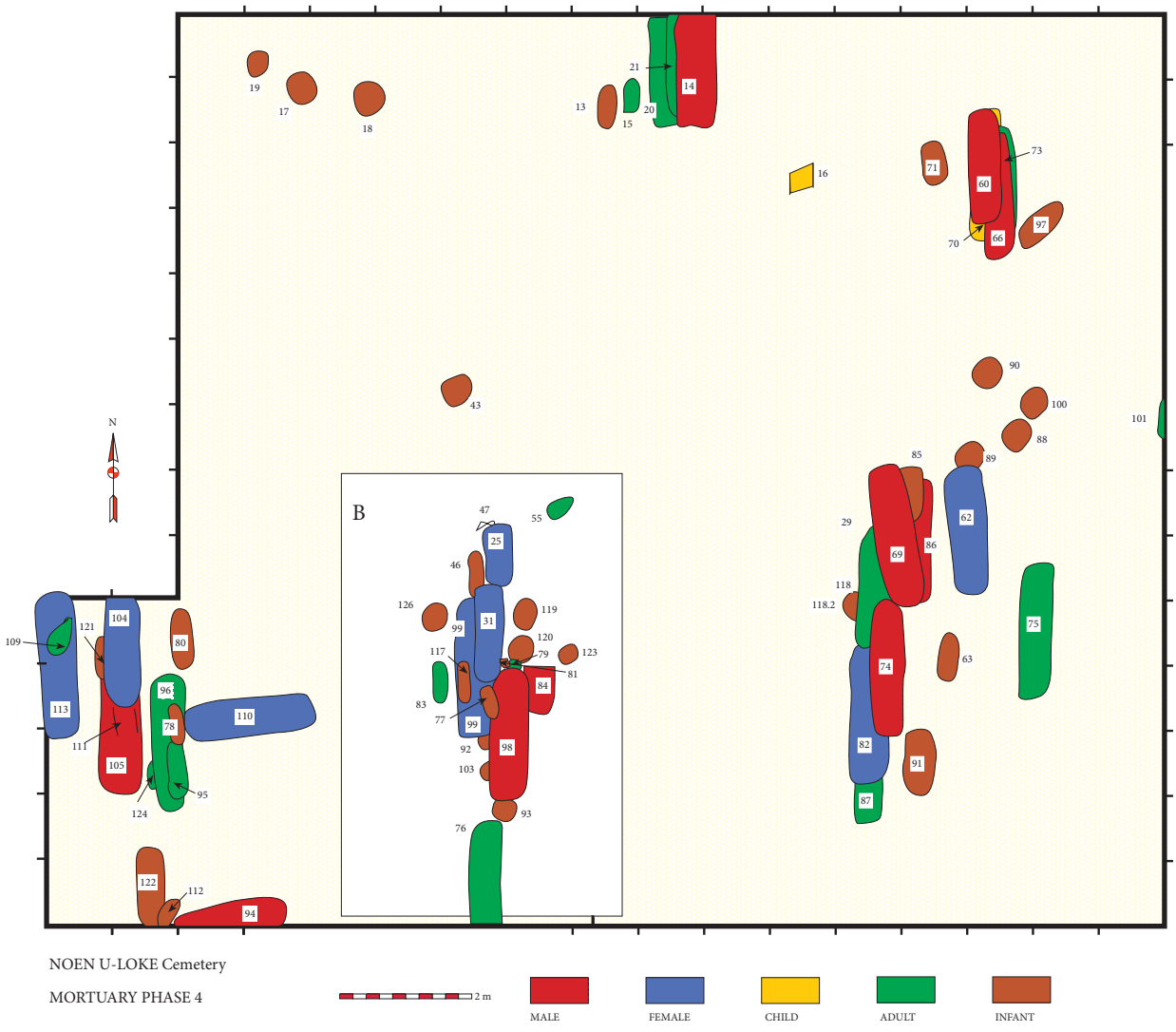


FIG. 12:1 The distribution of graves in mortuary phase 4 cluster B

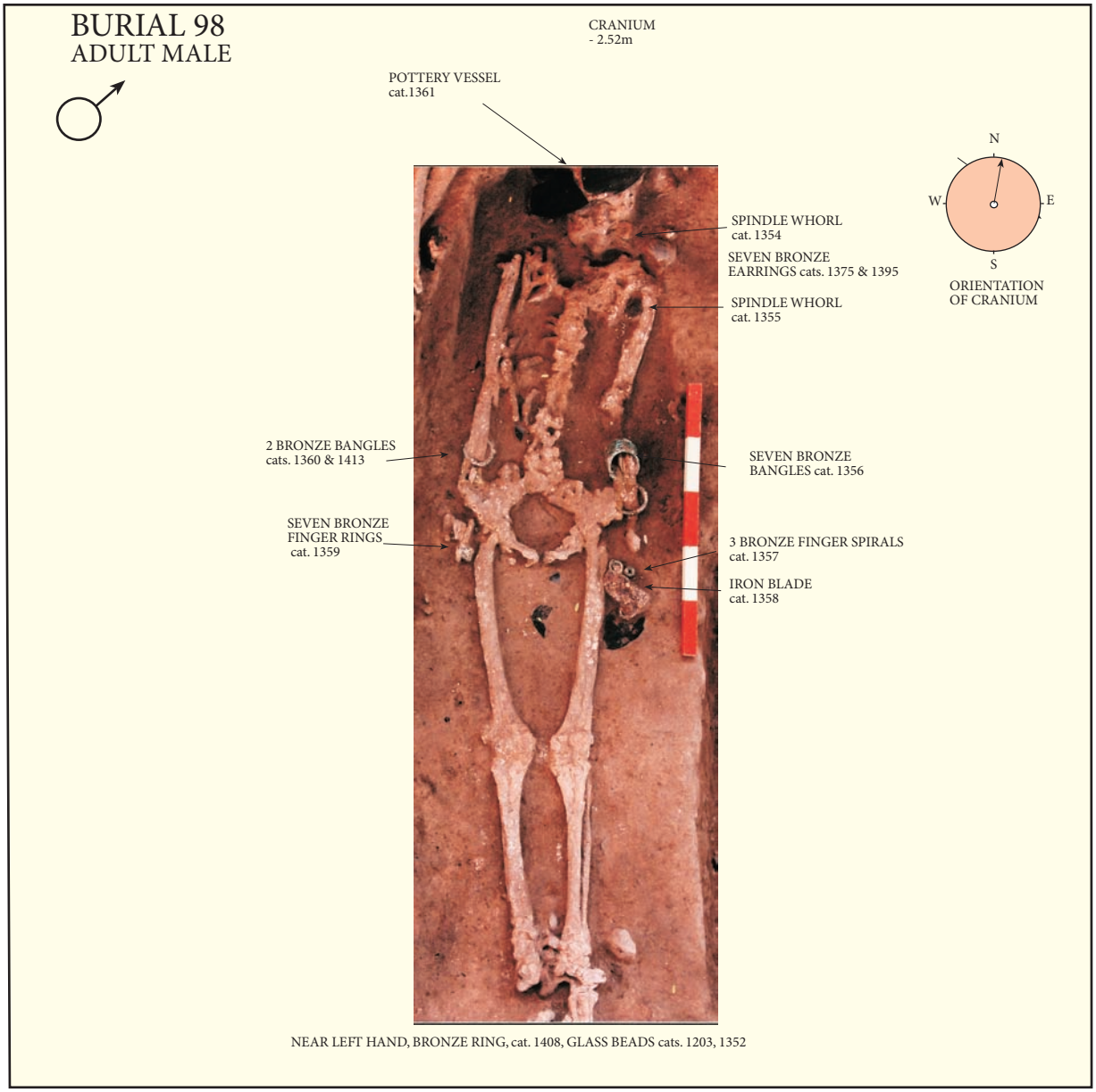


FIG. 12:2 Burial 98

possibly from a seventh at the base of the skull. An iron knife blade lay in the area of the left hand. A pottery vessel had been placed over the head and some glass beads were also found by the head.

Burial 84

The grave cut for this interment was visible as white silicified rice husks at a depth of 2.43 m, but it might well have originated at a higher level. The scattered bones within probably come from an adult male. A bronze ring and a glass bead were the only grave goods recovered.

Burial 99

The grave of this woman who died when aged over 40 years, was found alongside and slightly to the north of burial 98, at a depth of 2.43 m below datum. The lower limbs were excavated first, since the rest of the skeleton lay in the baulk. Her legs had been crossed at the ankles. An unusual feature of this burial, was that the woman's head lay within a large pottery vessel. She was also interred with four spindle whorls disposed two to the right and two to the left of the upper body. A complete pottery vessel on the left shoulder. Bronze jewellery incorporated four bangles on the left wrist and seven on the right. There were eight key-shaped earrings on each ear, a bronze ring by the neck and another by the left leg. She also wore an agate neck pendant and a glass bead.

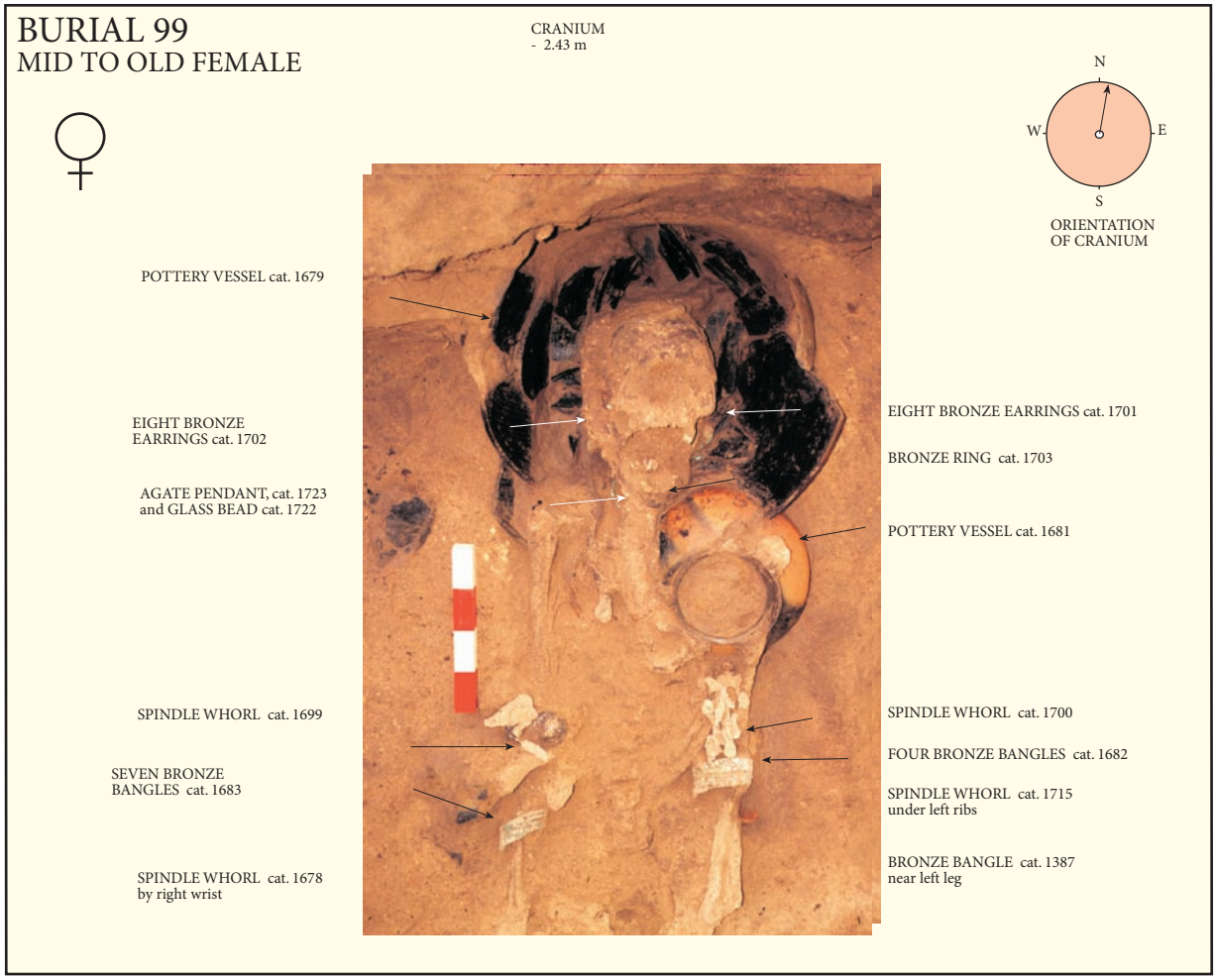


FIG. 12:3 Burial 99

Burial 47

This burial was the most northerly of cluster B. It comprises a bed of white rice, but only a bronze ring and a few scattered glass beads were recovered. From its width, it was probably designed for an adult. However, the base of pottery vessel cat. 556 was also found, which has the form of an infant burial jar. This has not been given a burial number. These finds were recovered from 2.70 m below datum.

Burial 83

As with burial 47, only the bed of rice representing a grave was found, within which, at a depth of 2.31 below datum, there lay parts of two pottery vessels and some glass beads. No human remains were recovered.

Burial 76

This grave, which contained the remains of an adult orientated with the head 20° to the west of south, was found at a depth of 2.48 m within a bed of rice. As a consequence of this proximity to the rice, the bones were not well preserved. Three pottery vessels were found beyond the head, and a spindle whorl and an iron knife blade lay to the right of head. Three bronze finger rings were found on the right hand, and 13 on the left. There was also a bronze earring on the left ear.

Burial 46

The infant in this burial died when between 1.5 and 4 years of age. A bed of rice filled the base of the grave, at a depth of 2.58 m below datum. Three pottery vessels were associated with the body, one above the head, one under the skull and the third to the left of the ankles. An iron knife blade was present below the feet and a second indeterminate iron artefact was found in the same area. Jewellery comprised an agate bead, a glass bead, and two bronze bracelets.

Burial 77

The remains of a late foetal or newly-born infant were found at a depth of 2.18 m below datum, and at the right shoulder of burial 98. The infant wore four bronze anklets,

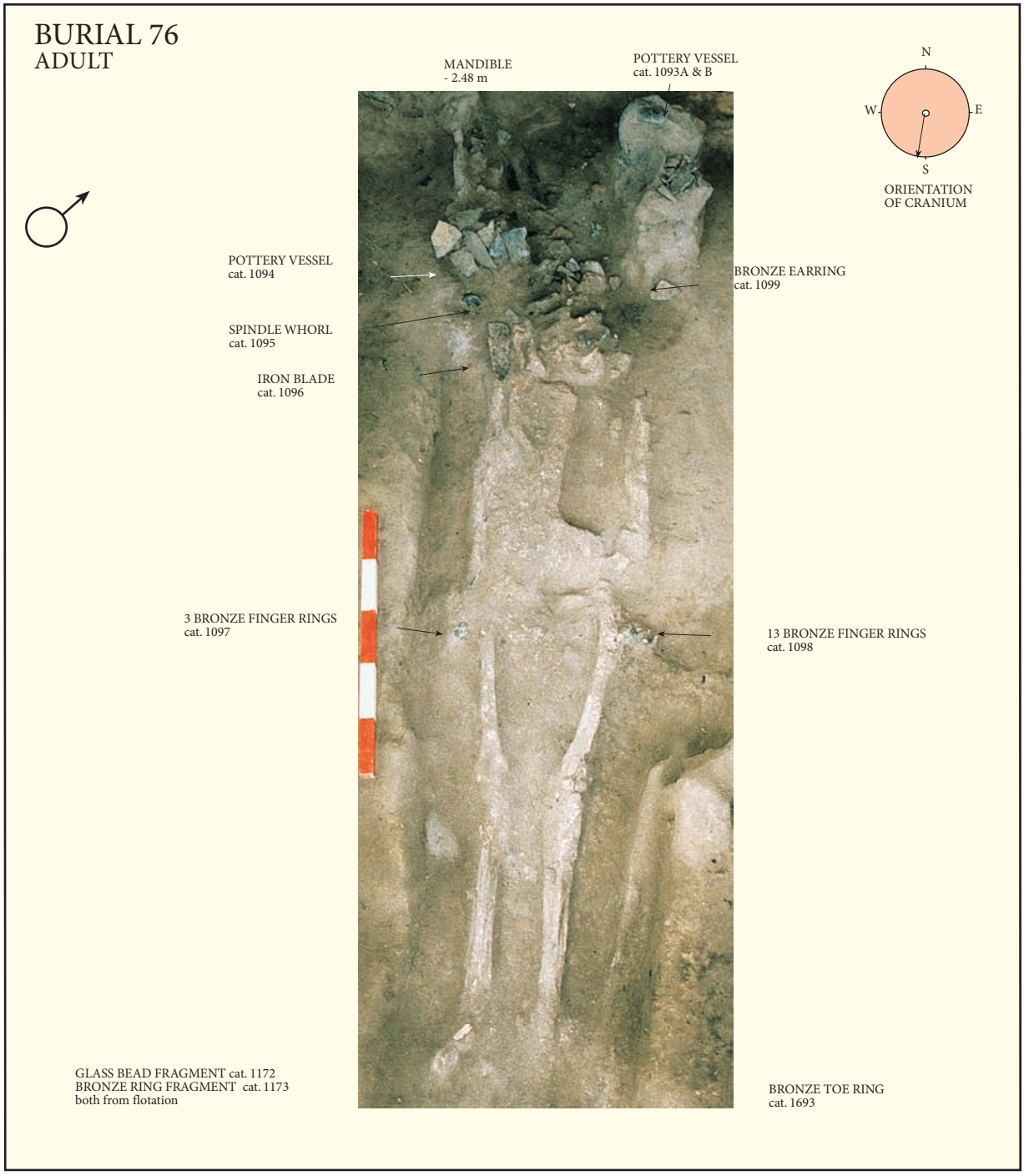


FIG. 12:4 Burial 76

a bronze bangle and a bronze ring. A pottery vessel was also found in the grave. The orientation of the body could not be ascertained.

Burial 79

This grave contained the skeleton of an infant who died when aged about 3-9 months. The body was orientated 5° east of north, and grave goods included a pottery vessel and two bivalve shellfish. Bronzes incorporated two anklets on the right leg and three on the left, and two bronze bangles on each arm.

Burial 81

The remains of this neonate were found just west of the feet of burial 79 and on the same orientation. The cranium lay below part of a pottery vessel, and the bronze ornaments worn comprised an anklet on each leg, four bronze bangles, a fragment of a finger ring and glass

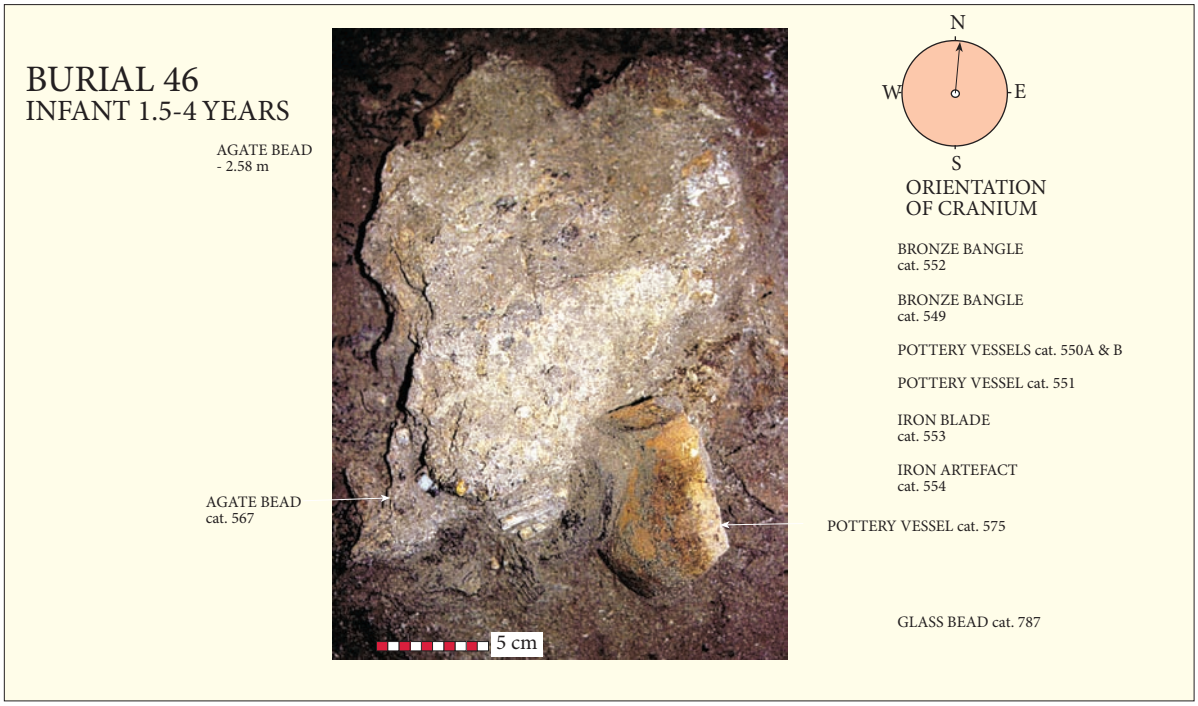


FIG. 12:5 Burial 46

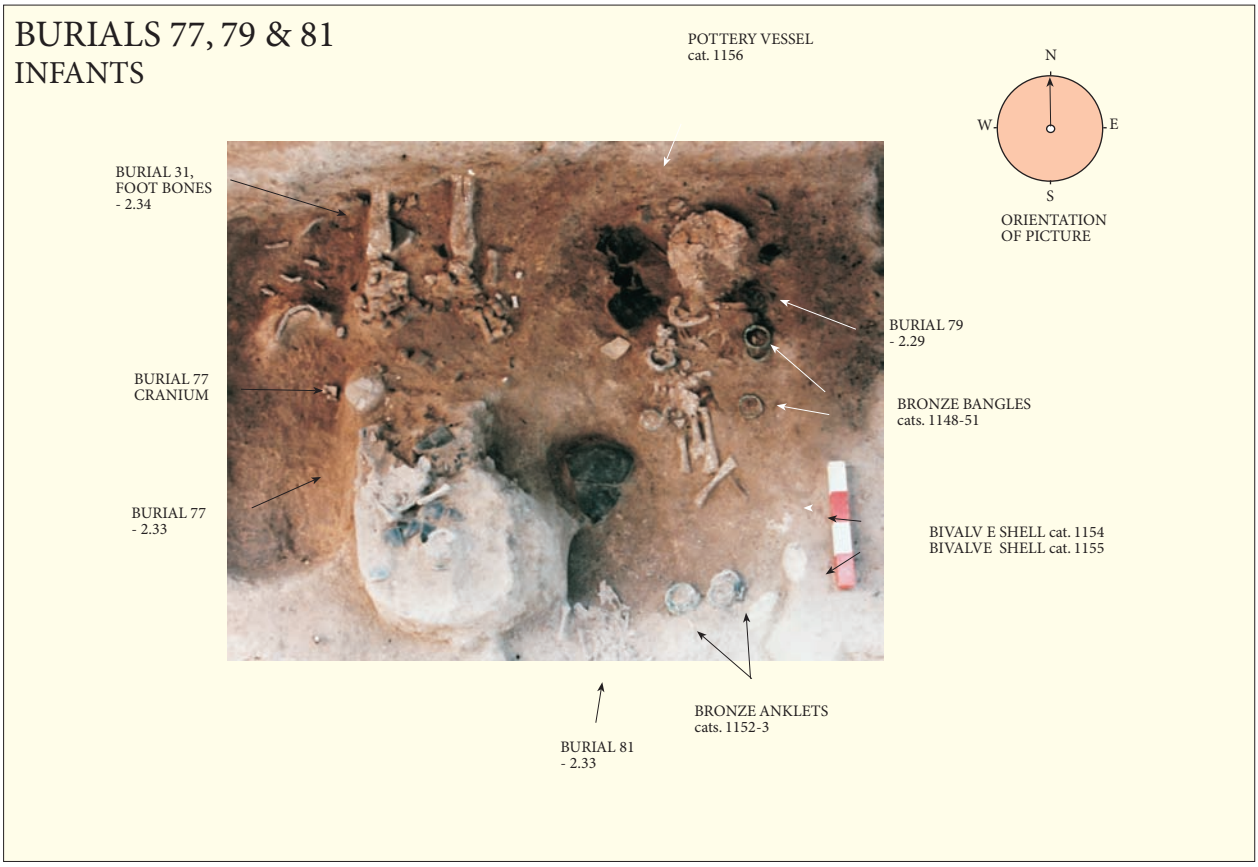


FIG. 12:6 Burials 77, 79 and 81

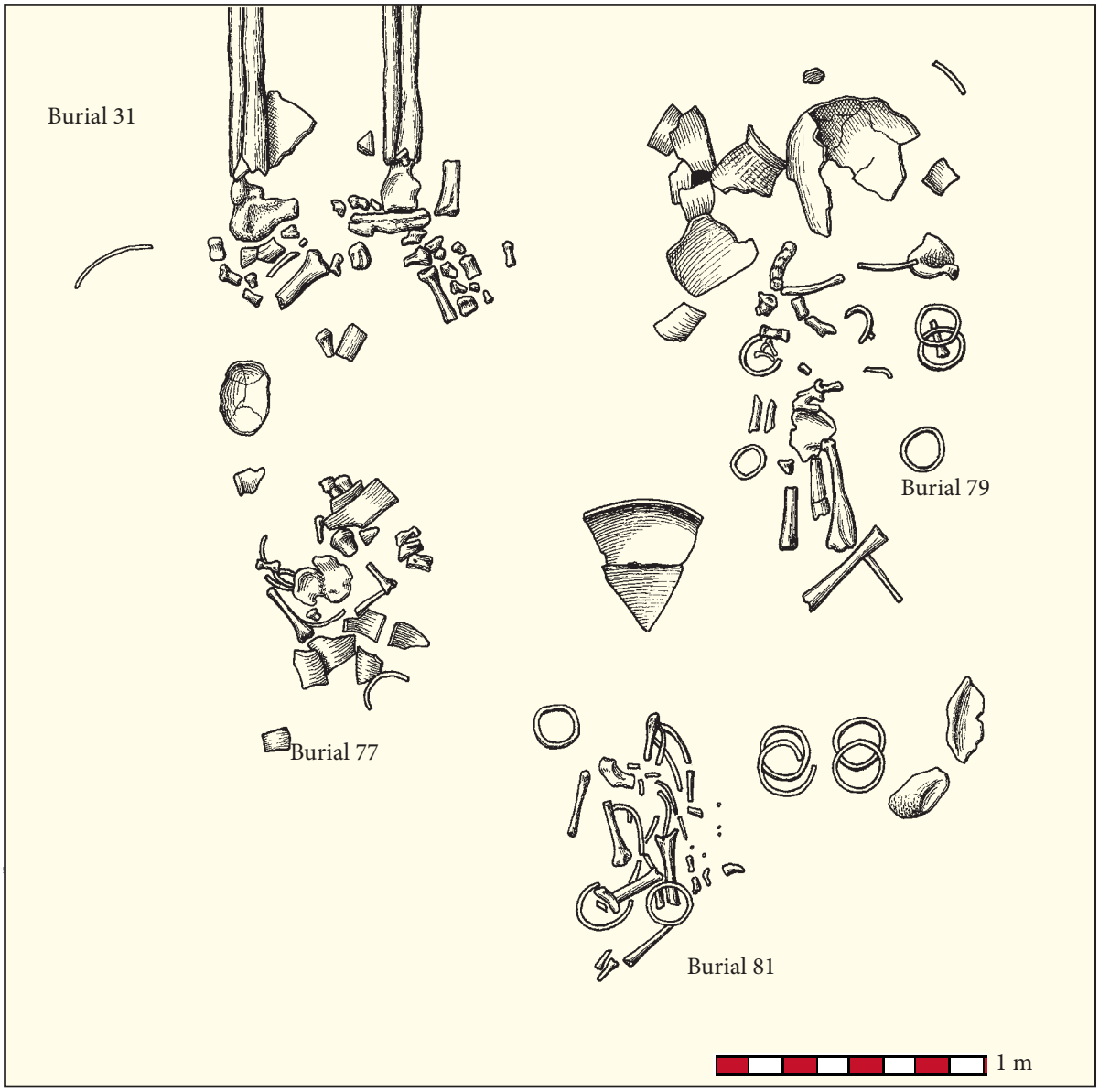


FIG. 12:7 The distribution of infant burials 77, 79 and 81 relative to adult burial 31

beads. More bangles were recovered as fragments from the flotation chamber.

Burial 92

Only the foot bones of this 2-4 year-old infant were found, together with a bronze anklet.

Burial 93

This neonate was interred in a pottery vessel, at the feet of burial 98. It was found 2.49 m below datum. There were no grave goods.

Burial 103

Only the base of this mortuary vessel was found, located under burial 98. It contained the remains of a neonate.

Burial 117

The mandible and rib of 3-5 year-old infant were found in the grave fill of burial 99.

Burial 119

The burial jar of this infant was cut into and severed by burial 120. It contained the remains of a neonate.

Burial 120

This very large burial jar, with a diameter of almost half a metre, contained the remains of a neonate. The infant was interred with a two further pottery vessels and for jewellery, wore three agate pendants, four bronze anklets on the left leg and three on the right, and a bronze bell. The vessel was encountered at a depth of 2.70 m.

Burial 123

A further neonate was found in a disturbed jar burial, at a depth of 2.91 m below datum.

Burial 126

This mortuary jar contained the remains of a very young infant, possibly a neonate, which, as far as can be ascertained, was placed prone within the vessel. It was found at a depth of 2.50 m.

Burial 25

The rice bed grave of this 2-4 year-old child was found at a depth of -2.38 m below datum, and just beyond the head of burial 31. The body had been laid out with the head pointing to the north. Grave goods included a pottery vessel and two spindle whorls. There was also a considerable number of glass beads. Nine were found round the waist, 15 in the vicinity of the head, with 222 being recovered from the area of the body. The child also wore several bronze ornaments: an earring, bracelet, six anklets

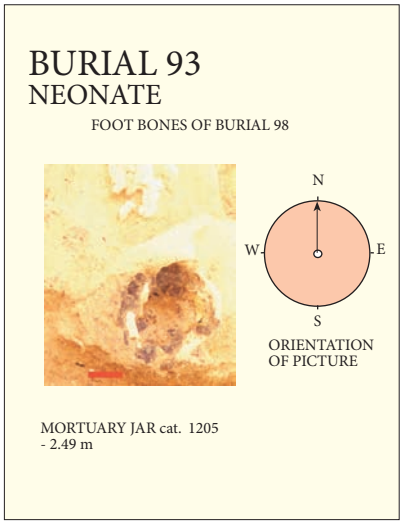


FIG. 12:8 Burial 93

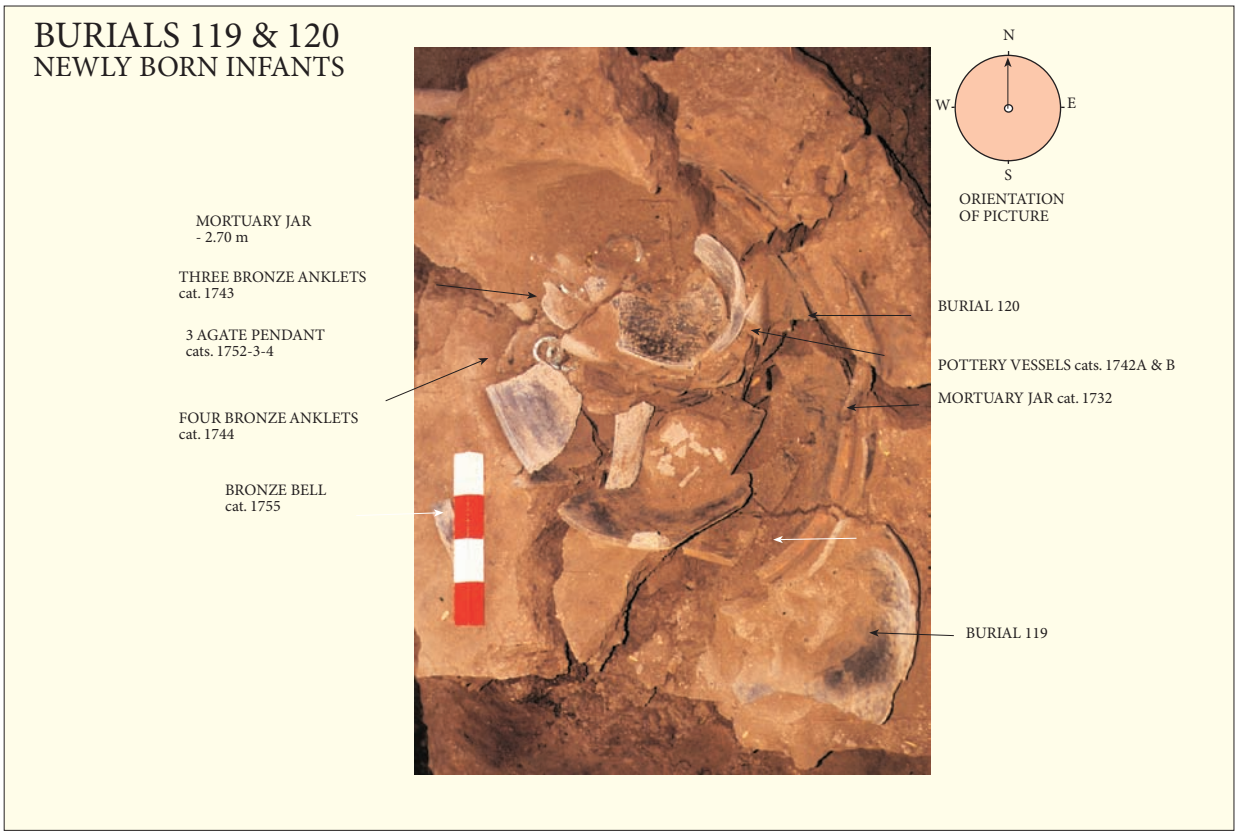


FIG. 12:9 Burials 119 and 120

and a finger ring.

Burial 31

Most of burial 31 was found in the baulk B1/C1. The cranium was present in square B1 and the foot bones lay in square C1. The body was found at a depth of 2.18 m with the head orientated 10° west of north. It partially overlies burial 99. This was the grave of a child who died when aged about 12 years. The head lay over a pottery vessel. Bronze ornaments comprised a bangle on each arm, six rings and a spiral on the right hand, and a long spiral on the other, and an earring on the left ear. An egg had been placed near the left hand. It is the size of a hen's or a duck's egg.

CLUSTER B: SUMMARY

There is no stratigraphic evidence to provide a relative chronology for cluster B and A. This reflects the absence of clay grave capping in cluster B graves, and hence difficulty in determining the depth from which the graves originated. The mortuary ritual remained basically similar in terms of orientation and the use of burnt rice husks to fill the base of the grave.

Fourteen of the 20 burials in this cluster come from infants or children, an extraordinarily high fraction even for prehistoric societies. Since there is only one female skeleton in the assemblage, it is considered probable that some, at least, of the three adults for whom it has not been possible to estimate the sex were also women. Unlike cluster A, there is no gold or silver jewellery, but other ornaments were similar, including the agate pendants, bronze bangles, ear and finger rings. This group, however, seemed to prefer placing the human head in or on a pottery vessel, rather than using one to cover the head. Iron knife blades were found in four of the burials. The woman of burial 99, who attained an age of over 40 years, was buried with four spindle whorls, and ten in all accompanied cluster B graves. This is a much higher frequency than for cluster A. The impression gained from the distribution of the cluster B graves is of a small core of adults, and an exceptional level of infant mortality.

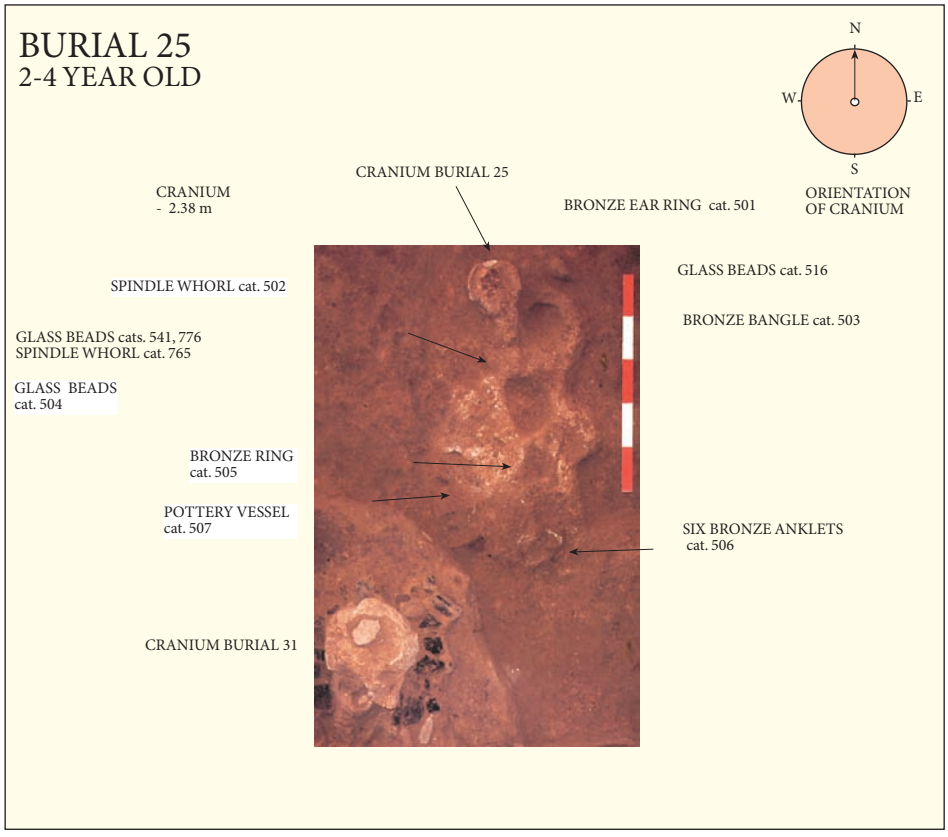


FIG. 12:10 Burial 25

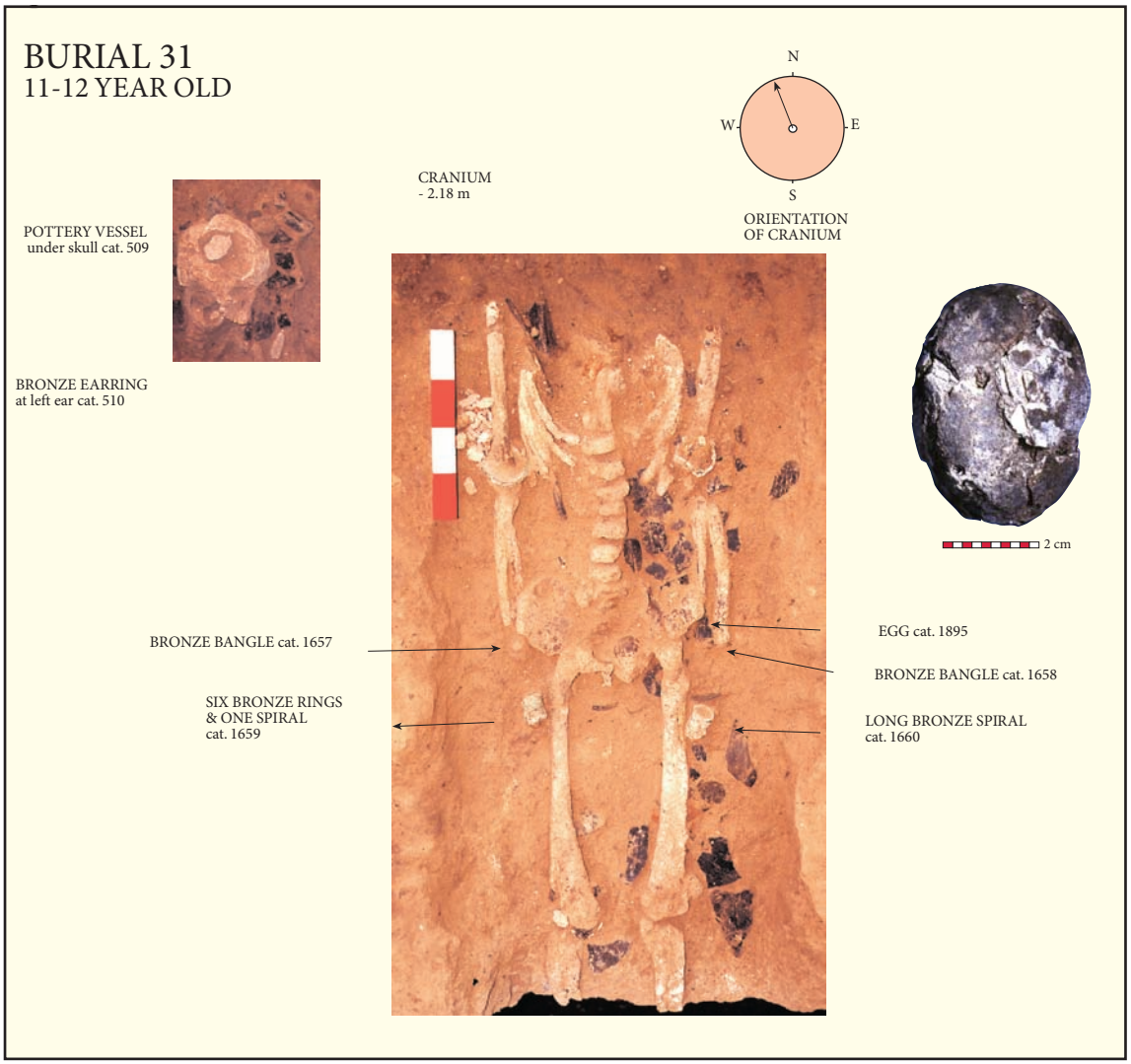


FIG. 12:11 Burial 31

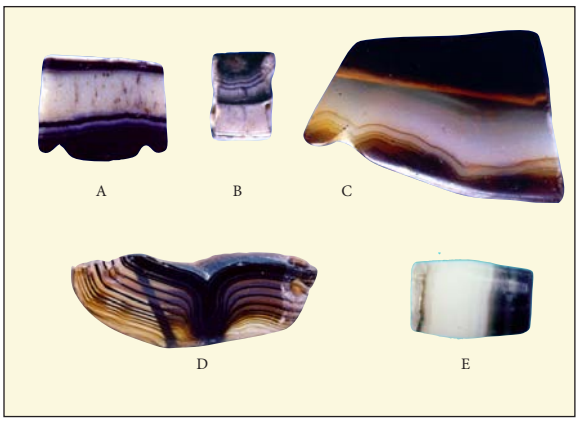


FIG. 12:12 Agate ornaments from mortuary phase 4B. A.Burial 120 cat. 1752, B. Burial 120 cat. 1753, C. Burial 120 cat. 1754, D. Burial 99 cat. 1723, E. Burial 46, cat. 567. A-D actual size, E x 2



FIG. 12:13 Pottery vessels from mortuary phase 4 cluster B. A. burial 46 cat. 550A, B. burial 46 cat. 550B, C . burial 46 cat. 551, D. burial 83 cat. 1192a, E. burial 83 cat. 1192b, F. burial 99 cat. 1681, G. burial 120 cat. 1742, H. burial 120 cat. 1732, I. burial 99 cat. 1679

XIII. THE BURIALS OF MORTURAY PHASE 4 CLUSTER C

C.F.W. HIGHAM AND R. THOSARAT

Cluster 4C burials lie four metres to the east of those belonging to cluster B. They comprise three males, two females, three adults of unknown sex, a child and seven infants. Most lie between 2.29 and 2.51 m below datum, but the lid of the jar containing burial 100 was found at 2.80 m, and burial 62 was found much higher, at 1.54 m below datum while burial 63 was found at 1.62m. Four of the infant jar burials concentrated at the north east of the group as a whole.

Burial 69

This grave contained a male who died when aged between 25-30 years. It was first recognised in the form of two pottery vessels at a depth of 1.82 m. He lay in a bed of rice with the head orientated 20^0 east of south. Four pottery vessels were associated, two beyond the head, one over the shoulder and the fourth over the chest. Bronze ornaments were abundant. Two large, circular plugs were found on each side of the skull, and their position suggests that they had been inserted into the ear lobes. He was also buried wearing four bronze belts. Nine bronze bangles were present on the left wrist, and at least 11 on the right. Over 59 finger rings were present on the right hand, and at least 65 on the left. Toe rings were also abundant, particularly on the right foot, where over 26 were recovered, compared with seven on the left foot. Loose bronze bangles were found beyond the head and over the chest, and four bimetallic rings were recovered, two on the big toe of the

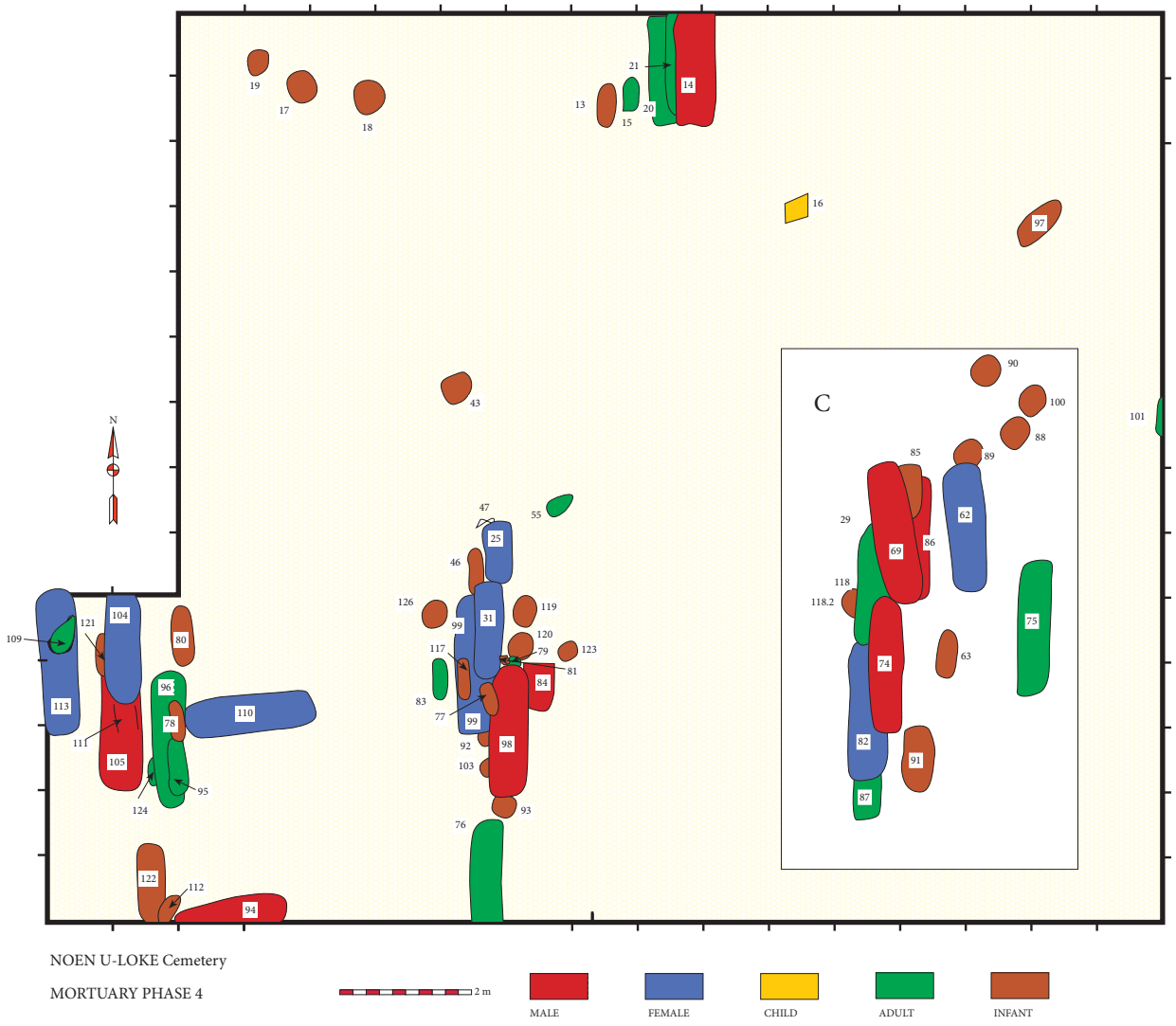


FIG. 13:1 The distribution of graves in mortuary phase 4 cluster C

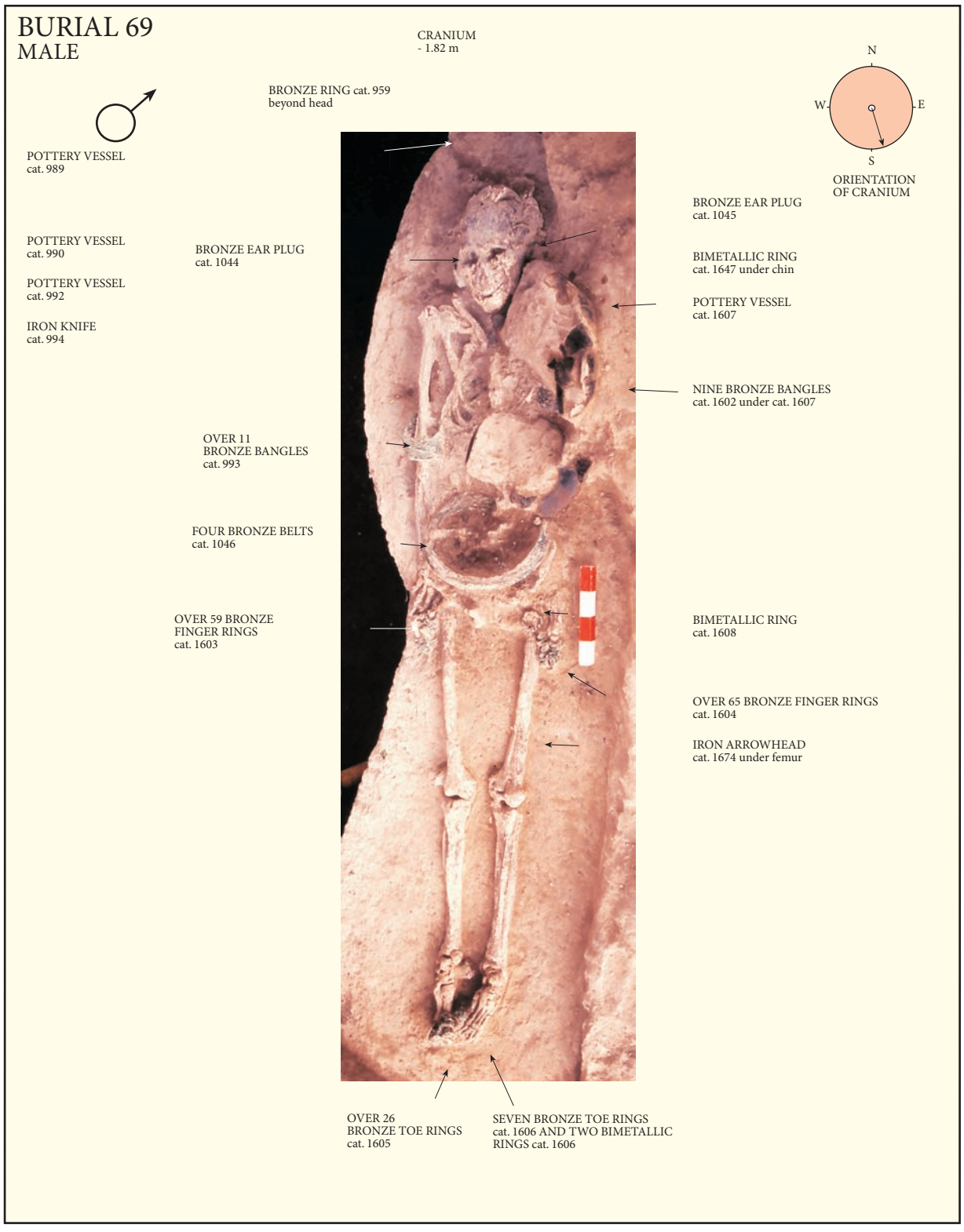


FIG. 13:2 Burial 69

left foot, another over the left femur and the fourth under the chin. An iron knife blade had been placed to the right of the head, and an iron point, possibly an arrowhead, was present under the leg. Finally, a glass bead was recovered from the matrix of the grave fill during the routine flotation of this material.

Burial 74

This male, who died when aged between 25-30 years of age was found just to the south of burial 69, and on the

same orientation with the head pointing to the south. The grave overlies burials 82 and 118. The femur lay 2.29 m below datum. Three pottery vessels were found in the vicinity of the head, and a bimetallic ring was also found in the area of the neck. A bronze toe ring was found on the left foot, and a further bronze ring fragment and a glass bead was recovered during the flotation procedure.



FIG. 13:3 The foot bones of burial 69, showing the bronze toe rings. Two are bimetallic. Scale 5 cm



FIG. 13:4 The left hand of burial 69, showing the finger rings and a bimetallic ring at the top of the femur. Scale 5 cm



FIG. 13:5 Burial 69, showing the four bronze belts and finger rings. Scale 5 cm.



FIG. 13:6 The cranium of burial 69, showing the ear ornaments

Burial 86

This burial involved a male aged 25-30 years at death. His rice-filled grave lay under burials 69 and 85 at a depth of 2.30 m below datum, and had been disturbed to the point that the bones had been bundled and redeposited. Grave goods which were found in the vicinity of the human remains included two pottery vessels, one of which contained a complete, socketed iron spade, covered in rice remains. It appears likely that the pot had formerly contained rice grains. Glass beads were also found in the grave fill, together with a bronze finger ring, at least one and possibly three earrings, an agate pendant, bronze bangle, and an iron knife.

Burial 62

This grave contained the complete skeleton of a woman who died when aged in the vicinity of 35-40 years. She lay with the head orientated 20° to the west of north, with the cranium at a depth of 1.54 m below datum. The grave lay parallel with and to the east of burial 69, but the high level suggests that she was among the latest interments in this cluster. The grave retained white burnt rice fill. Three pottery vessels were present, placed by the right elbow, the right arm, and over the left shoulder. There was also an abundance of bronze jewellery: five anklets on each leg, 36 finger rings on the left hand and at least 28 on the right, 15 bangles on the right wrist and 11 on the other, and six earrings on the left ear with at least one on the right. There was also an agate pendant and three bimetallic rings. Two tiny red glass beads were recovered from the flotation procedure, while an iron knife had been placed on the left forearm.

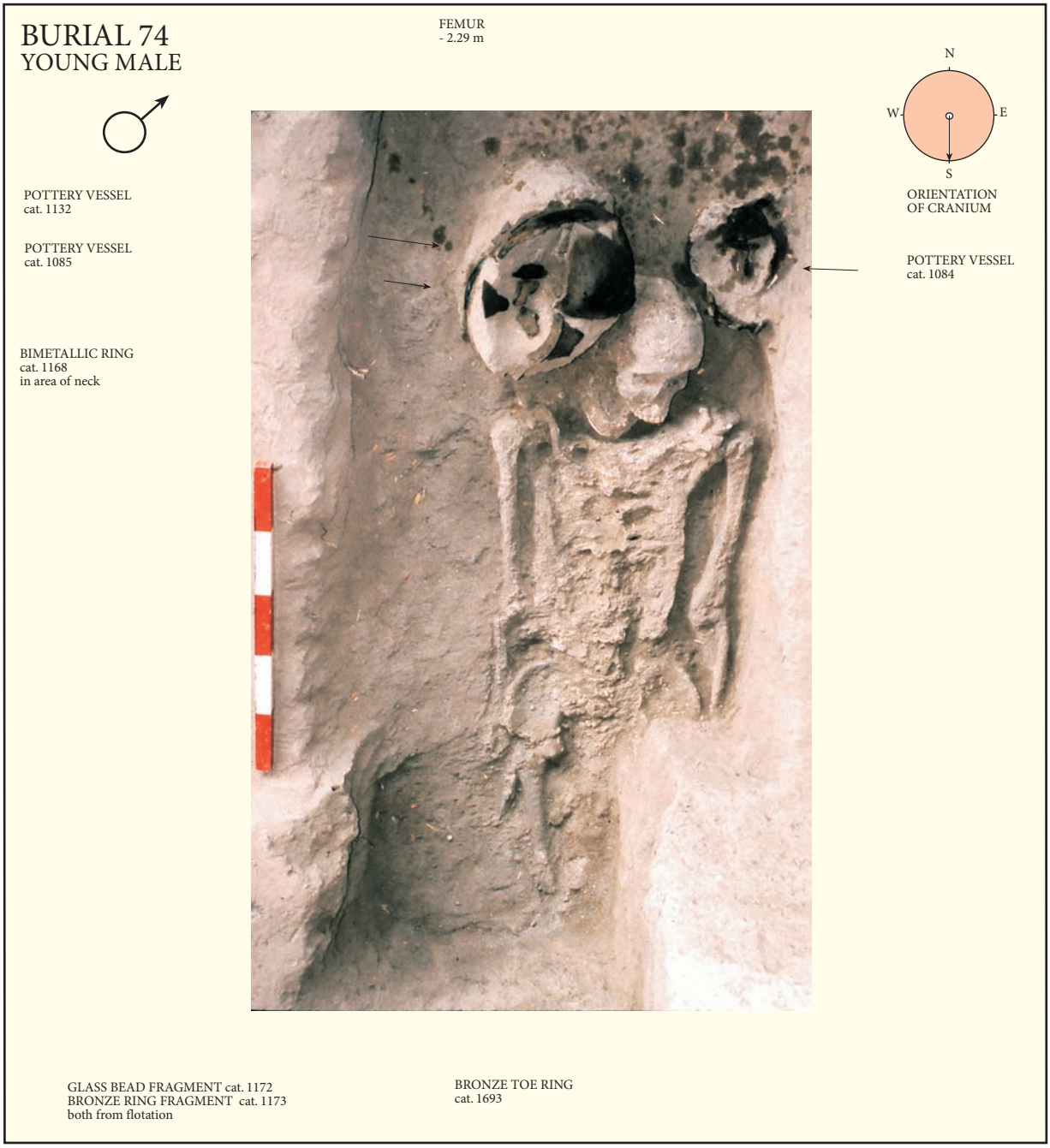


FIG. 13:7 Burial 74



FIG. 13:8 Burial 62

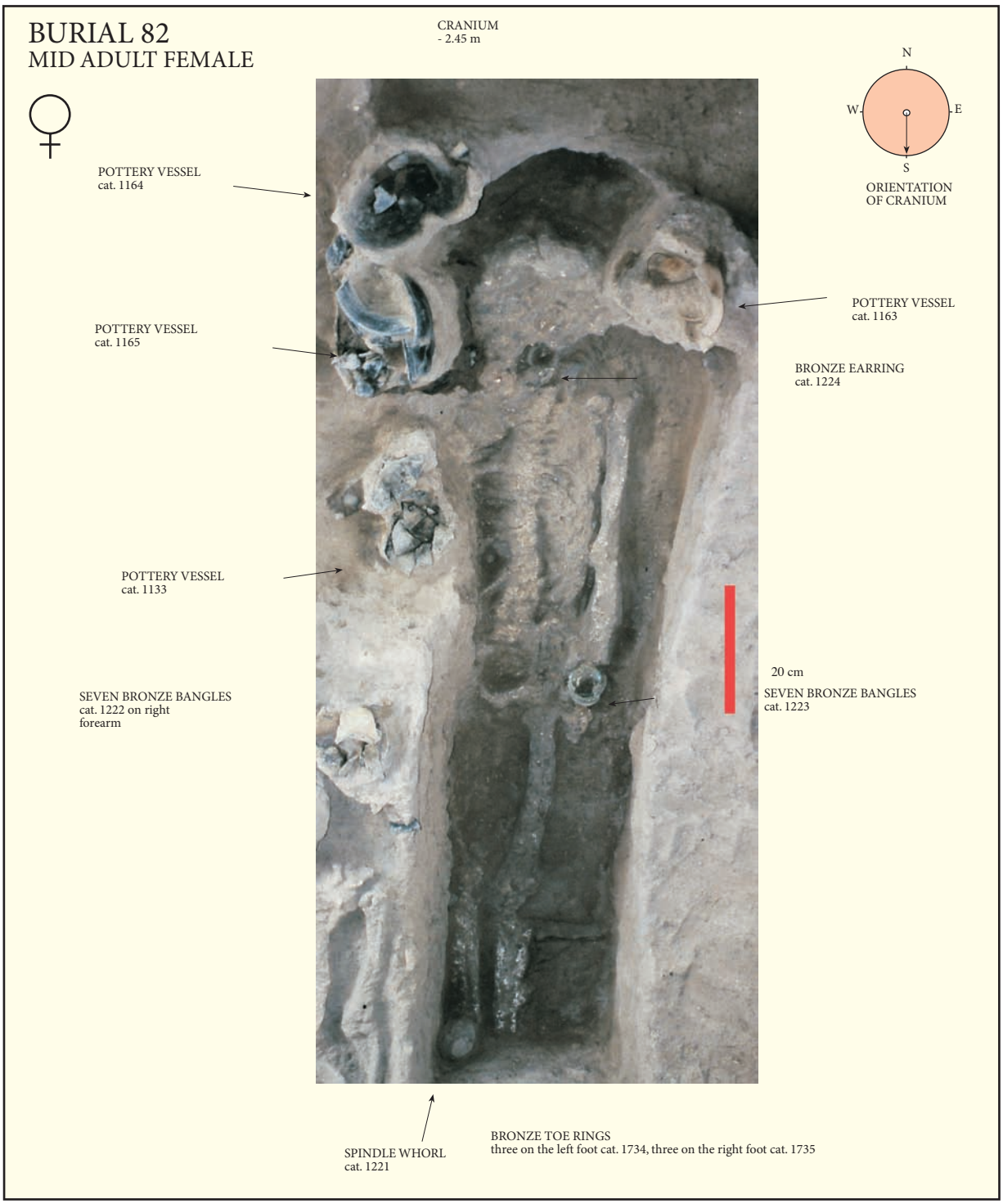


FIG. 13:9 Burial 82

Burial 82

This burial of a 35-40 year-old woman was found at a depth of 2.45 m below datum. She lay with her head to the south. The grave cut into that of burial 87, but was overlain by burial 74. Burial 118 lay just beyond the feet, at the same depth. Five pottery vessels were associated, four disposed round the head, and the fifth beside the right arm. Bronze jewellery comprised seven bangles on each arm, three toe rings on each foot, and an earring. A spindle whorl was found by the right ankle.

Burial 75

This grave contained the remains of a young adult who reached the age of 16-20 years. The grave was recognised as a clay cap at the depth of 2.01 below datum. The human remains lay 2.48 m below datum. An oval configuration of postholes dug from the same level as the grave appear to form a pattern centred on this burial, and might represent the foundations of a mortuary structure (Fig. 13:11).

The upper part of the body was intact, but the lower was disturbed and in disarticulation. Two of the five pottery vessels were found in the grave fill, one beyond the feet, a second by the right thigh. The remaining five vessels had been placed round the head. An iron blade lay beside the head, and a bronze earring was the only item of jewellery recovered.



FIG. 13:10 Burial 75, showing the clay cap to the grave. A pottery vessel in the fill, cat. 1107, can be seen

Burial 87

This burial comprises the foot bones of an adult, lying to the south of burial 82. There were three bronze toe rings on the right foot (cat. 1166).

Burial 118

This grave contained the bones of an adult of indeterminate age, with some disarticulated bones of a child



FIG. 13:11 View to the north of burial 75, including a ring of post holes in the vicinity of the grave. The excavation is 4 metres in width



FIG. 13:12 Burial 118, showing the circular carnelian bead and a concentration of iron in the form of arrowheads or ornaments. Scale 2 cm

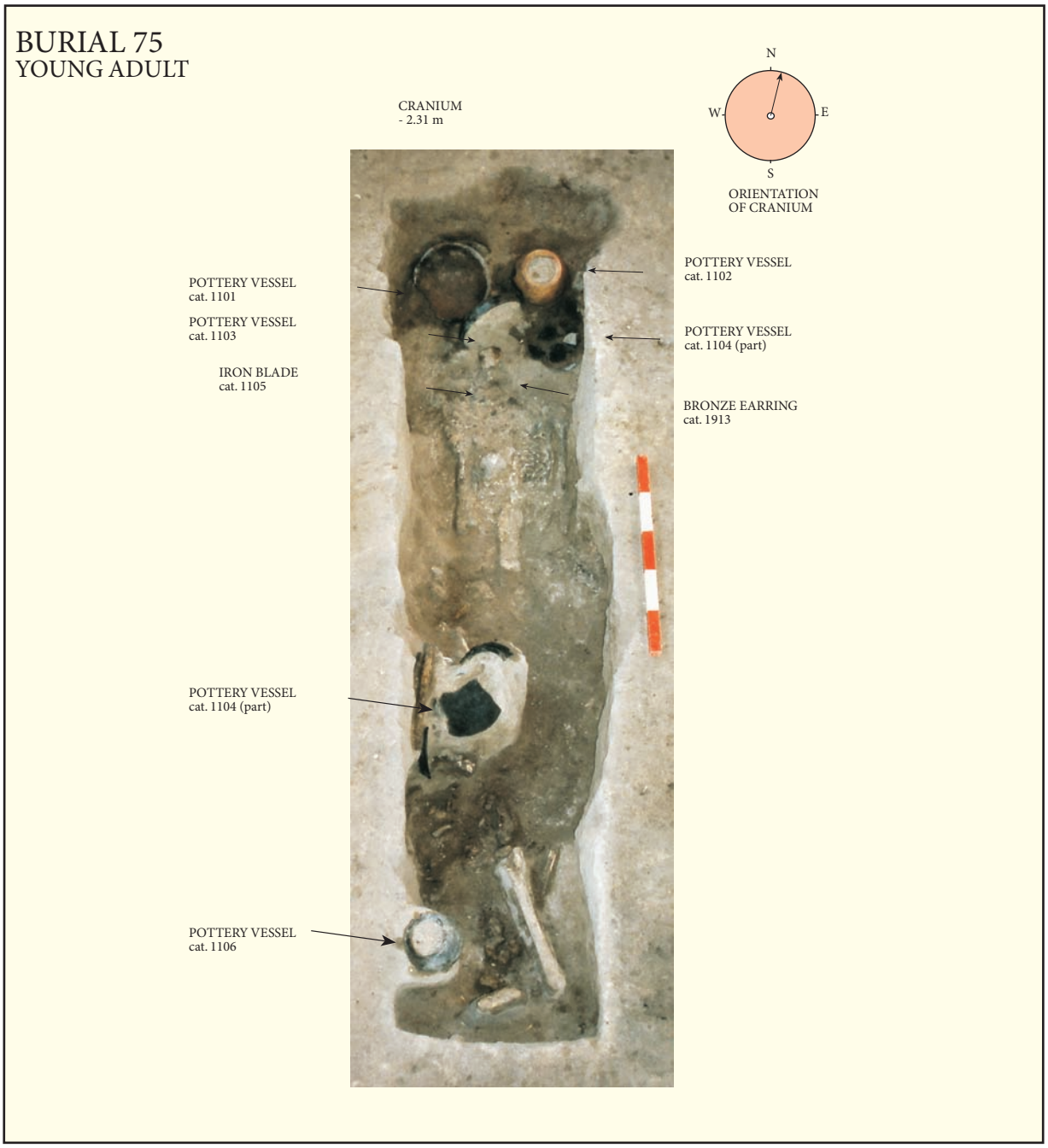


FIG. 13:13 Burial 75

aged 14-16 years at death. The former lay with the head orientated to the south, and lying just next to the foot bones of burial 82. They were encountered at a depth of 2.48 m below datum. Two pottery vessels were associated with the body, one positioned to the right of the head, and the second to the left. The only carnelian bead of mortuary phase 4 was found on the chest. It differed from the elongated beads of mortuary phase 3 in being spherical. There were also two sets of enigmatic iron objects in the area of the neck. They have the appearance of arrowheads, but their shape belies such use. The shaft is a thin but broad strip of iron, and the point is a hollow within folded over but thin extensions of these strips. The location in the area of the neck suggests as an alternative, that they were ornamental iron pendants. Seven bronze bangles were present on the left wrist, and two on right. There were also five bronze rings on the fingers of the right hand, and 23 bronze toe rings, one of which was a spiral.

Burial 63

This infant, who died when aged between 3-9 months, was interred at a depth of 1.62 m below datum with the head pointing 15° west of north. The infant was associated with a large assemblage of mortuary offerings. These included

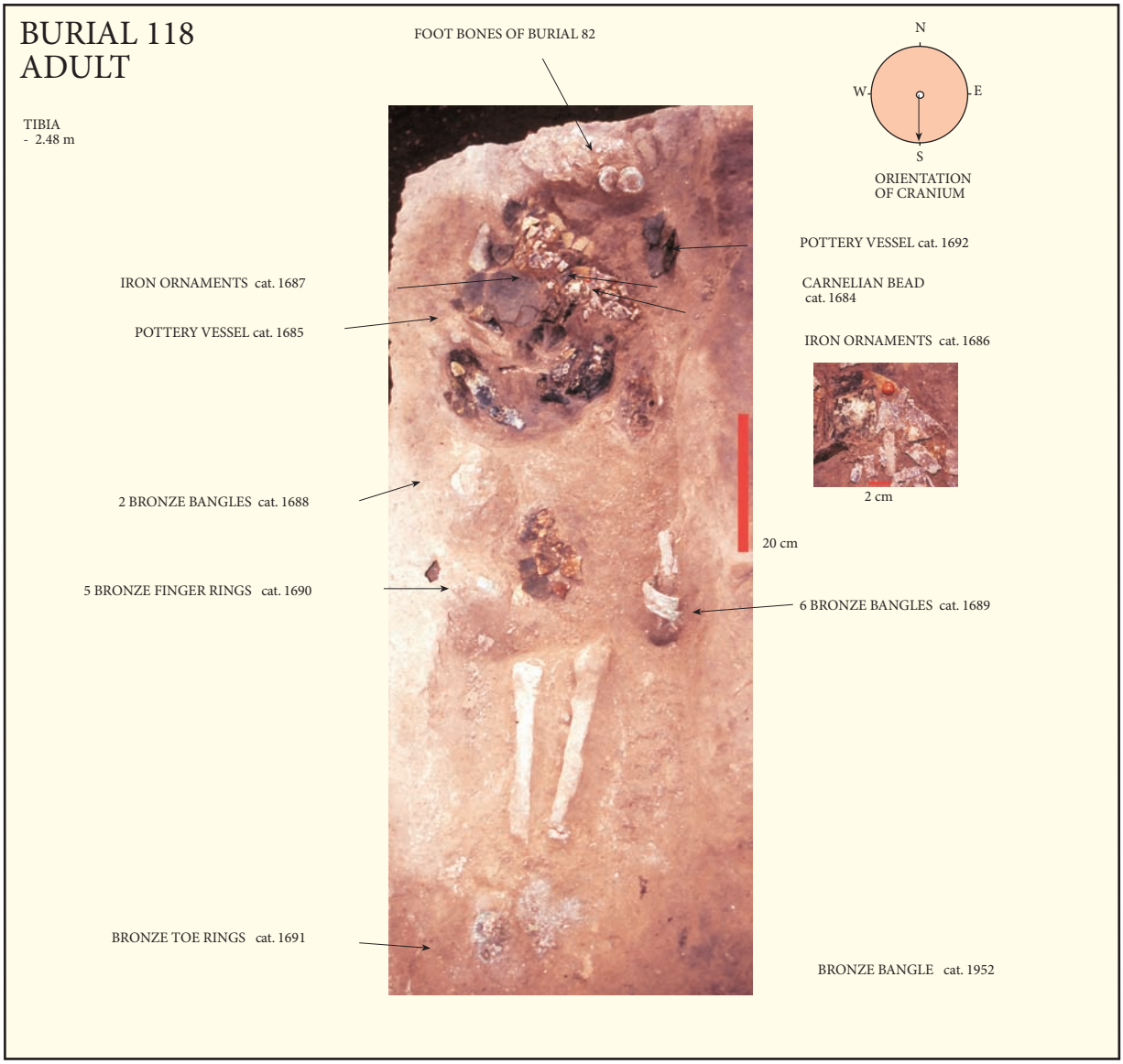


FIG. 13:14 Burial 118

five pottery vessels, which virtually enclosed the body on both sides. There was also a glass bead necklace. Bronzes comprised six bangles on the left arm and the same number on the right, three anklets on each leg and an earring. There were in addition, a further anklet near the left leg, two loose bangles and five fragments of rings. Two bimetallic rings were also present, one over the chest and the other under one of the pottery vessels located by the left arm.

Burial 85

This neonate was not interred within a mortuary vessel. It was, however, associated with a rich array of offerings, found at a depth of 2.38 m below datum. These included at least four pottery vessels one of which, cat. 1283, contained a concentration of rice. An iron knife blade and a bimetallic ring lay in the area of the neck. The infant also wore three such bimetallic rings on the right arm, and a further four on the left. Two bronze rings were found under the knife blade, while the flotation procedure recovered some glass beads and fragments of bronze.

Burial 88

This neonate was interred in a group of infant jar burials to the northeast of the main cluster. The lidded vessel was found at a depth of 2.46 m. Within, the infant lay in a crouched position with the head pointing to the north, under a bed of white silicified rice. Glass beads were present within the vessel.

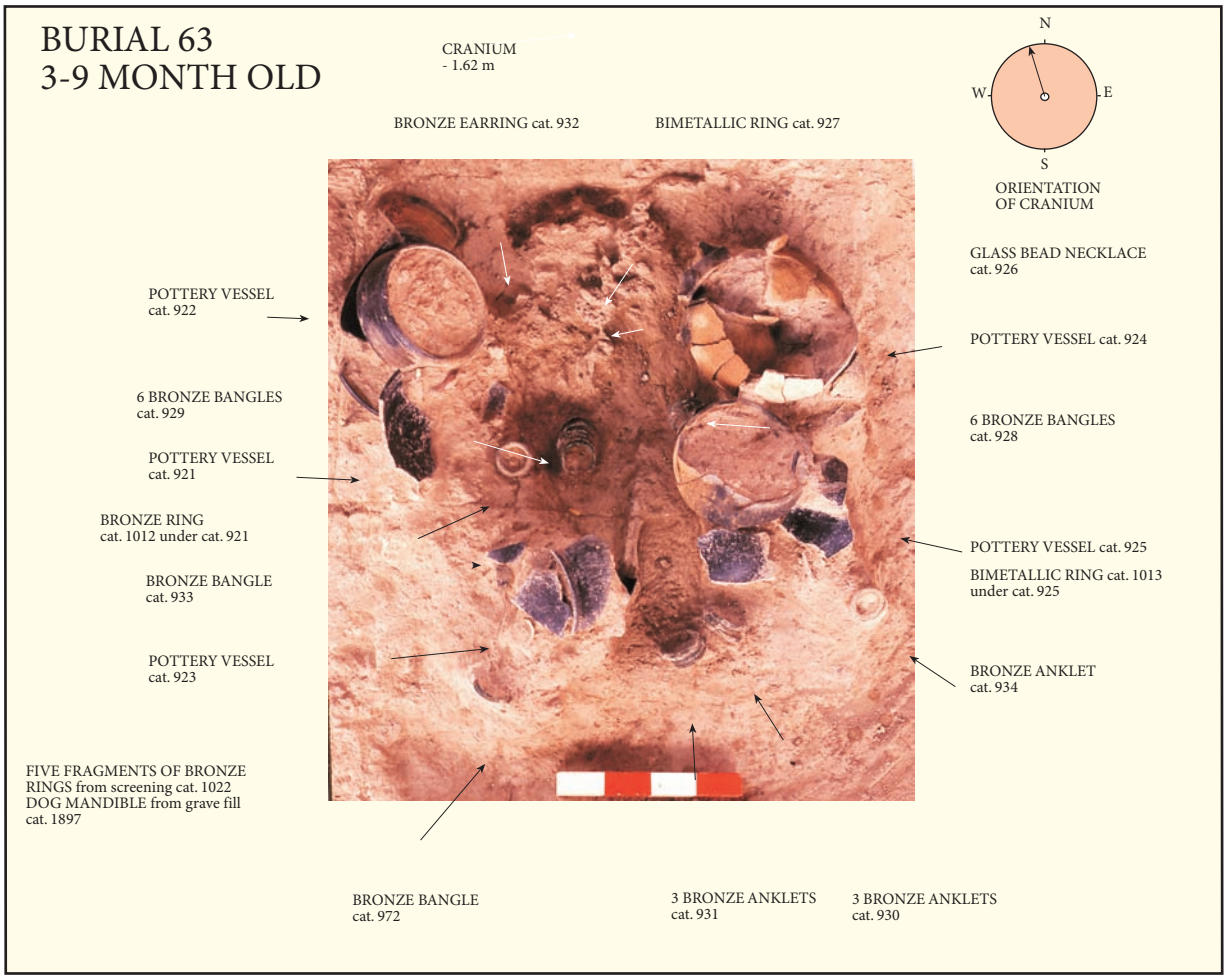


FIG. 13:15 Burial 63

Burial 89

This jar burial, in the same group as burial 88, contained a late foetal infant. The vessel lay at a depth of 2.52 m below datum.

Burial 90

This neonate was interred in a mortuary vessel at a depth of 2.45 m below datum. The jar contained a bivalve shellfish.

Burial 91

The infant in this grave died when aged up to 3 months. It had been interred in a rice bed grave at a depth of 2.51 below datum. The body was orientated with the head to the north. One pottery vessel lay beside the head, and another by the left ankles. There was an agate pendant in the area of the neck, and a bivalve shellfish in the vicinity of the abdomen. Bronzes comprised four bangles on each wrist, two bronze anklets on the left leg, and an earring.

Burial 100

The jar containing this neonate was found at a depth of 2.80 m. The infant lay in a prone position orientated with the head to the north. No grave goods were found apart from some fragments of fish bone.

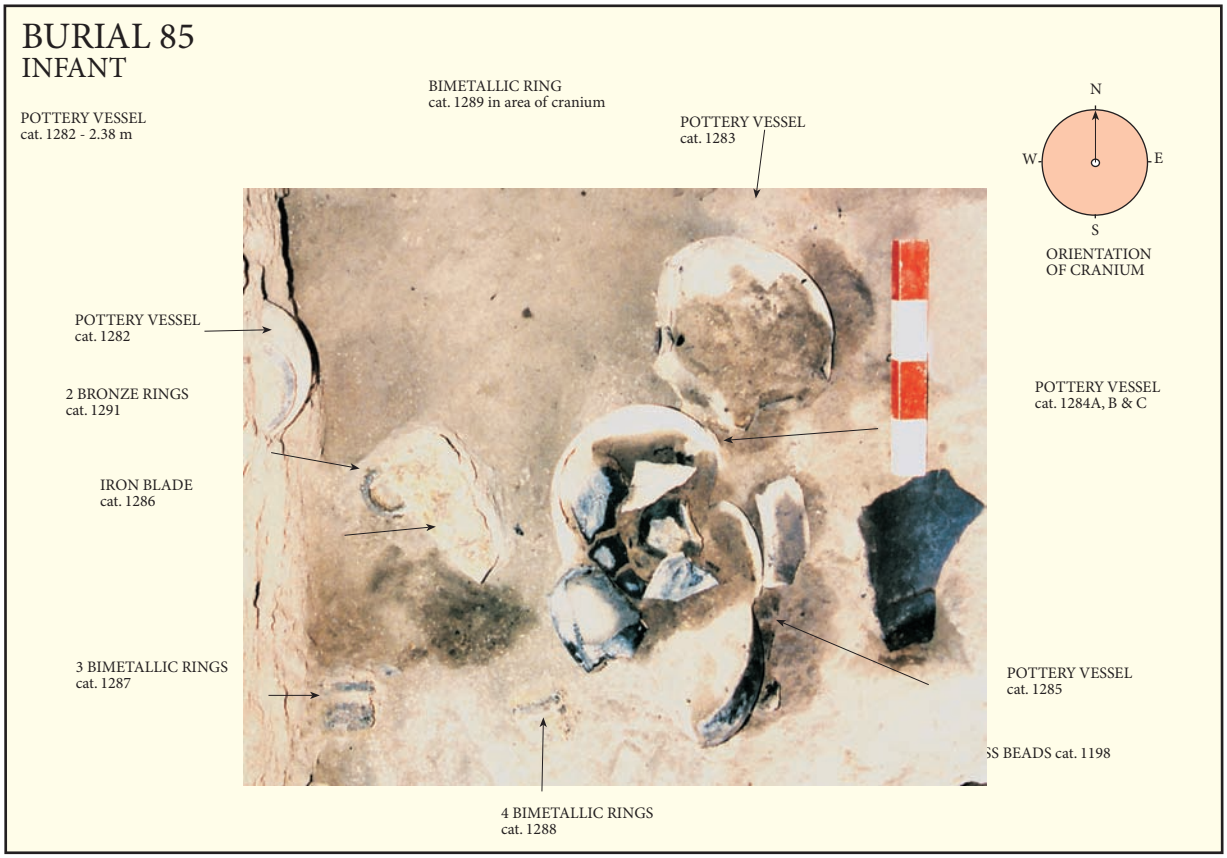


FIG. 13:16 Burial 85

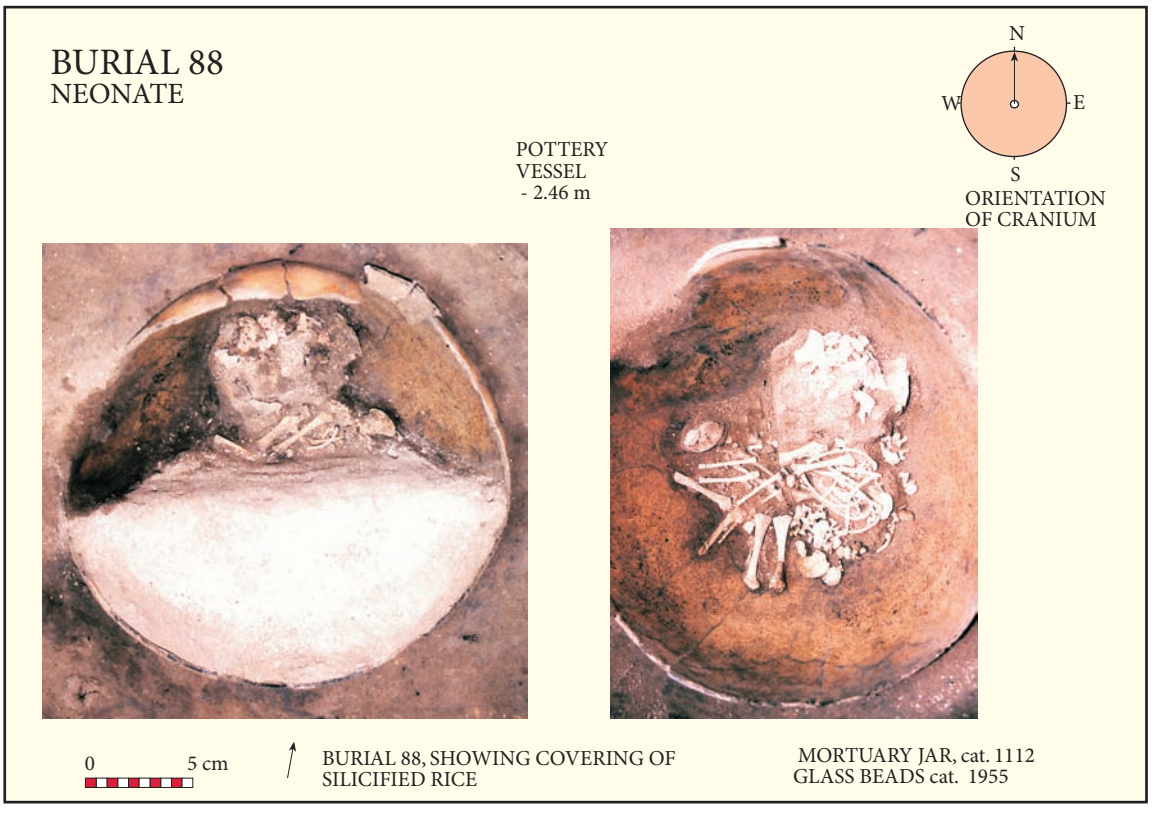


FIG. 13:17 Burial 88

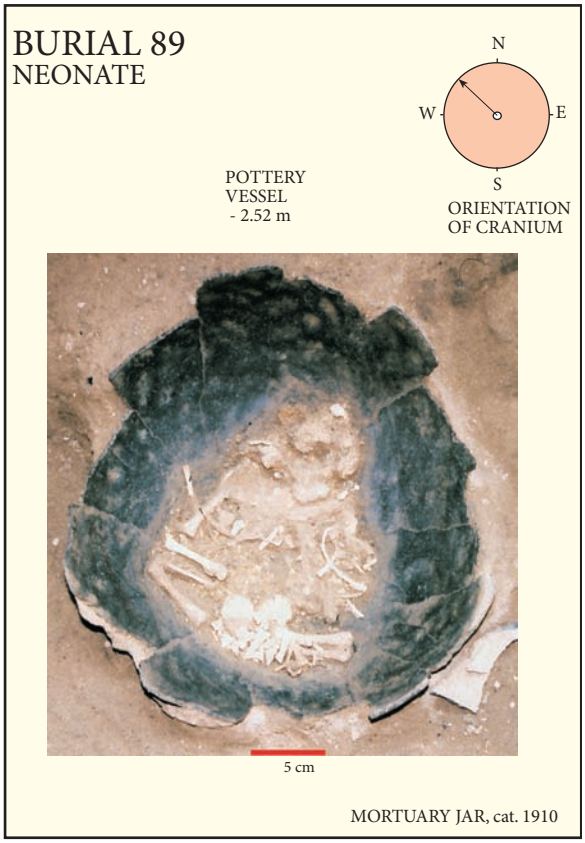


FIG. 13:18 Burial 89

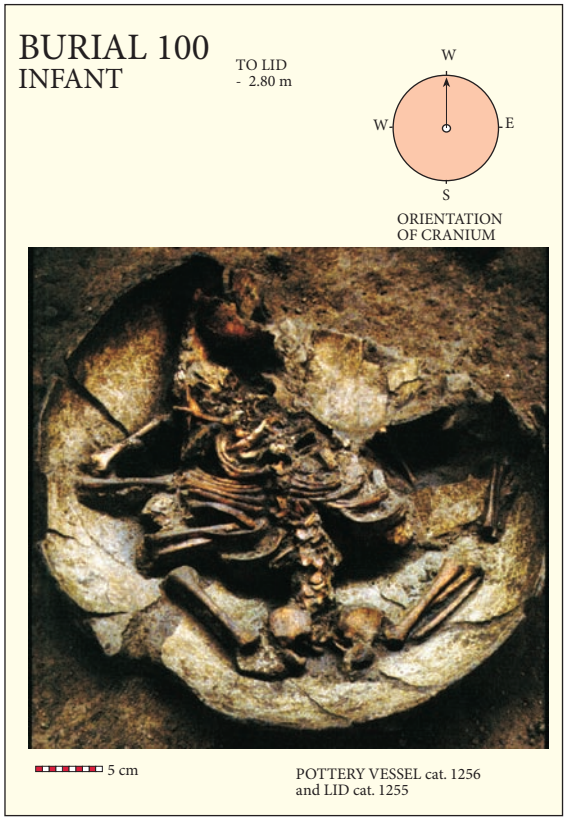


FIG. 13:19 Burial 100

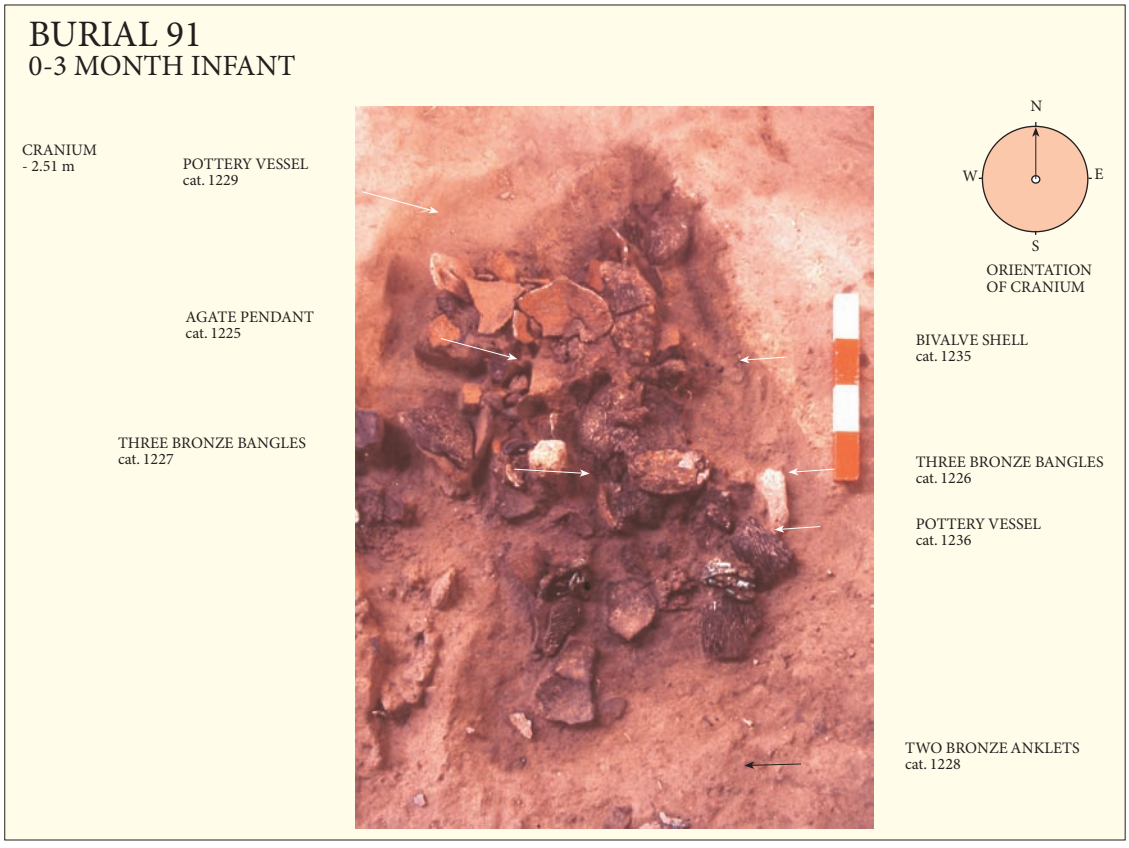


FIG. 13:20 Burial 91

CLUSTER C: SUMMARY

This cluster of graves displays the same proliferation of bronzes as was noted for clusters A and B. Burial 69 is prominent in this respect, with four bronze belts in addition to multiple bangles, finger and toe rings. It also has two unparalleled bronze ear plugs. Iron knives were relatively frequent, and two further unique items were recovered, a spade and a set of possible iron neck ornaments. Only one spindle whorl was found in this group, and a small number of three agate pendants were present. There was also a unique globular carnelian bead.

There is no stratigraphic evidence to place cluster C graves in a sequence relative to clusters A and B. In the case of burial 75, the clay capping to the grave was found at a depth of 2.01 m.

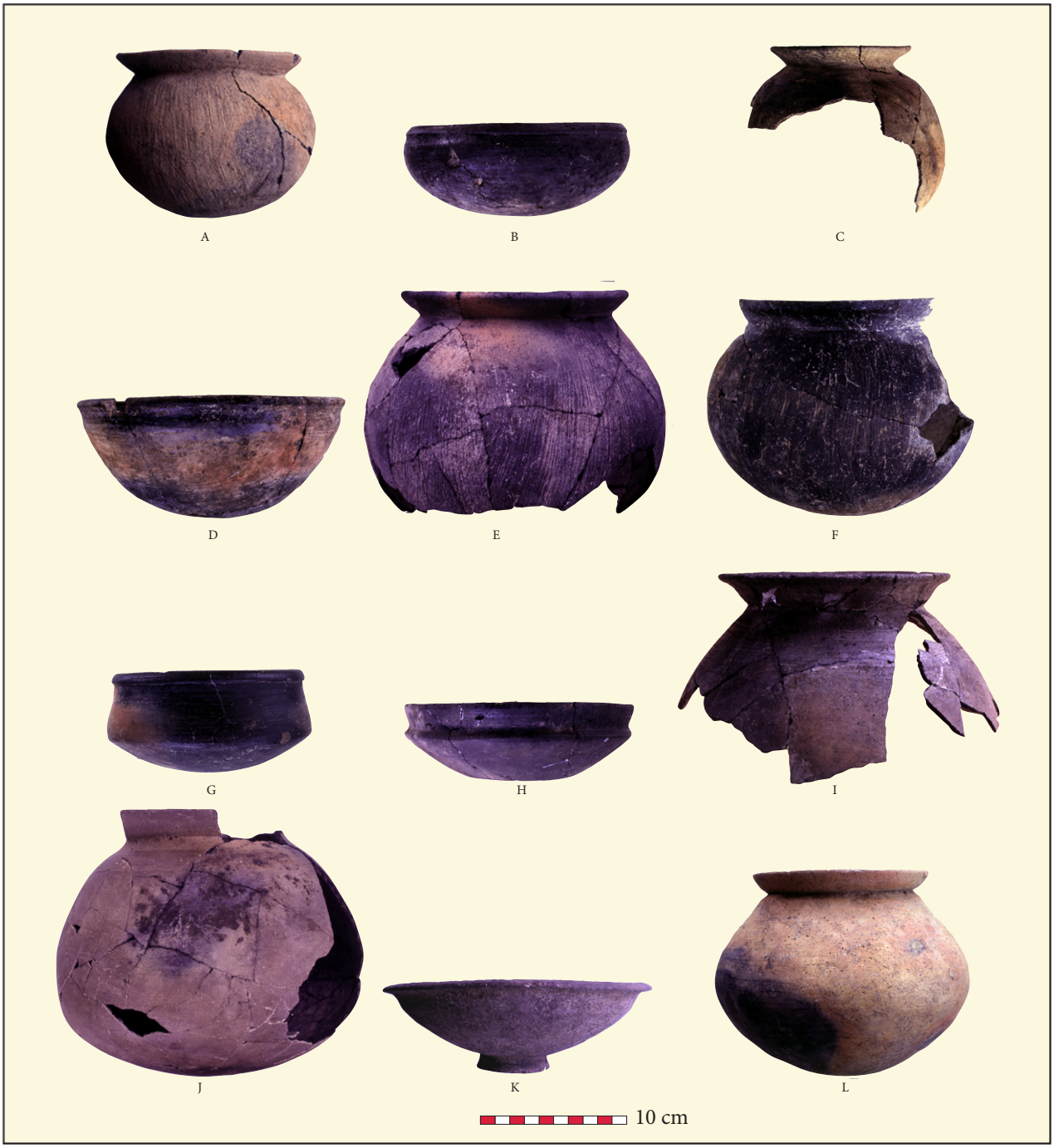


FIG. 13:21 Pottery vessels from mortuary phase 4C graves. A. burial 62 cat. 917, B. burial 62 cat. 920, C. burial 62 cat. 918, D. burial 63 cat. 921, E. burial 63 cat. 924, F. burial 63 cat. 923b, G. burial 63 cat. 922, H. burial 69 cat. 989, I. burial 69 cat. 990, J. burial 74 cat. 1084a, K. burial 75 cat. 1101a, L. burial 75 cat. 1102

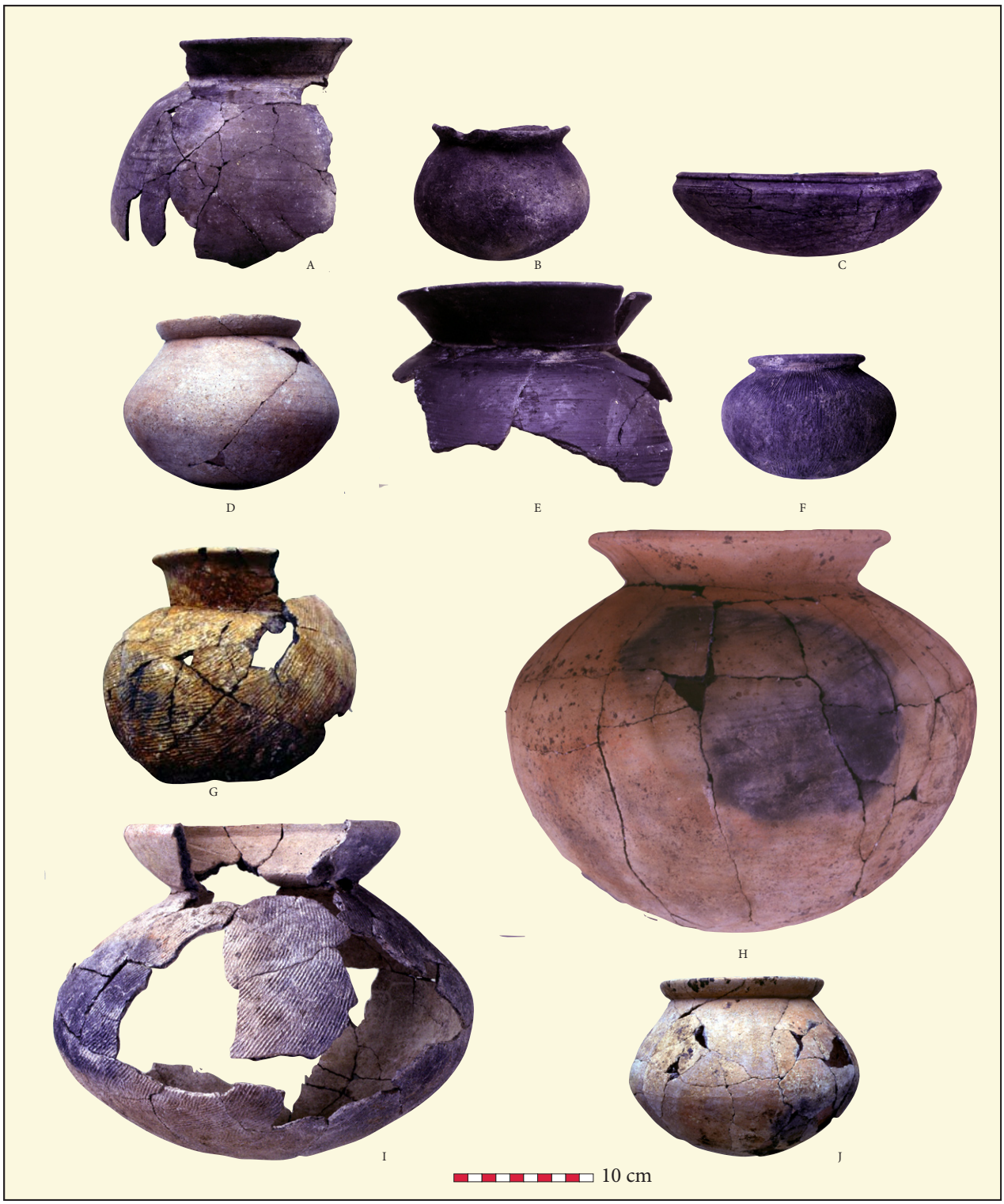


FIG. 13:22 Pottery vessels from mortuary phase 4 cluster C. A. burial 75 cat. 1104, B. burial 75 cat. 1106, C. burial 75 cat. 1103, D. burial 82 cat. 1163, E. burial burial 82 cat. 1165a, F. burial 85 cat. 1282, G. burial 86 cat. 1270, H. burial 88 cat. 1110, I. burial 100 cat. 1256, J. burial 91 cat. 1229

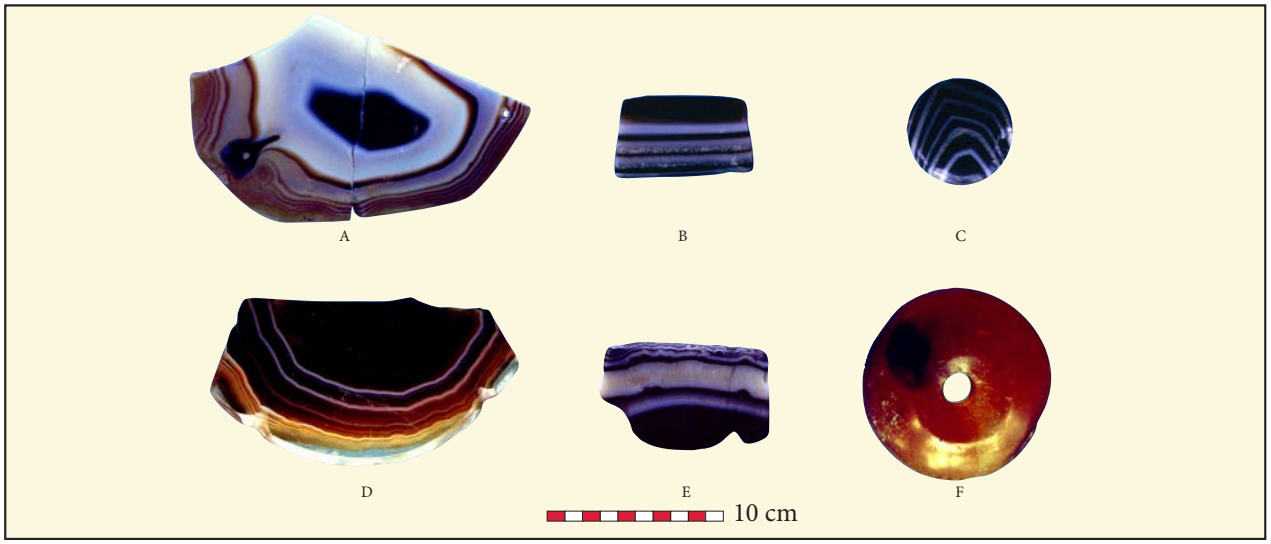


FIG. 13:23 Agate and carnelian pendants from mortuary phase 4c. A. Burial 13 cat. 179, B. Burial 62 cat. 1109, C. Burial 20 cat. 323, D. Burial 91 cat. 1225, E. Burial 86 cat. 1127, F. Burial 118, cat. 1684. All actual size except F, which is twice actual size

XIV. THE BURIALS OF MORTUARY PHASE 4 CLUSTER D

C.F.W. HIGHAM AND R. THOSARAT

This cluster lies at the extreme northern limit of the excavated area, and it is highly likely that more burials lie unexplored. The available burials incorporate a male, a female, an adult, one grave within which the age and gender are not known, and an infant. Only one of these, burial 14, is undisturbed, and in this case, the cranium just lay within the bounds of the excavation.

Burial 14

This grave contained the remains of a male aged 35-40 years at death. His grave incorporated white burnt rice, and the skeleton was recovered at a depth of 2.01 m below datum. He was, with the possible exception of burial 113, the richest recovered in terms of grave offerings. At least eight pottery vessels were recovered, and more may well lie beyond the excavated area. One lay just left of the cranium, two to the right of the head and three more over the lower part of the face, the upper left arm and the elbow area of the right arm. A further vessel was present beside the right knee. The last pot was recovered from 15 cm below the body and may not be in association. Many glass beads were associated as grave goods. A concentration was

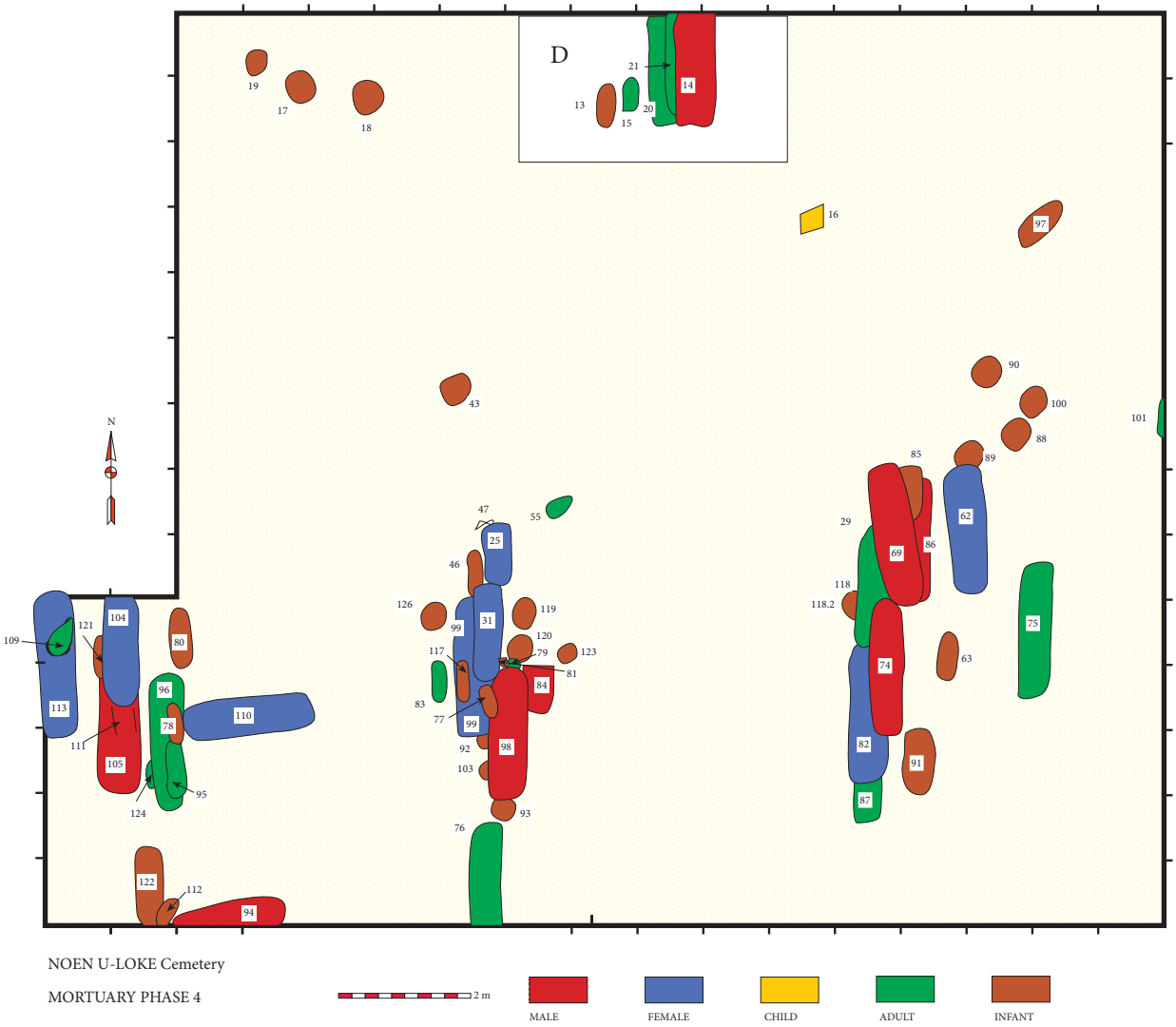


FIG. 14:1 The layout of phase 4 burials, showing the location of cluster D

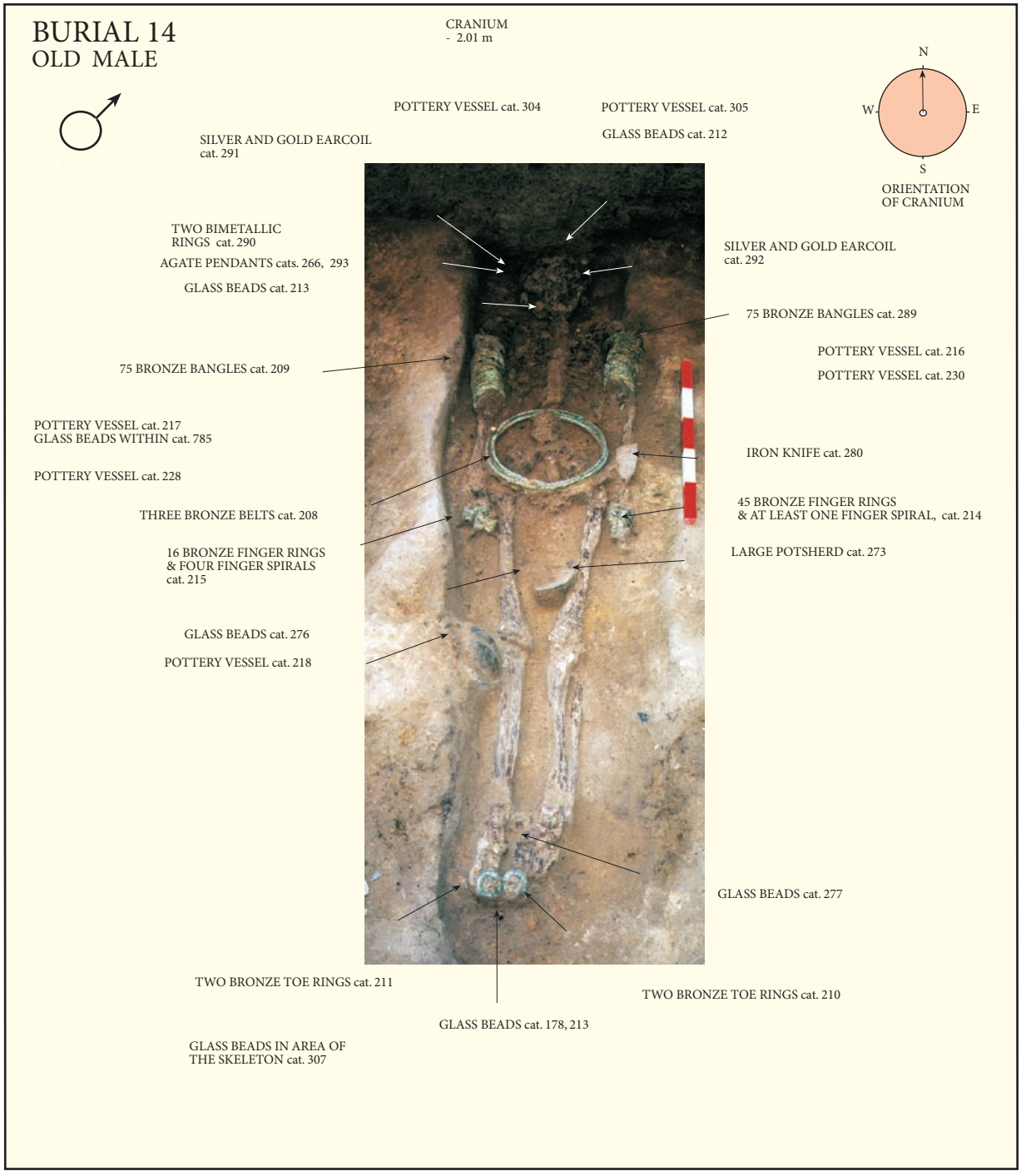


FIG. 14:2 Burial 14

recovered from the area of the feet, others from betweeen the lower legs, and the head.

An iron knife was found over the left wrist. Perhaps the most impressive part of the assemblage of bronzes, however, was the quantity of bronze. Seventy-five bangles were present on each arm. There were also 45 finger rings, and at least two novel finger spirals on the left hand and 16 rings and four spirals on the right. There were also two bronze toe rings on each foot. This man wore two ear coils, an ornament not previously encountered, made of silver covered in gold foil. There were also two agate pendants and two bimetallic bronze rings in the area of the neck.



FIG. 14:3 Burial 14, showing some of the pottery vessels. Scale 10 cm



FIG. 14:5 The skull of burial 14, showing the silver and gold ear coils, agate pendant and bronze rings at the neck. Scale 10 cm



FIG. 14:4 The 75 bronze bangles on the upper left arm. Scale 10 cm



FIG. 14:6 Burial 14, showing the three bronze belts, finger rings and iron knife blade. Scale 10 cm

Burial 15

This burial comprises a disturbed set of adult human bones lying between burials 13 and 14. A ceramic vessel, cat. 242, was found in the vicinity of the bones, and an agate bead was recovered from the flotation procedure (cat. 274).

Burial 20

This grave contained the disturbed remains of an adult, at a depth of 2.45 m. There was a very clear cutting seen in the distribution of white silicified rice. The grave goods within the cutting were a circular agate bead in the area of the head, a bronze earring, two finger rings and two bronze bangles.

Burial 21

This grave underlies burial 14 at a depth of 2.26 below datum. It contained the remains of an adult with the

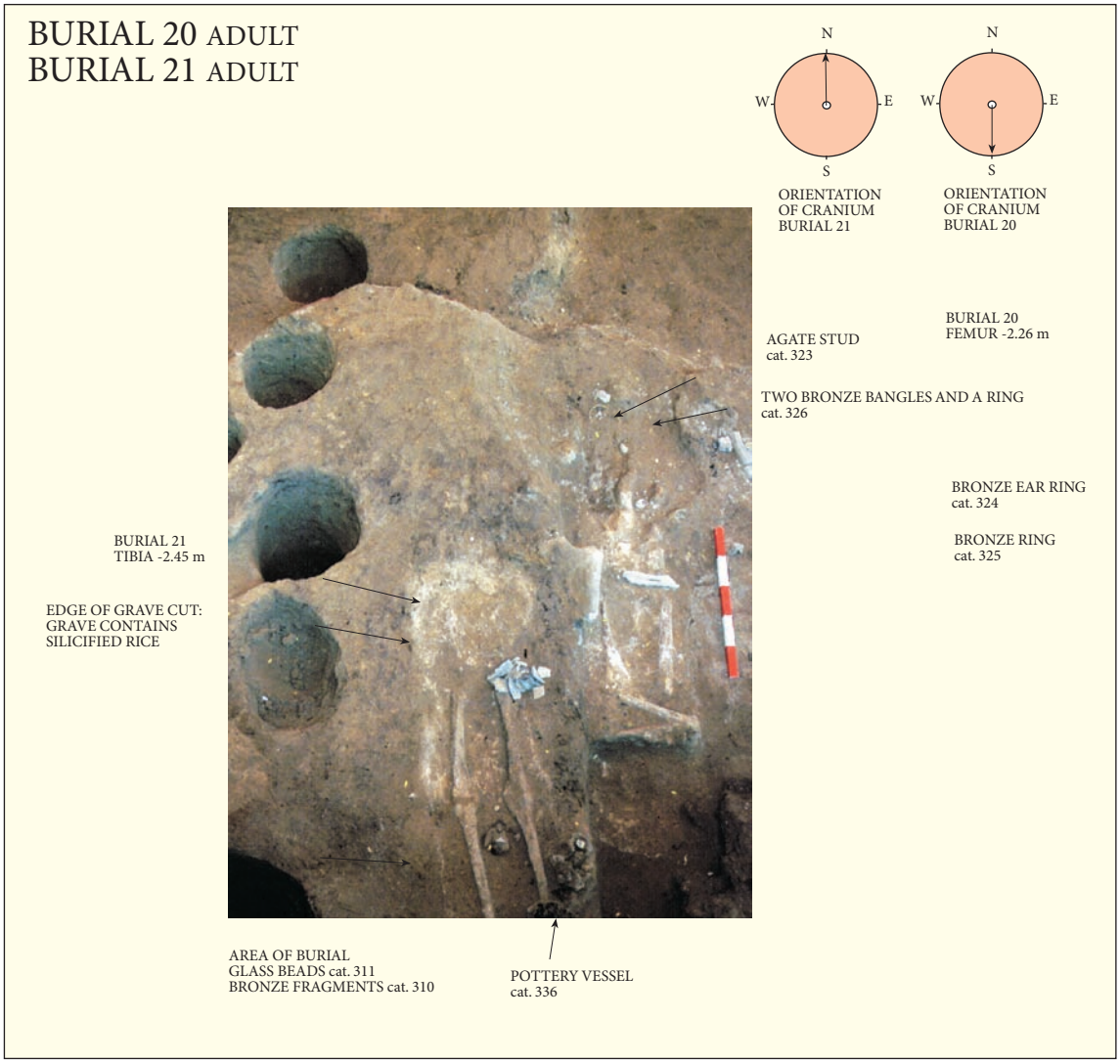


FIG. 14:7 Burials 20 and 21, showing part of the row of postholes to the east of burial 21

head orientated to the north, within a rice-filled grave. Offerings incorporated glass beads, a pottery vessel and fragments of bronze.

Burial 13

This three-month-old infant was interred in a rice bed grave at a depth of 1.99 m below datum. The grave was west and on the same orientation as burial 14. It was richly-endowed with grave goods, but the infant bones were few and poorly preserved. Two agate pendants were found to the left of the area where the skull would have lain, and two pottery vessels were recovered. One, cat. 194, lay over the grave and might well represent a separate infant jar burial. Three bimetallic rings were encountered, and at least two bronze bangles, although a further bronze ring and a fragment of an earring were found through the flotation procedure. Many glass beads lay over the area of the body, and part of what may have been an iron spear point was also recovered from the general area.

CLUSTER D: SUMMARY

The complete recovery of all the graves in this cluster is a priority for future work at Noen U-Loke, because stratigraphically, it is the latest in mortuary phase 4, and in terms of burial 14, undoubtedly the richest. Burial 14 was recovered at or near the same depth from which some of the cluster A, B and C graves were cut. The unparalleled weight of bronzes, in addition to the silver and gold ornaments found with burial 14, reveal a further increase in mortuary wealth towards the end of the fourth mortuary phase. The infant burial 13 is also richly endowed, but unfortunately, the other interments in this cluster were disturbed in antiquity.

The dating of these burials is permitted by five radiocarbon dates which bracket the period during which the

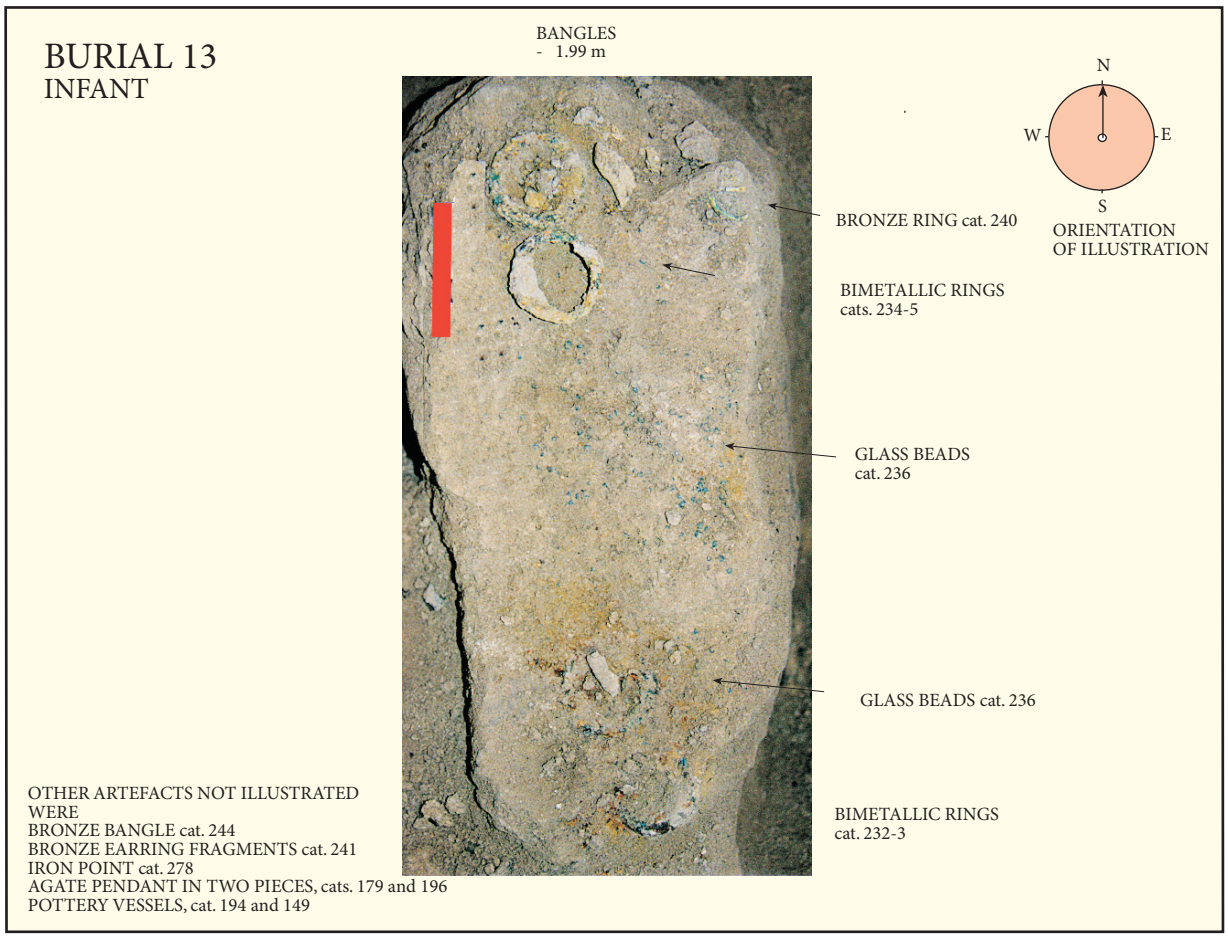


FIG. 14:8 Burial 13. Scale, 5 cm

graves were cut. Three, which provide a *terminus post quem*, come from upper layer four, and corrected at two sigma, are AD 65-343, 18-375 and 79-337. The other two dates derive from upper layer 3, and post date the cutting of the graves. These are AD 140-597 and 346-786. It is, therefore, suggested that these graves probably lie within the period AD 200-400.

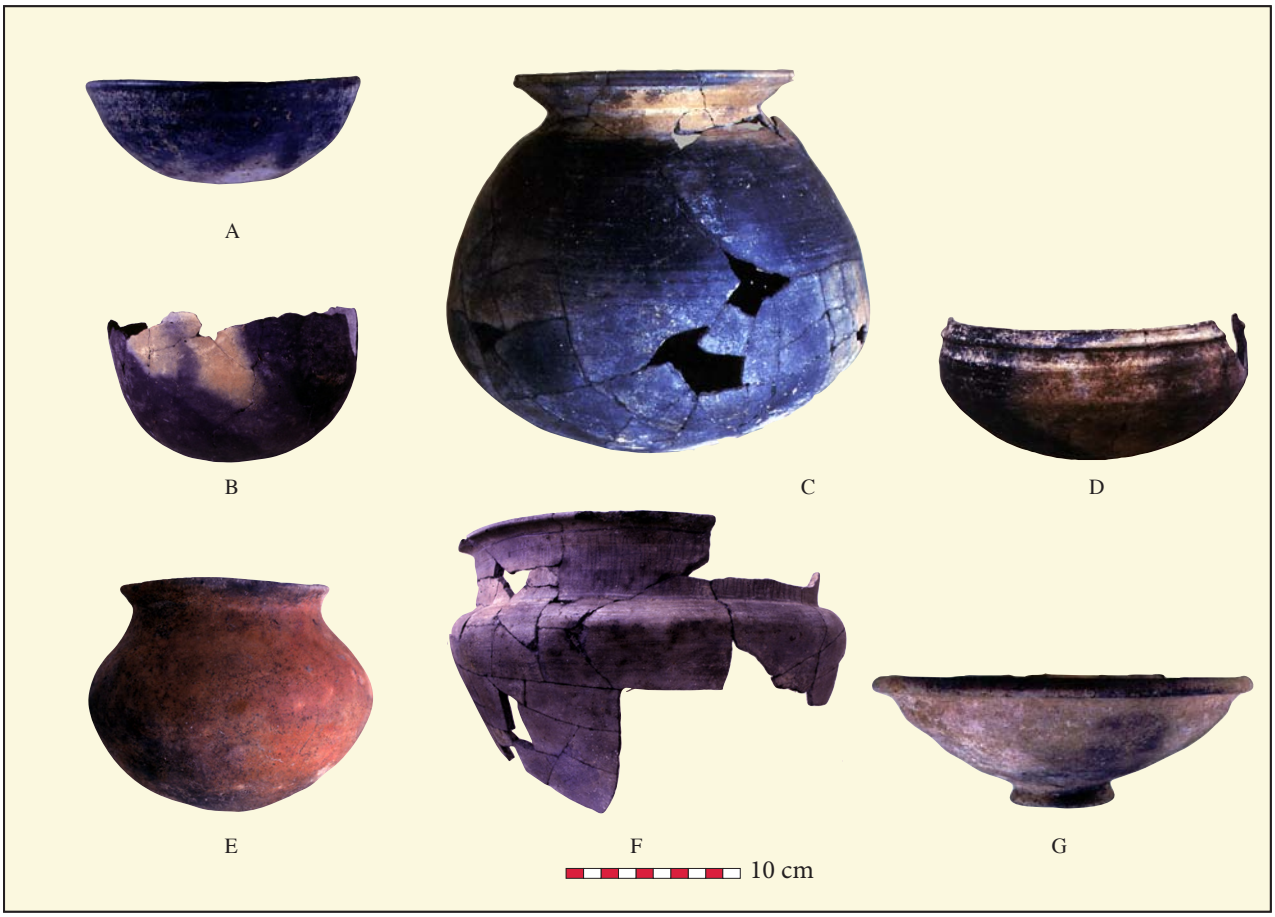


FIG 14:9 Pottery vessels from the phase 4 cluster D burials. A. burial 14 cat. 242, B. burial 14 cat. 280, C. burial 14 cat. 217, D. burial 14 cat. 228, E. burial 13 cat. 149, F. burial 13 cat. 194, G. burial 16 cat. 246

XV. THE MISCELLANEOUS BURIALS OF MORTUARY PHASE 4

C.F.W. HIGHAM AND R. THOSARAT

While most mortuary phase 4 burials were disposed in clusters, several were found isolated, or without clear reference to a major grouping. Four of these were infant jar burials in the northwest part of the excavated area. They might well belong to a cluster lying beyond the excavated area, for in the case of cluster C, it is evident that infants were interred on the periphery of a group. Burial 97 is isolated and singular, since the child suffered from cerebral palsy.

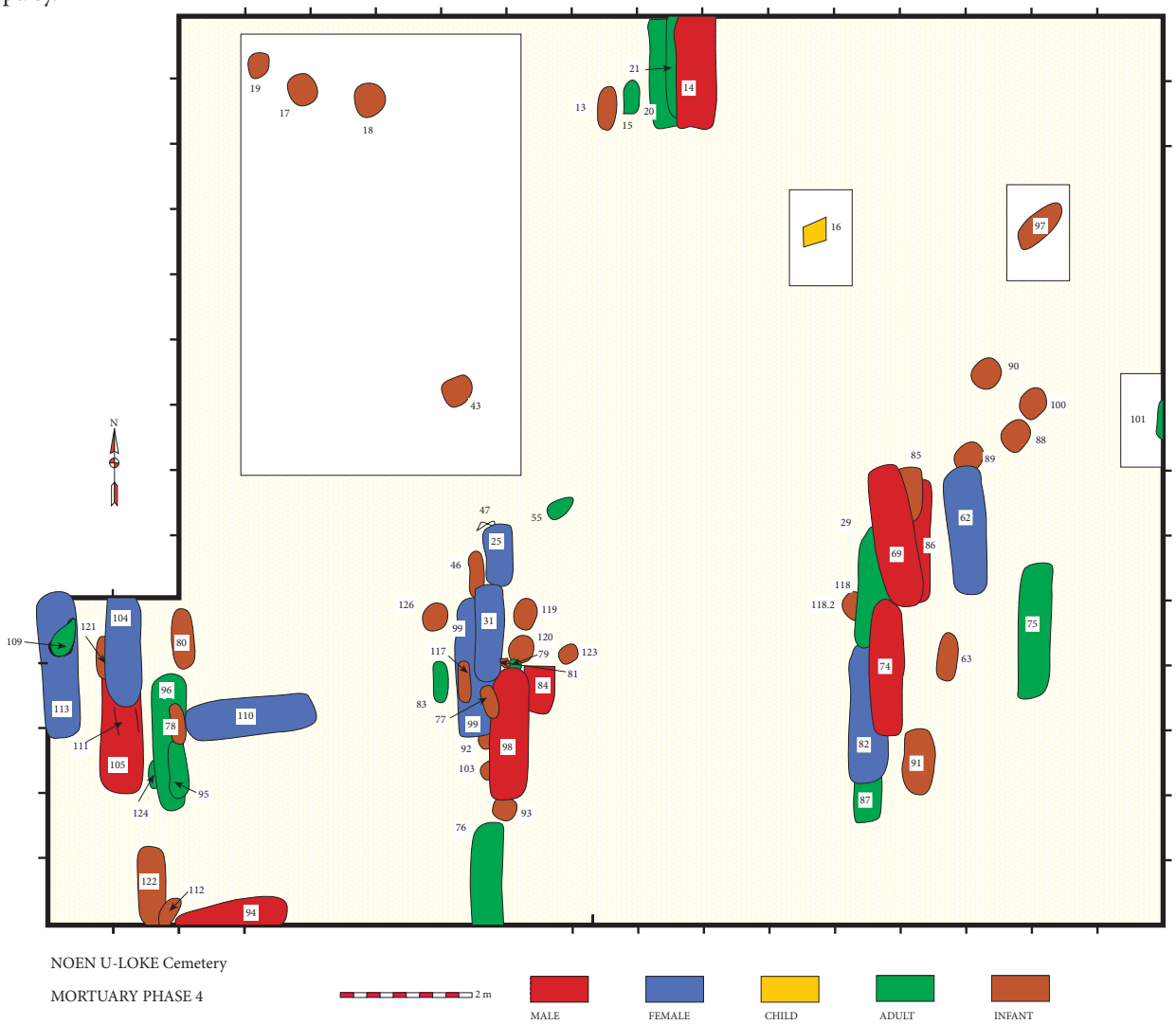


FIG. 15:1 The layout of mortuary phase 4 miscellaneous graves

Burial 16

This grave contained the very disturbed remains of a woman who died when aged between 20-25 years. She lay at a depth of 2.08 m below datum, but the orientation of the body could not be determined other than a general north-south direction. Parts of a pottery vessel were found in the area of the bones, and other grave goods included a small iron point, a red glass bead and two bimetallic rings.

Burial 101

The foot bones of an adult were found, within a cutting containing white burnt rice, in the eastern section. The balance remains in the unexcavated area.

Burial 17

This neonate was interred in a jar at a depth of 2.52 m below datum. A second vessel found adjacent to the mortuary jar probably represents the lid. Some carbonised rice was found within.

Burial 18

This neonate jar burial was recovered at a depth of 2.62 below datum. The lidded vessel contained three smaller pottery vessels in addition to the human remains.

Burial 19

This third neonate burial was found within a lidded mortuary jar at a depth of 2.36 m below datum. Fragments of rice chaff and straw were noted within the vessel.

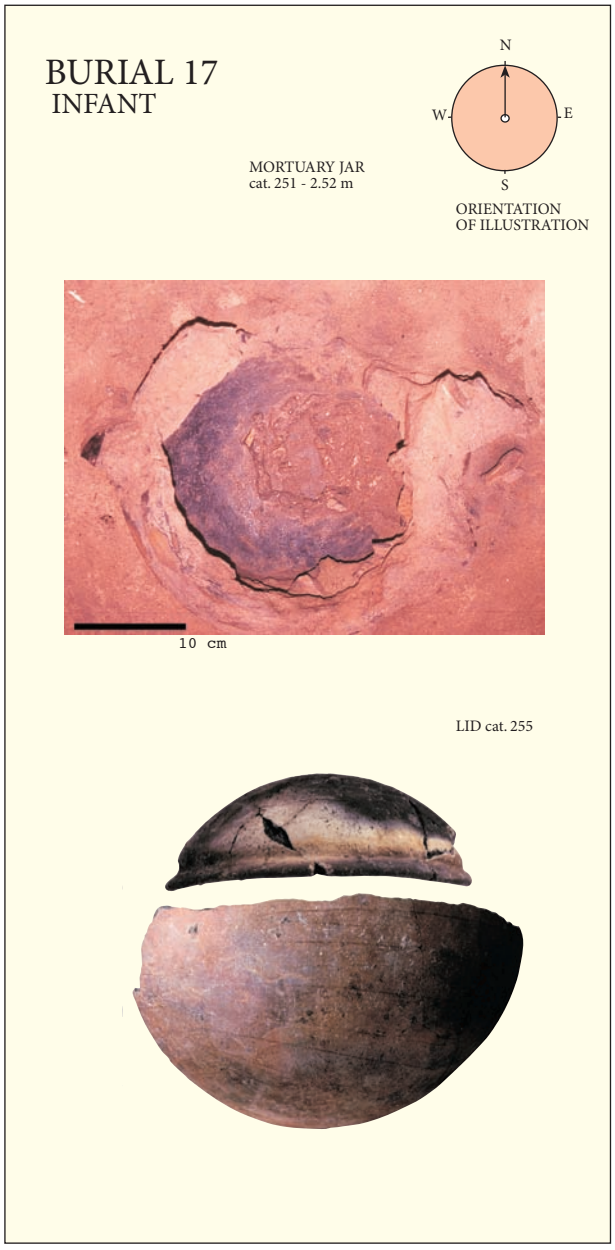


FIG. 15:2 Burial 17

Burial 43

This neonate was interred in a lidded mortuary jar at a depth of 2.68 m to the bones within the jar. The only possible other mortuary good was a clay pellet bow pellet.

Burial 97

The two to three-year-old interred in this isolated grave, at a depth of 2.62 m below datum, was orientated at an unusual angle of 50° east of north. The infant presented unusual physical characterstics which are compatible with a person suffering from cerebral palsy (Tayles 2001). Associated grave goods were three ivory bangles on each arm, and an agate bead at the neck.

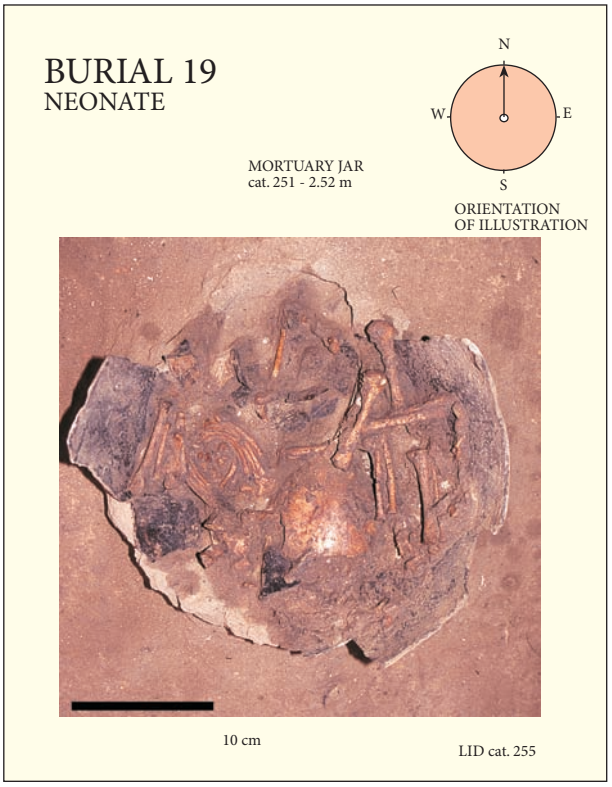


FIG. 15:3 Burial 19



FIG. 15:4 Burial 18

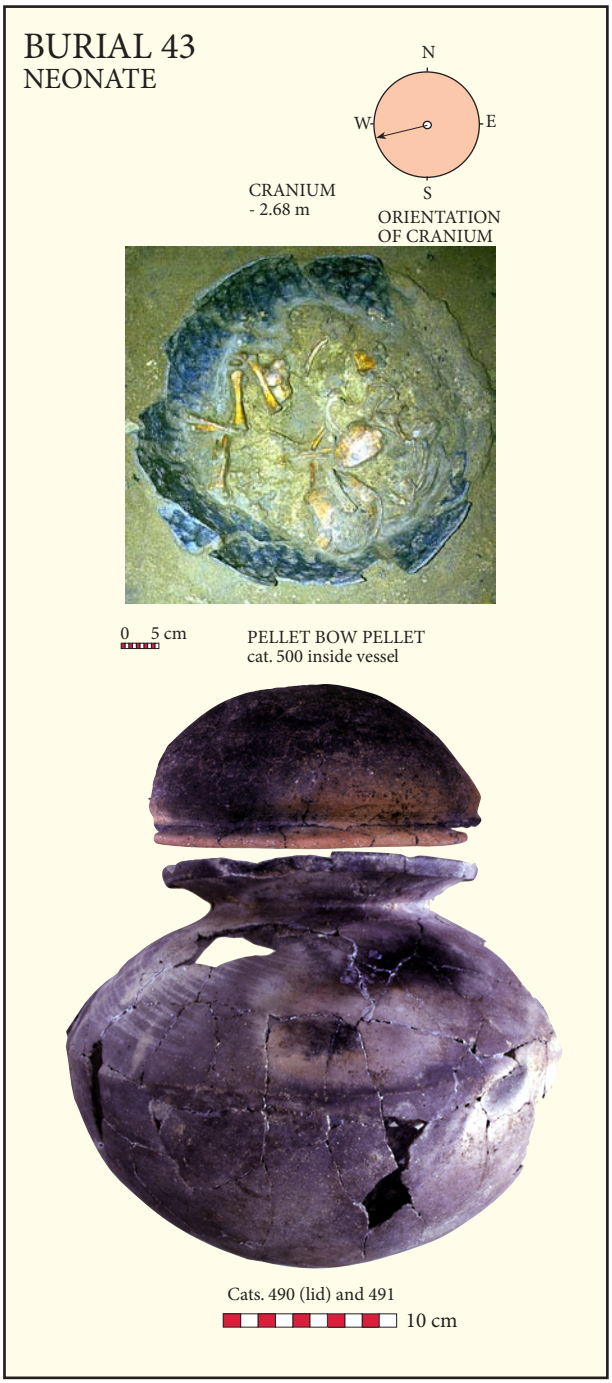


FIG. 15:5 Burial 43

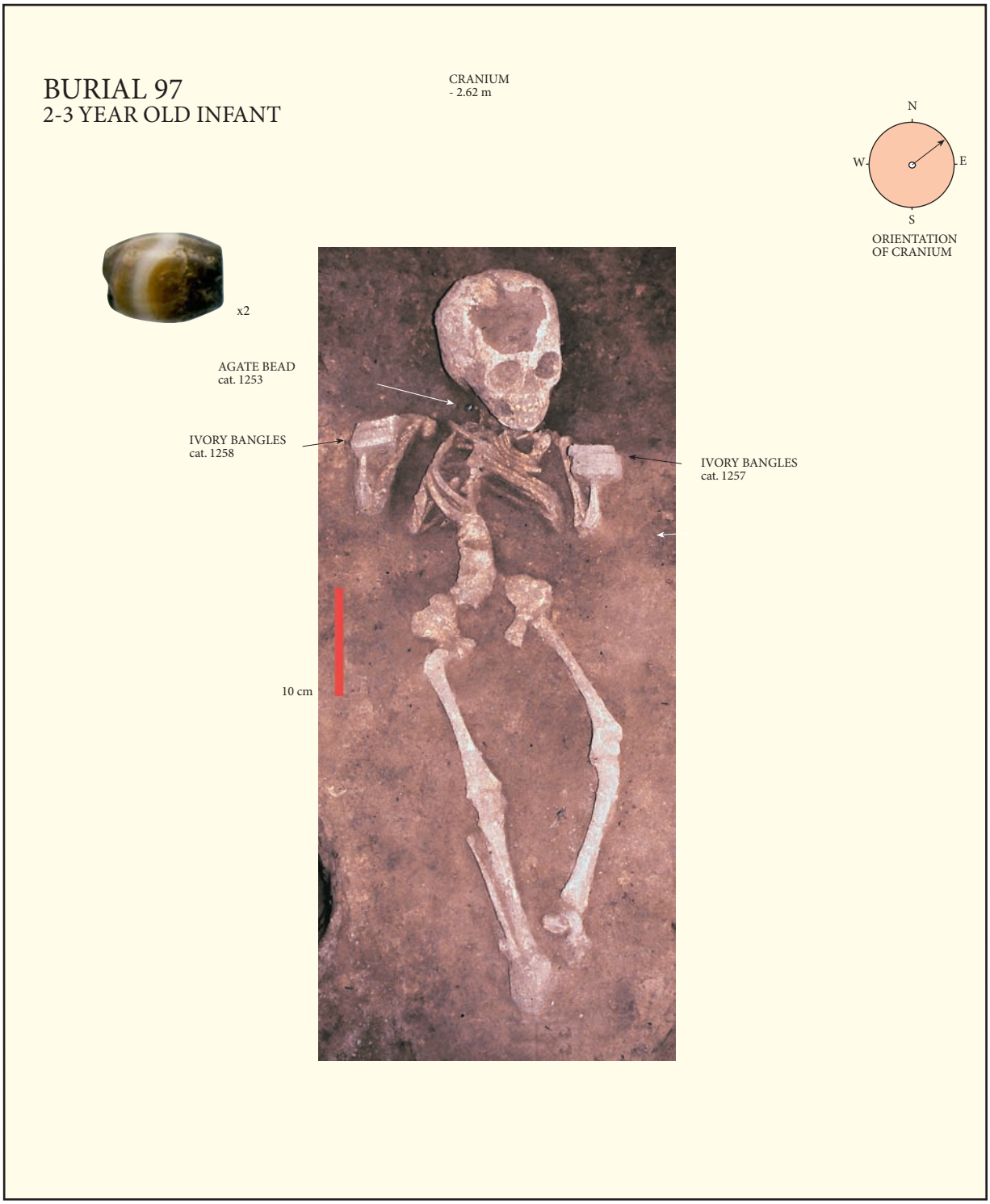


FIG. 15:6 Burial 97

XVI. THE BURIALS OF NOEN U-LOKE MORTUARY PHASE FIVE

C.F.W. HIGHAM AND R. THOSARAT

The spatial distribution of mortuary phase 5 burials reveals far less of the tight nucleation evident in the preceding phase. However, there is some evidence for grouping, particularly in the case of six burials in the northeastern part of the excavated area, where four people were superimposed over a depth of 68 cm. There are other examples of such superpositions, while burials 4, 5, 9 and 12 might comprise a group, since all were interred at a similar depth and orientation. Phase 5 burials probably cover a reasonable period of time, since the lowest was found 1.77 m below datum, while the uppermost lay only .58 m below datum, which is effectively the present mound surface. It would seem highly likely that the earliest burials belong to upper layer 3 while the latest date to the highest of the prehistoric occupation in layer 2. It is noted that the orientation of the dead remained similar to that seen in phase 4, but we lack the rice bed burials, and the grave goods, while still abundant, did not reach the heights seen in burials 14, 69 and 113. There were also changes in the nature of the offerings, seen in both the style of the ceramics and the range and number of iron implements. Thirty-one burials were recovered, comprising seven males, three females, seven adults, two children and 12 infants.

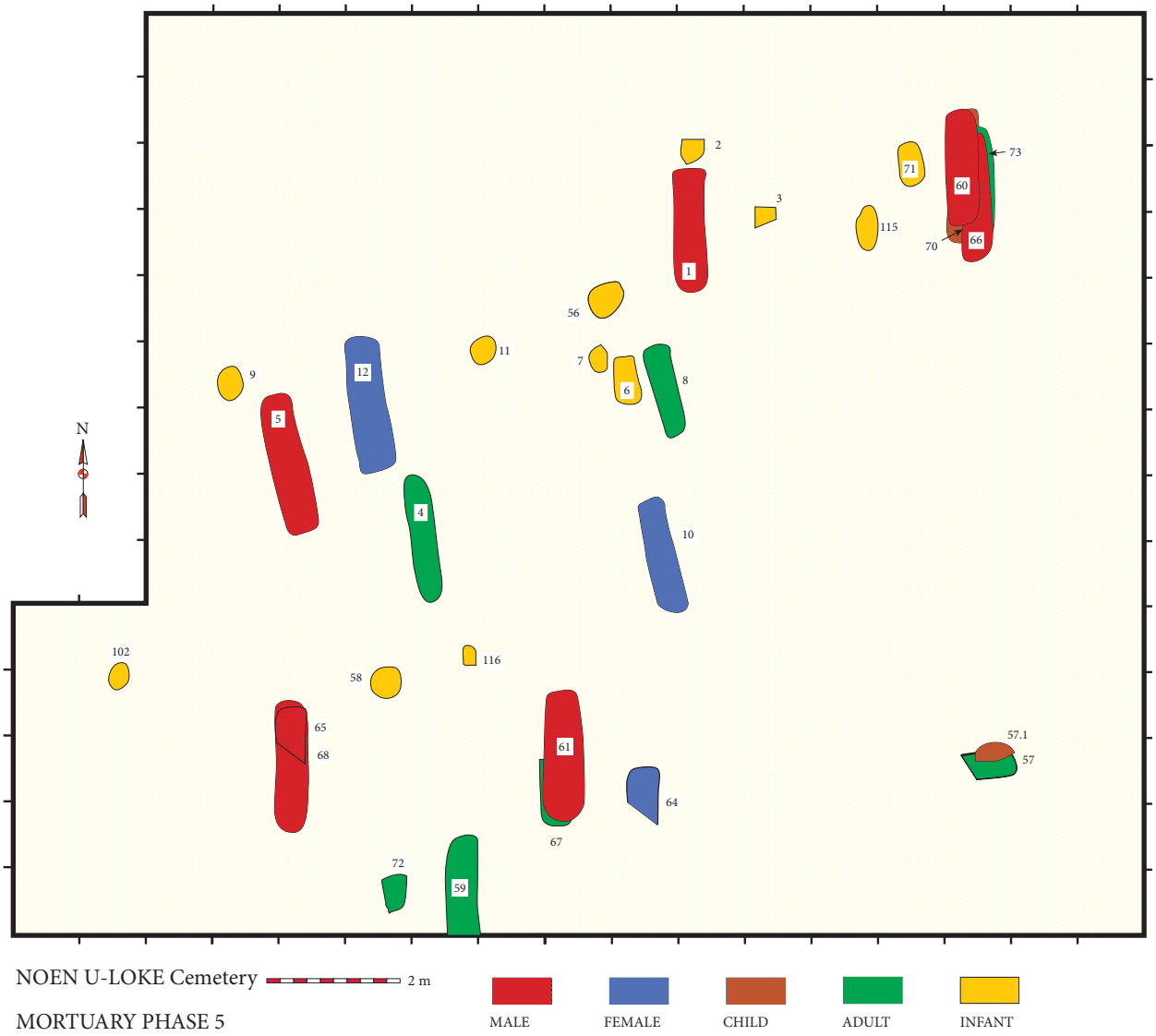


FIG. 16:1 The distribution of phase 5 burials



FIG. 16:2 Burial 1

Burial 1

The 35-40 year-old male in this grave was interred prone at a depth of 1.45 m, and directly to the south of the infant jar burial 2. Apart from the group of potsherds next to his head, which probably come from up to three vessels, most of the grave goods recovered took the form of bronze ornaments. These incorporated 14 bangles on

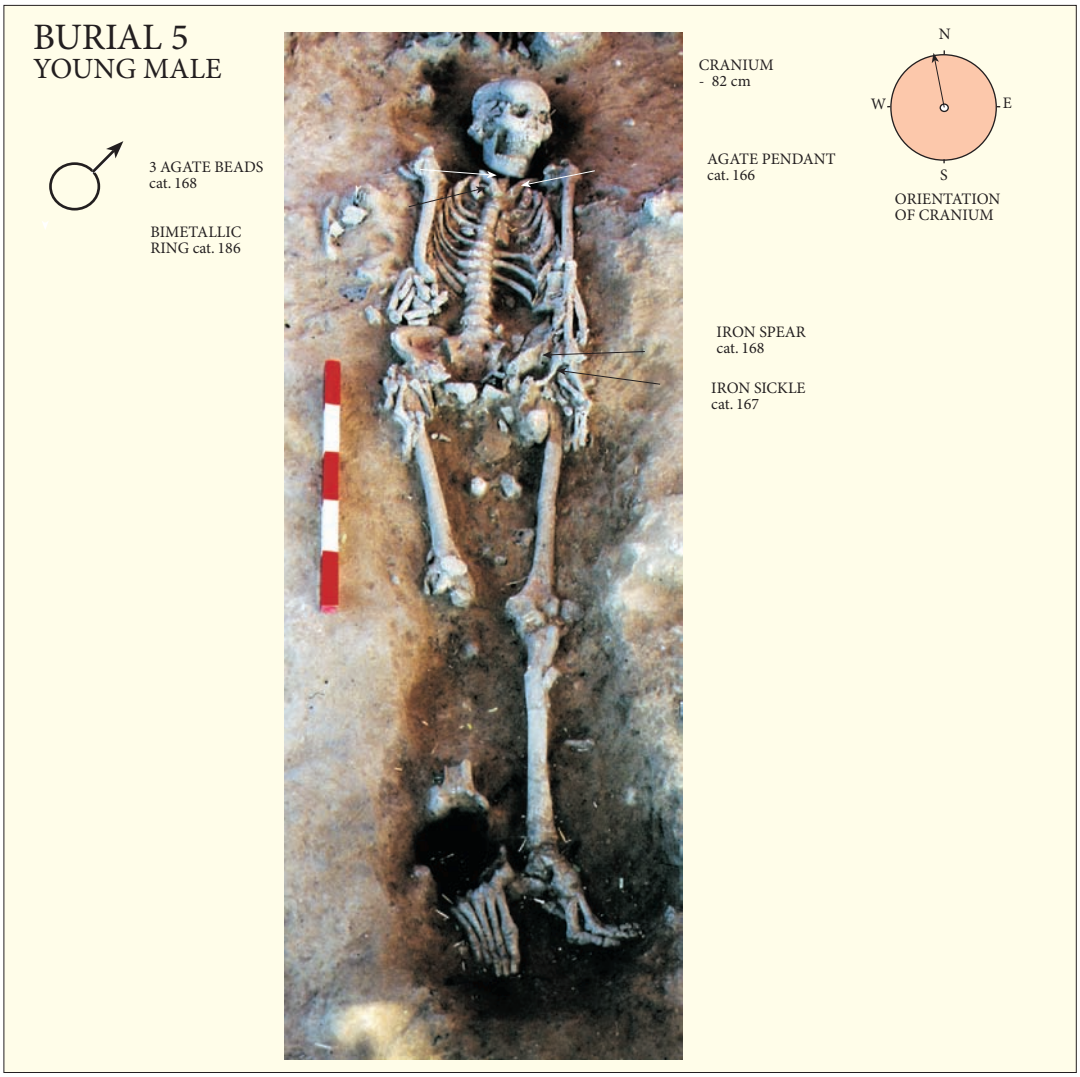


FIG. 16:3 Burial 5

the right hand and eight on the left. He wore an earcoil on each ear and at least 27, possibly 33 rings on this right hand, including two on the thumb. A further 26 rings were found on the left hand. Bimetallic rings continued to be favoured, two being located by the upper left leg, and two more by the right shoulder.

Burial 5

This 20-25 year old probable male was found, with the head orientated 10° west of north, at a depth of 82 cm below datum. He wore an agate pendant and necklace of agate beads. A bimetallic ring were also found in the neck area. Two iron implements lay by his left hand. One looks like a modern sickle, and the other a tanged spearhead.



FIG. 16:4 Burial 5, showing the iron sickle and spear by the left hand. Scale 5 cm

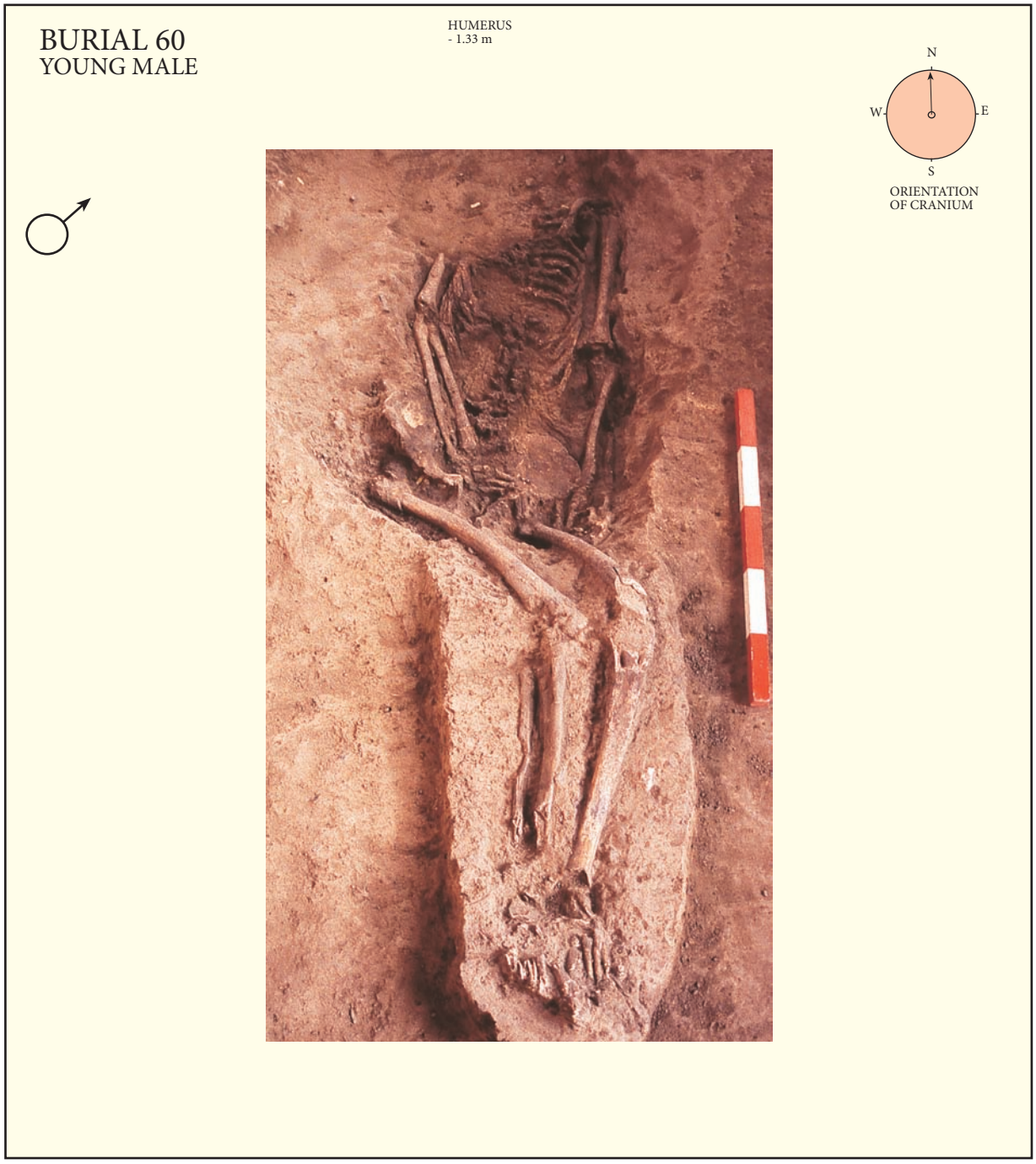


FIG. 16:5 Burial 60

Burial 60

This 20-25 year-old male was found in a most unusual position, in which legs projected well above the level of the body, as if the latter had slumped downward. The toe bones were found 1.09 m below datum, but the upper body was 30 cm deeper. No grave goods were found.

Burial 61

The man in this grave lay prone, with the head pointing 10° east of south. The grave goods were sparse: a bronze bangle on each arm, two bronze rings on a right hand finger and a bronze earring. The most interesting aspect of this burial was the recovery of a tanged iron projectile point lodged in the man's spine. Its position indicated that it entered the body from in front and slightly below, and it was surely a fatal wound.

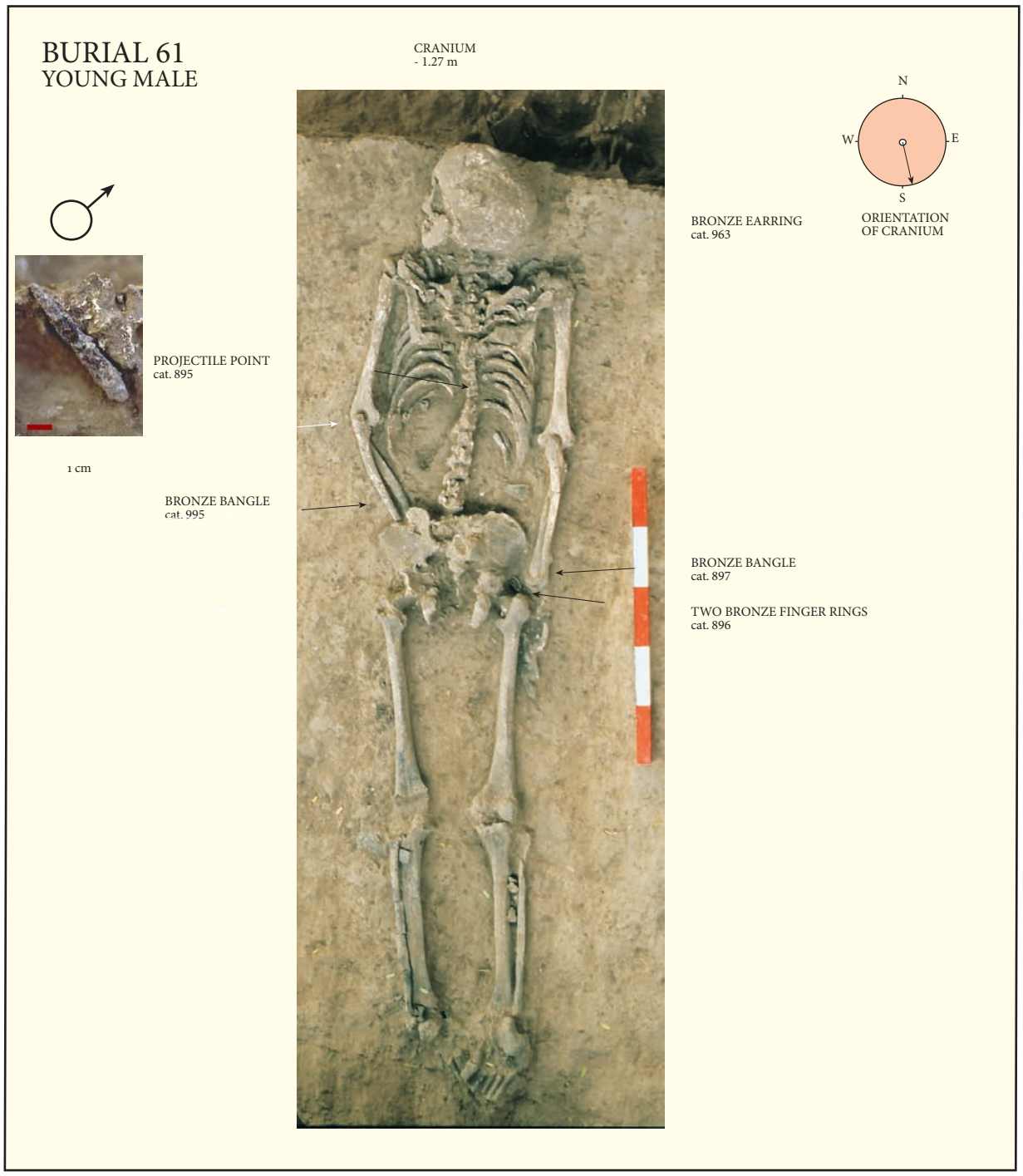


FIG. 16:6 Burial 61

Burial 65

Unfortunately, the skeleton of this adult probable male was severely disturbed. The bones lay at a depth of 1.02 m below datum, and the grave goods recovered from the area of the grave included a pottery vessel, fragments of two bronze bangles and an iron blade.

Burial 66

This older male, who died when aged between 35-40, was found at a depth of 1.52 m, below burial 60 and above burials 70 and 73. It was poorly preserved and no grave goods were found in association, but was clearly orientated with the head to the north.



FIG. 16:7 Burial 10

Burial 68

The remains of this 25-30 year old probable male lay under burial 65, and were equally disturbed. The bones were identified at a depth of 1.25 m below datum, and were accompanied by a bimetallic ring at the chest area, a bronze bangle and ring fragments in the area of the left hand and 53 circular gold beads in the vicinity of the neck which were presumably a necklace. Sherds possibly from three pottery vessels were recovered in the grave fill.

Burial 10

The woman in this grave died when aged over 40. The grave was found at a depth of 1.22 below datum, but the bones were rather disturbed, with the body orientated with the head 5° east of north. Several bronzes were recovered: six finger rings on the right and three on the

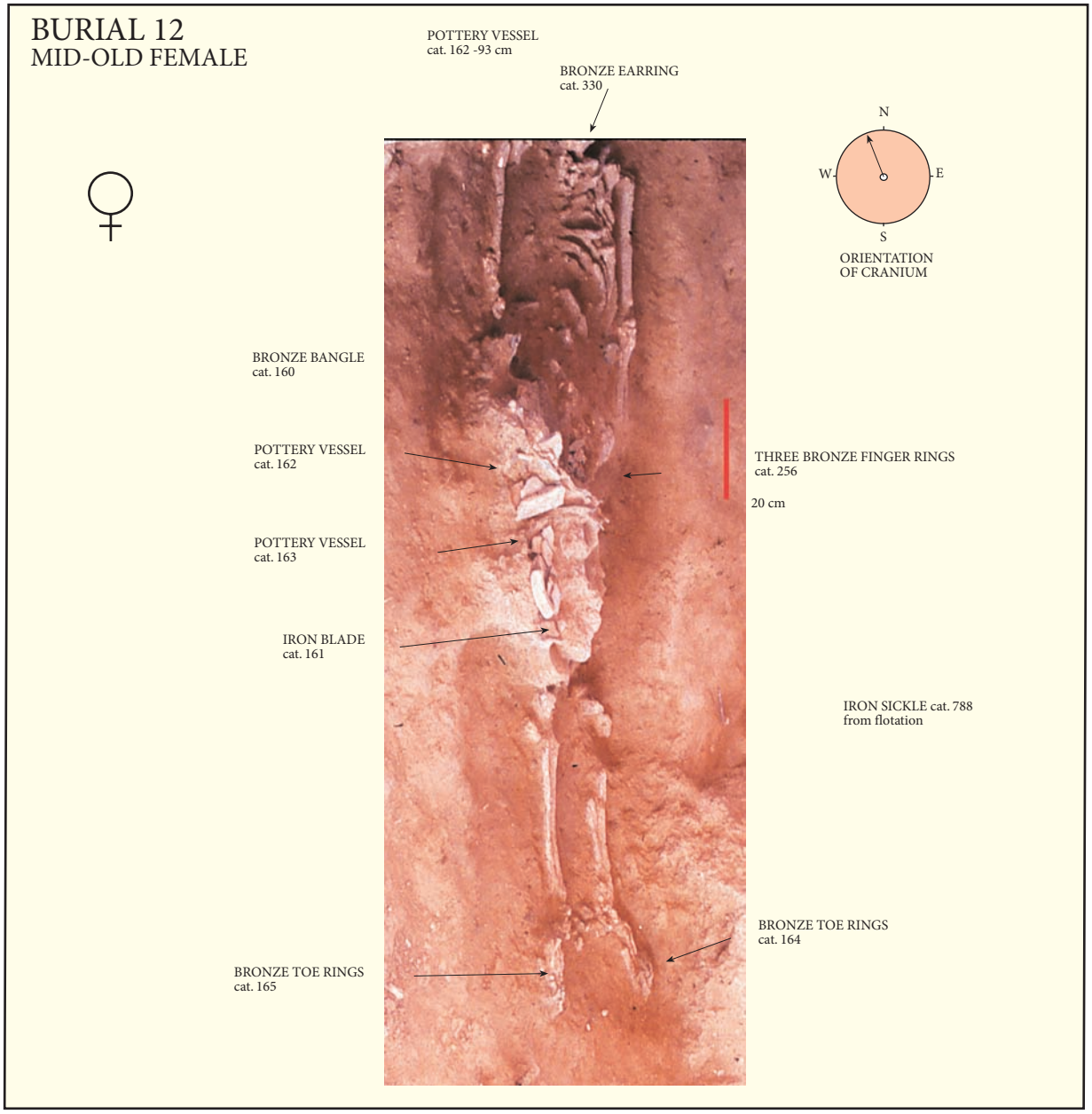


FIG. 16:8 Burial 12

left hand, three bangles on the right wrist, two earrings and an anklet on the right leg. An agate bead was found in the area of the neck, while an iron sickle and knife were found on the right upper arm.

Burial 12

This older female, who died when aged over 40 years, was found at a depth of 93 cm below datum. Her body was orientated with the head 20° west of north. Grave goods included two fragmented pottery vessels over the left thigh and abdomen respectively and several bronze ornaments. These comprised a bangle on the right arm, an earring, three rings on the fingers of the left hand and toe rings, three on the left and five on the right foot. An iron knife blade and sickle were also recovered.

Burial 64

The foot bones of an adult female were found in a disturbed condition at a depth of 1.57 m below datum, with the metatarsals protruding vertically. The grave lies to the east and parallel with burials 61 and 67, but no grave goods were found. The head would have been orientated to the south.

Burial 4

Burial 4 contained the remains of a 15-18 year-old, orientated with the head directed 15° west of north. The skeleton, which was virtually complete, lay at a depth of 76 cm



FIG. 16:9 Burial 4

below datum. Grave goods comprised an agate pendant at the neck, a bronze bangle on each wrist and three bronze rings on the left hand. There were two pottery vessels in association, both positioned over the abdomen. An iron knife and iron sickle complete the list of offerings. One of the pottery vessels, cat. 136, has the form of a phase 5 infant jar burial.

Burial 8

This burial of a young adult was found at a depth of 1.27 m below datum. It was orientated with the head 10° east of north. The grave goods comprised two pottery vessels placed over the chest and beyond the head, some glass beads in the area of the head, and an iron knife and sickle.

Burial 57 I and II

The scattered and disarticulated remains of an adult and a 12-15 year-old child were found at a depth of 55 cm below datum, in association with two pieces from an iron knife and a bronze bell and a fragment of a bimetallic ring.

Burial 59

This mid-aged adult was interred with the head pointing to the south. Grave goods included a bimetallic ring in the pubic area, a bronze bangle on each wrist, and seven bronze finger rings, three on the right hand and four on the left. There was also an iron blade and a sickle, and four pottery vessels, two over the abdomen, one over the right femur and another at the left shoulder. A silver earring was recovered by the left ear.

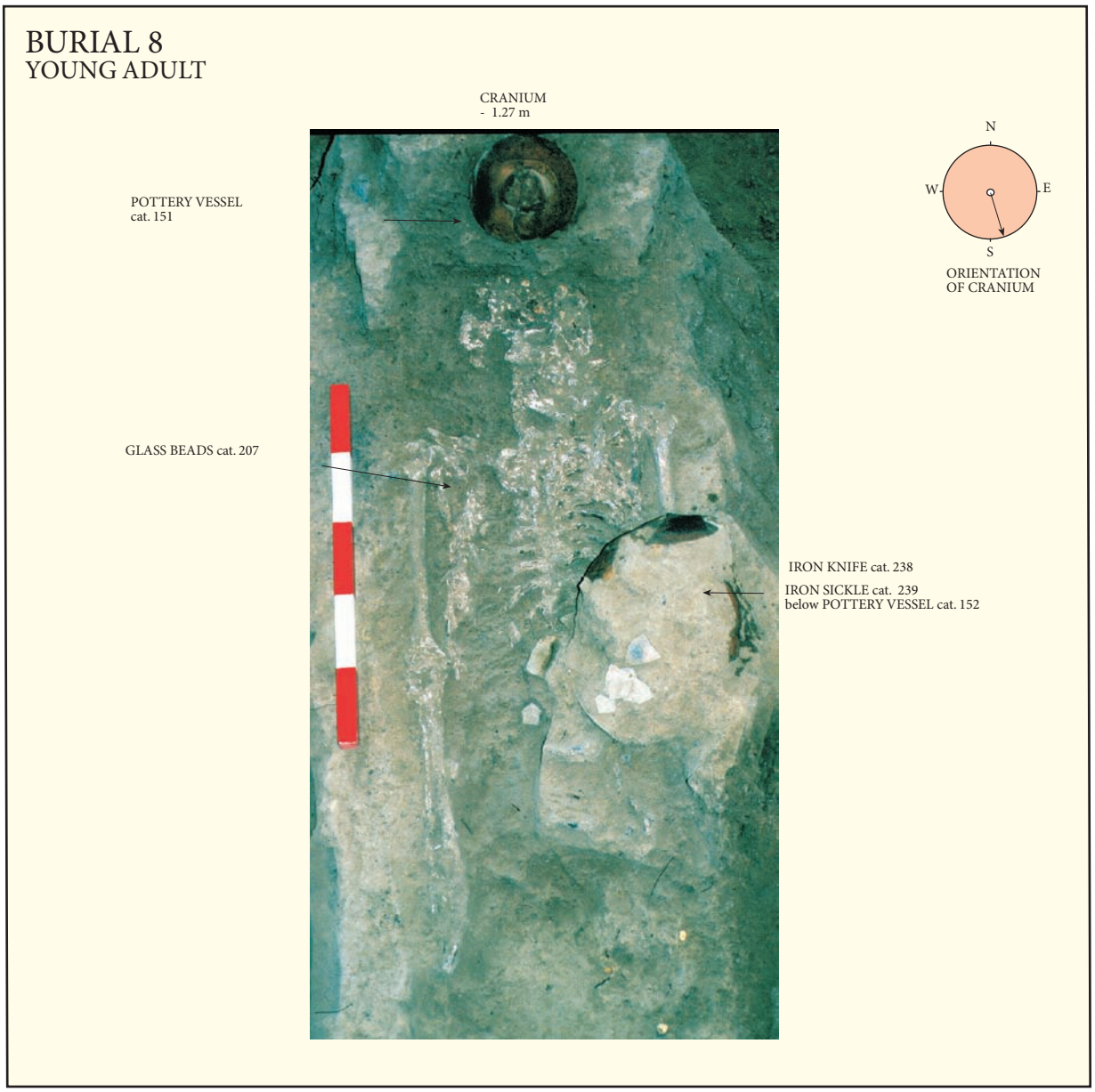


FIG. 16:10 Burial 8

Burial 67

This burial was recovered at a depth of 1.57 m below datum. The 20-26 year-old adult was interred with the head pointing 10° west of south. The screening of the material from the vicinity of the skeleton yielded two glass beads, part of a bronze ring and a bangle fragment. The other grave goods found were a bronze earring and a bored bivalve shellfish.

Burial 72

The very fragmentary burial contained the remains of the ribs, humerus and scapula, together with an iron knife above the left shoulder (cat. 1010).

Burial 73

This grave, which contained the skeleton of a 35-40 year-old adult, directly underlay burial 66 at a depth of 1.77 m below datum. The head was orientated 20° east of south. Grave goods comprised three pottery vessels positioned beyond the head, and an iron knife. There were also several bronze items of jewellery: nine toe rings on the right foot, six finger rings on the right hand and nine on the left and several ring fragments and four glass beads from the flotation process. There was also an agate pendant at the neck.

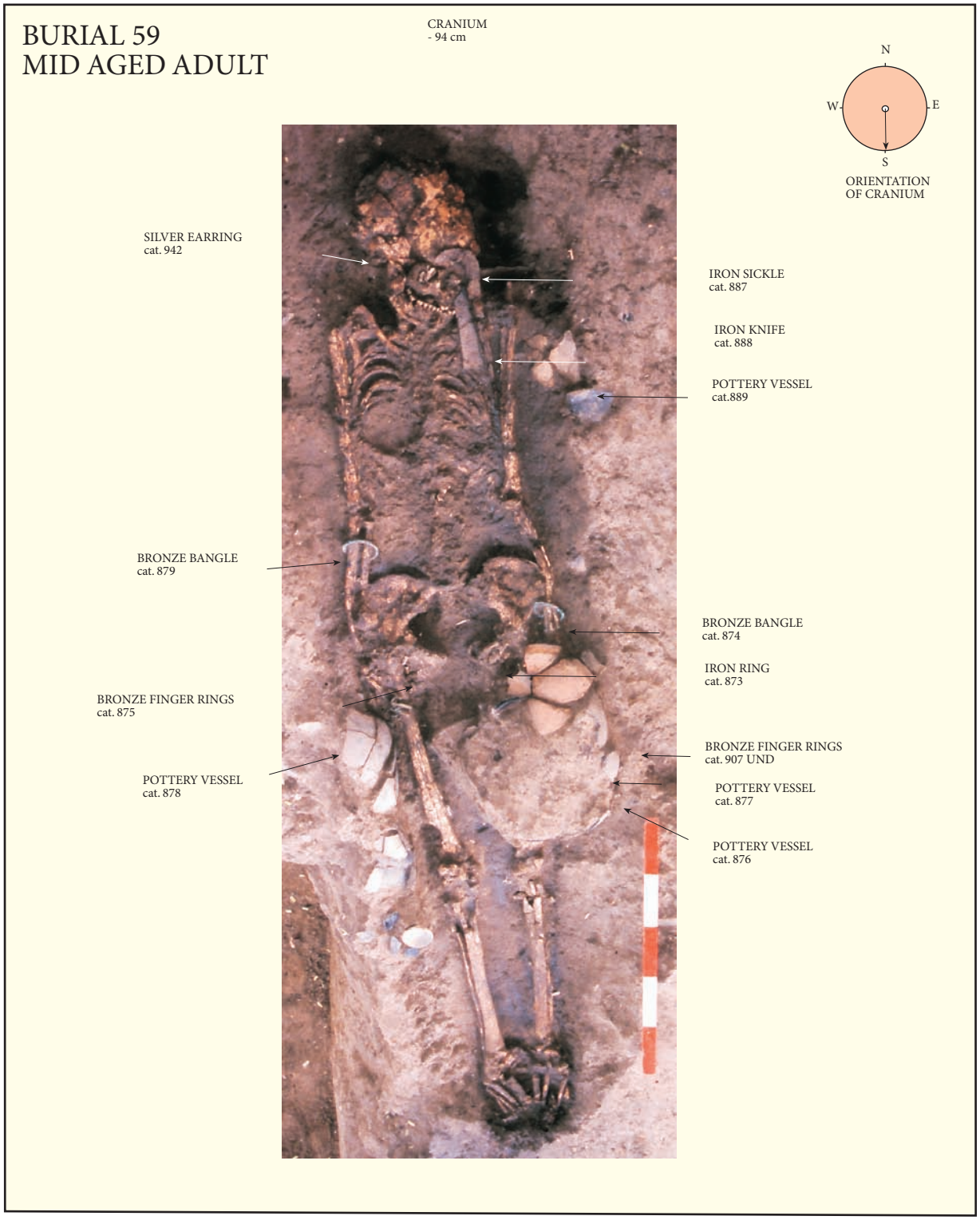


FIG. 16:11 Burial 59

Burial 70

This bundled, presumably relocated burial of a 4-10 year-old child, overlay the foot bones of burial 73. Three bimetallic rings were found in the vicinity.

Burial 2

The large mortuary jar of this neonate burial was found just beyond the head of burial 1 at a depth of 1.31 m below datum. The infant within was accompanied by two pottery vessels and an iron knife blade. Jewellery comprised

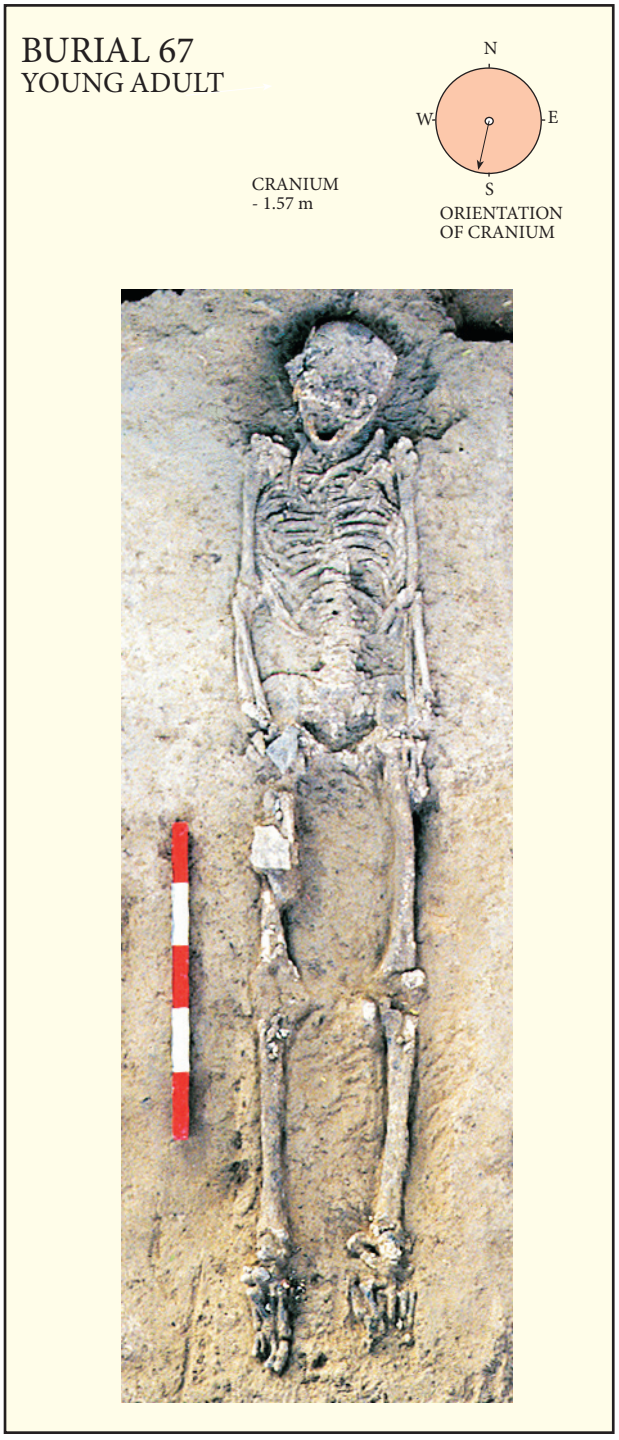


FIG. 16:12 Burial 67

a bimetallic bangle on the right arm, two on the left arm, a loose bimetallic ring at the lip of the mortuary vessel and an earring.

Burial 3

The remains of an infant, represented only by the humerus and radius, were found just to the east of burial 1 at a depth of 1.47 m below datum. They lay within three bronze bangles on one arm, and five on the area where the other arm would have been.

Burial 6

This neonate was interred in a lidded burial jar at a depth of 1.02 m below datum. No other grave goods were encountered.

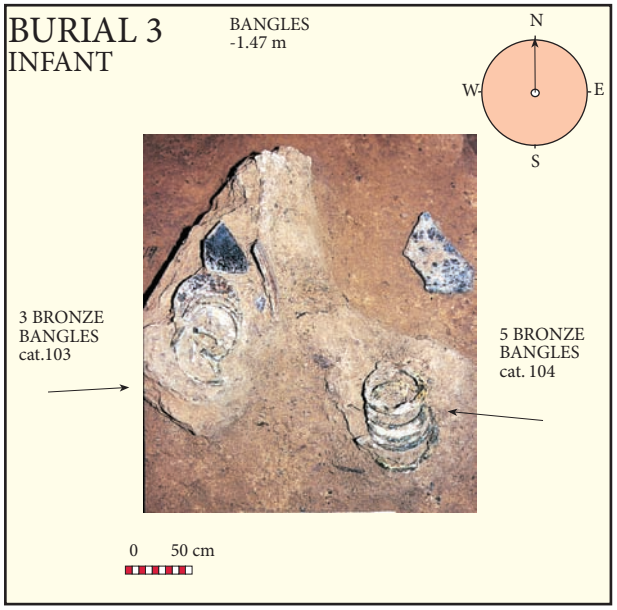


FIG. 16:13 Burial 3

Burial 7

The humerus of an infant aged under a year at death was found at a depth of 1.03 m below datum. It was accompanied by three bronze bangles and a bimetallic ring.

Burial 9

This neonate was interred within two mortuary jars. These had been placed mouth to mouth to contain the infant, at a depth of 69 cm below datum. A further pottery vessel was found within the two jars. The grave goods included an iron knife and sickle grouped to the left of the skeleton, which wore an agate bead necklace, and bronze earrings. There were also two bronze bangles one on each arm, and four bimetallic rings on the cranium.

Burial 11

The remains of a neonate were found within a frag-

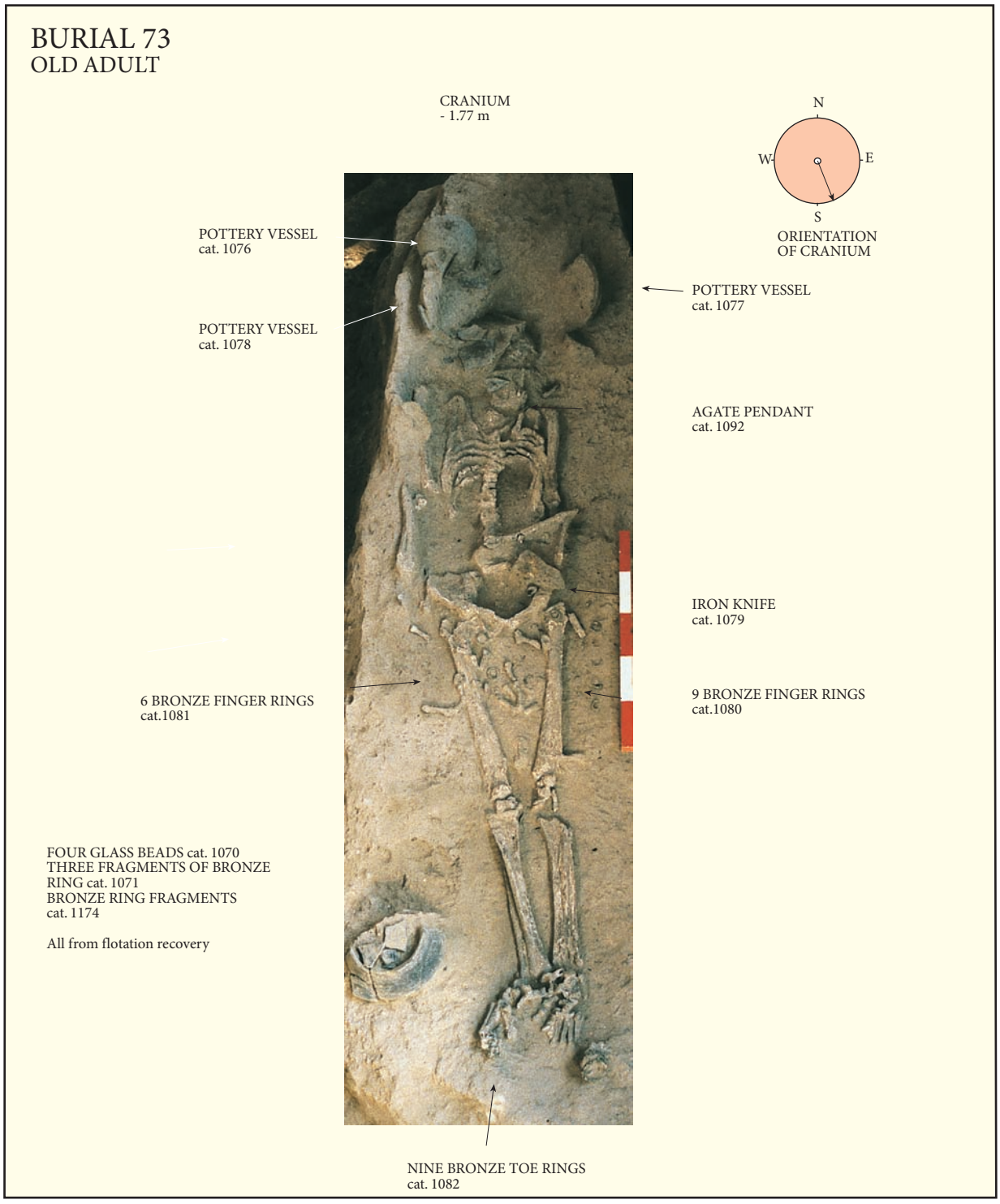


FIG. 16:14 Burial 73

mentary mortuary vessel at a depth of 76 cm below datum. No other grave goods were found.

Burial 56

This neonate was found within a burial jar at a depth of 95 cm below datum. A bowl was found in association, but there were no other grave goods.

Burial 58

A further neonate, this infant was buried within two mortuary vessels which faced each other. An iron sickle was found below these vessels and may have been in association as a grave good. The vessels were found at a depth of 58 cm below datum.

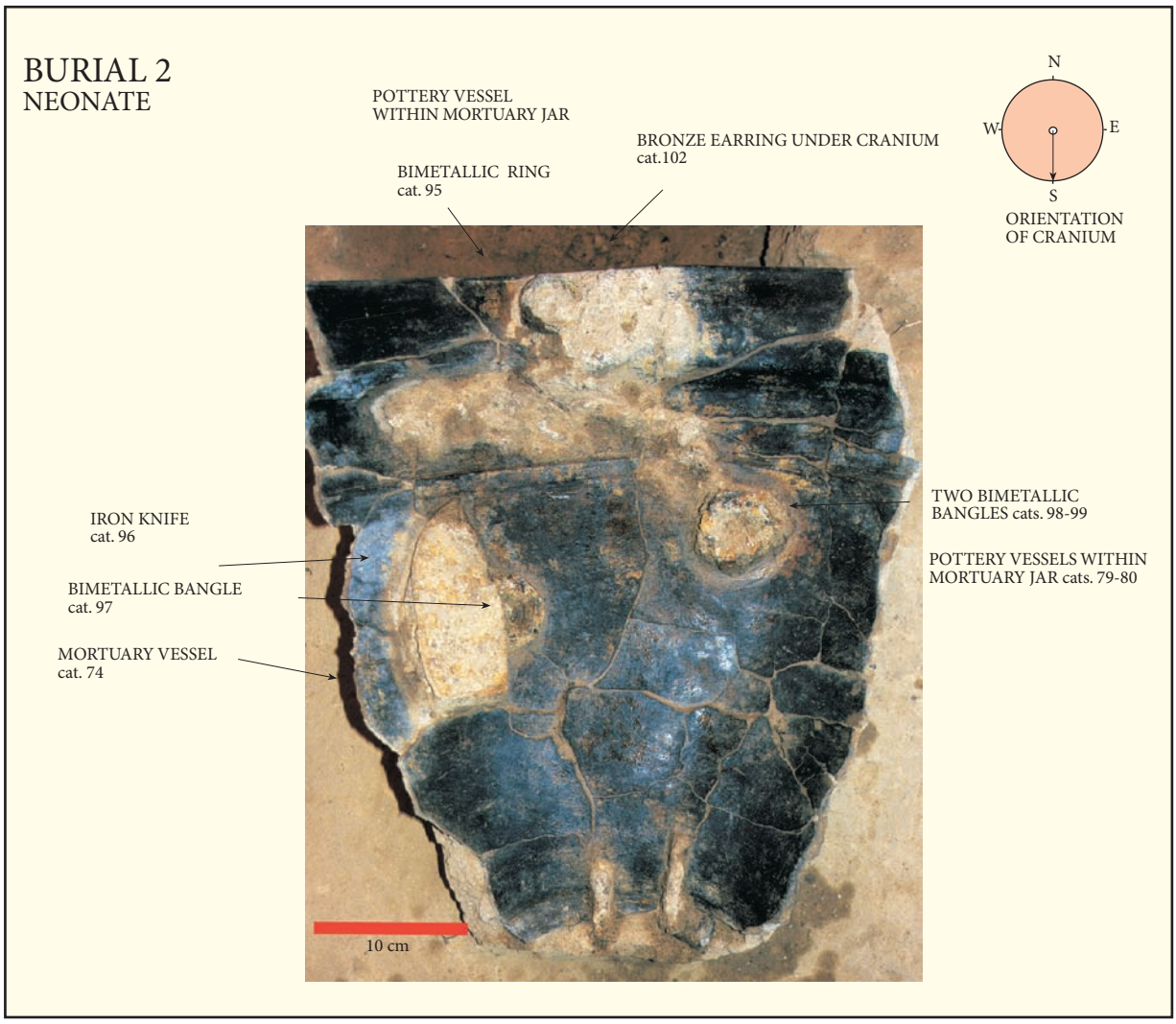


FIG. 16:15 Burial 2

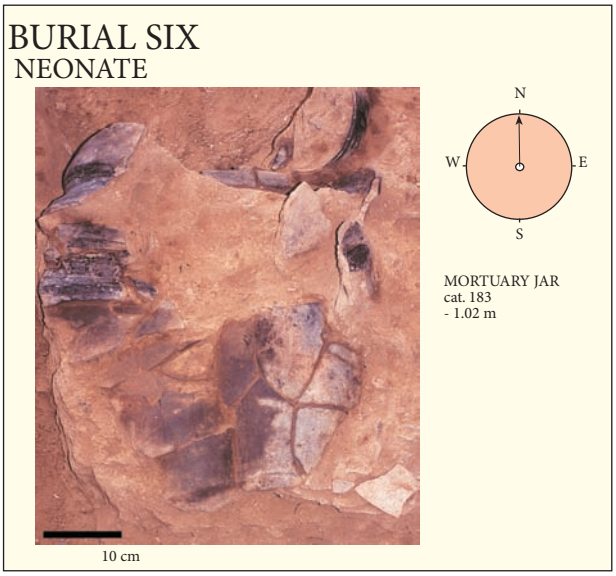


FIG. 16:16 Burial 6

Burial 71

The skull of a probable neonate was found under three pottery vessels at a depth of 1.77 m below datum. Other offerings and the most likely placement were an iron knife to the left of the body, two bronze rings, two bronze earrings and a bimetallic ring in the head area.

Burial 102

This jar burial of a neonate was found at the head of burial 96. The jar was found on its side. It contained a second pottery vessel, as well as a necklace of glass beads, five bronze bangles and a bimetallic ring. A pig's canine tooth may also have been a deliberate mortuary offering.

Burial 115

Unusually, this neonate was not interred in a mortuary jar, but was laid out in the same manner as adults during this phase, with the head orientated to the north. The skeleton was found at a depth of 1.24 m below datum,

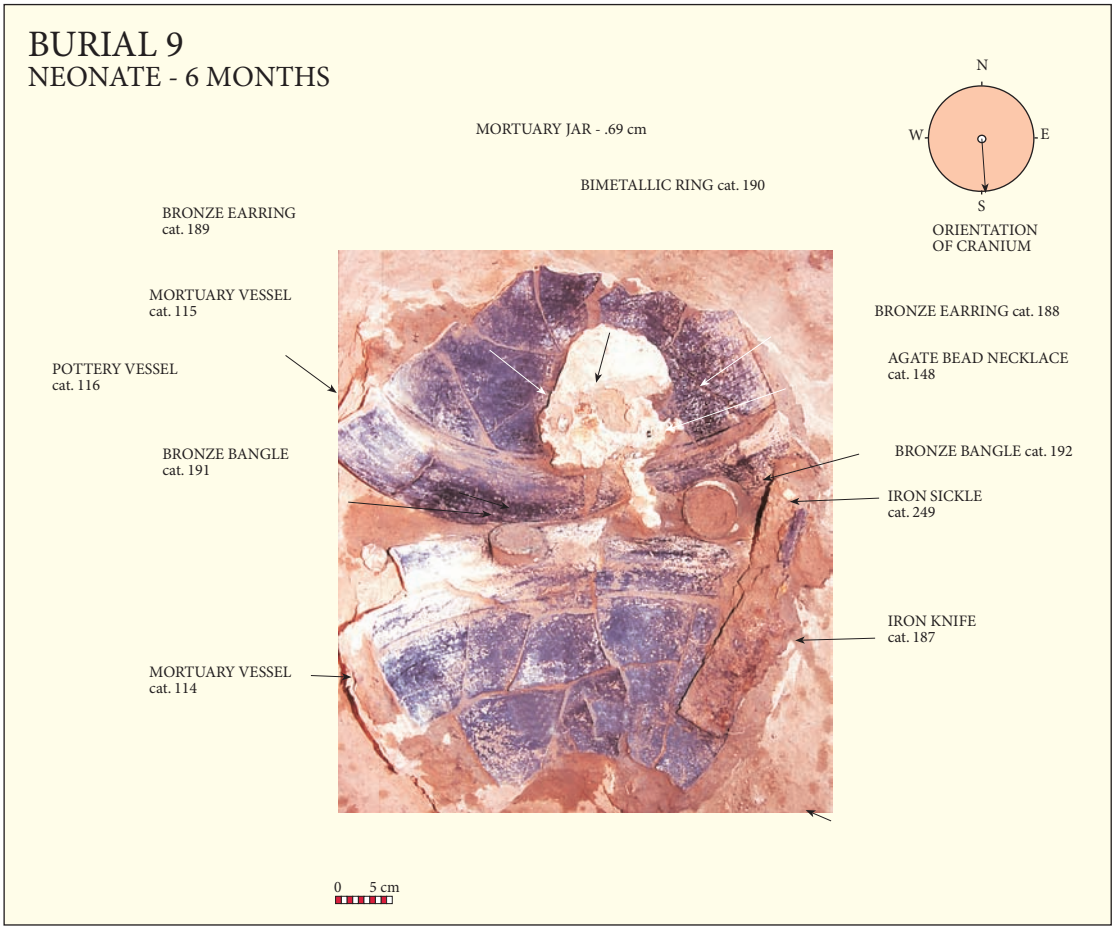


FIG. 16:17 Burial 9

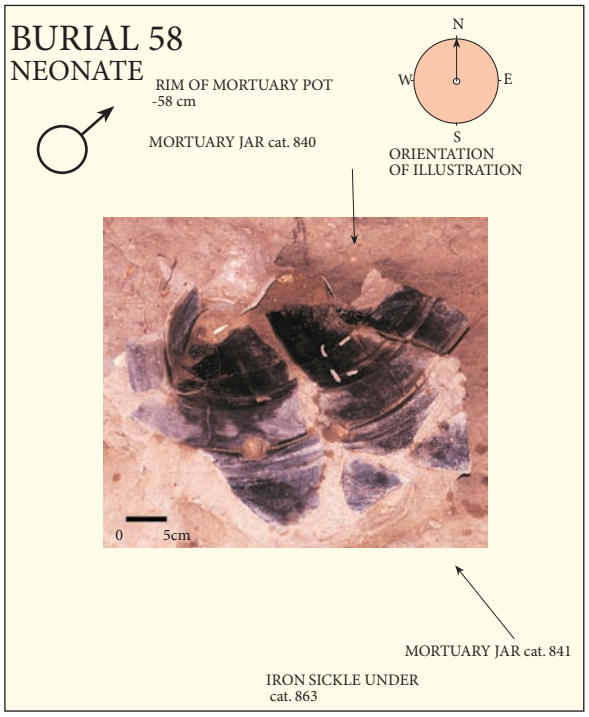


FIG.16:18 Burial 58

and lying parallel with the complete shed antler of a medium-sized deer. Other grave goods comprised 33 bronze bangles, five bronze anklets, a bronze earring and a bimetallic ring in the area of the skull. A further bronze ring was present in the general area of the body.

Burial 116

This neonate was found at a depth of 1.56 m below datum. Three pottery vessels were associated, two over the head and one by the right ankle. The infant wore a glass bead necklace, and a bimetallic ring lay beside the head. An iron knife blade was found to the left of the skull, and another iron object was recovered from the general area.

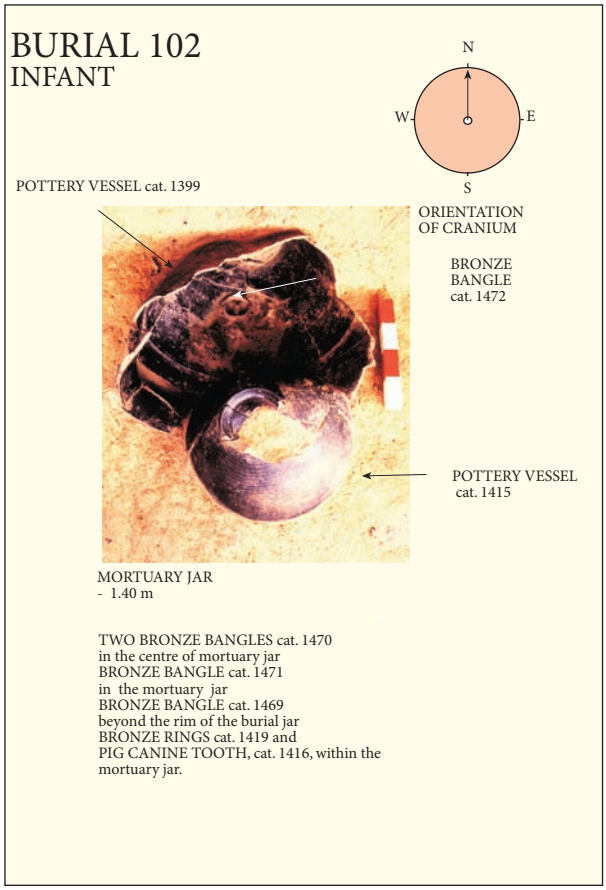
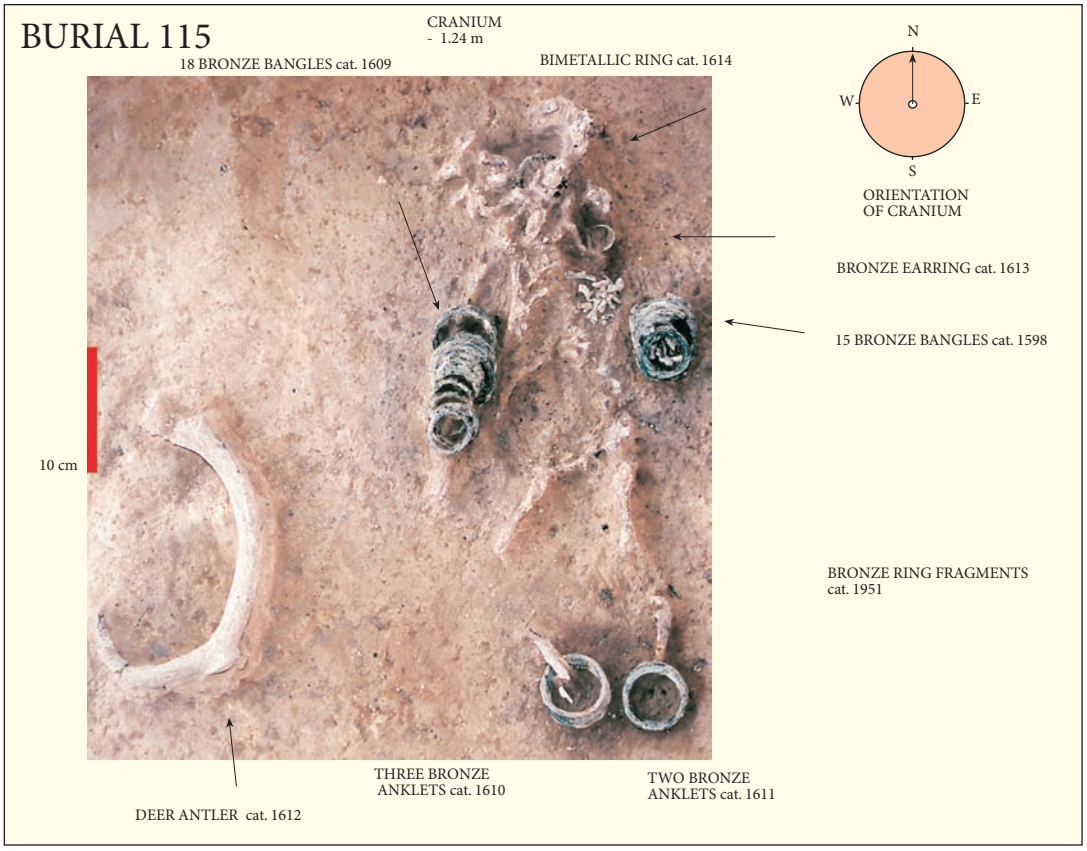


FIG. 16:19 Burial 102 (to the left), and FIG. 16:20 Burial 115 (below)



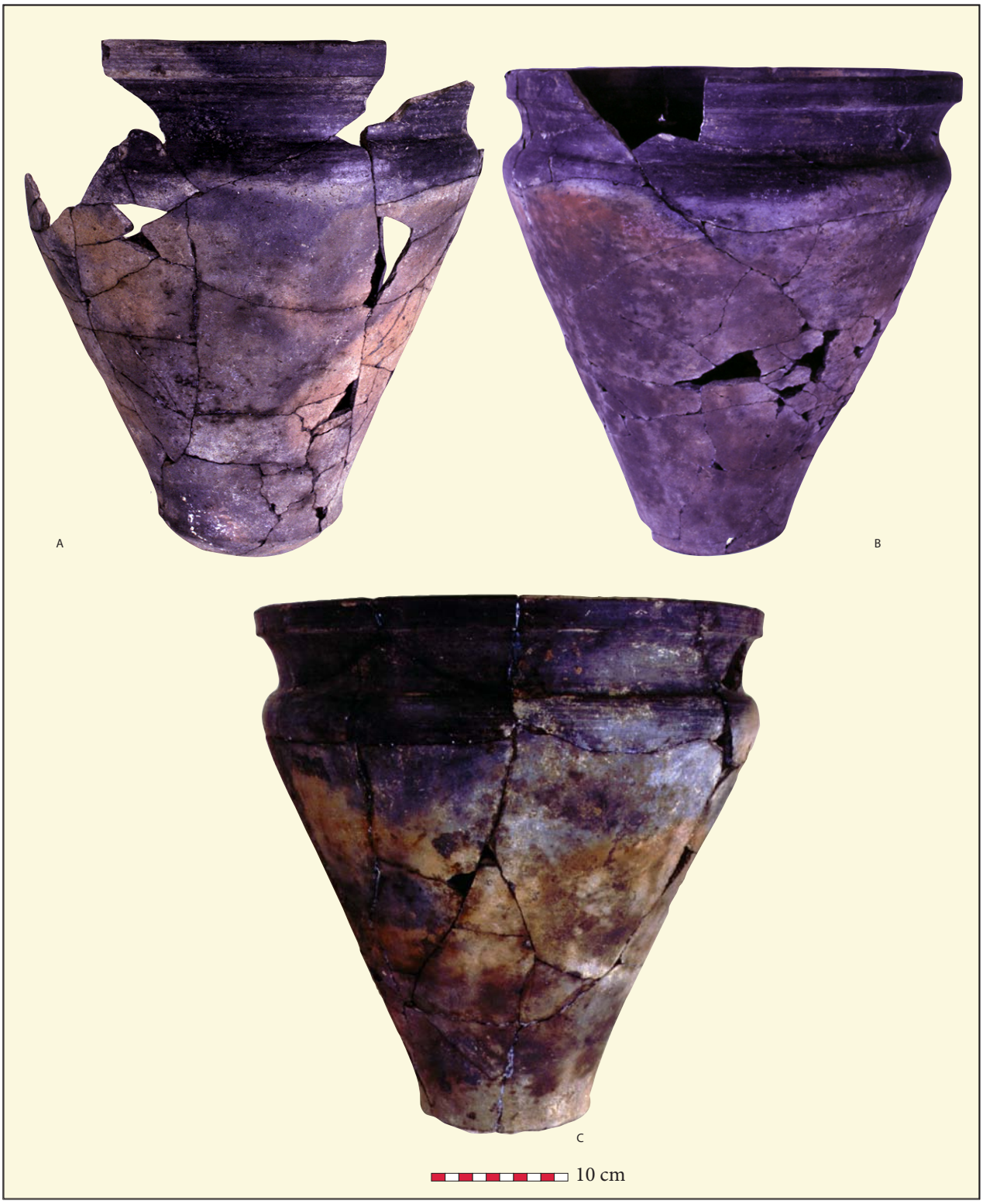


FIG. 16:21 The single jar burial mortuary vessels. A. burial 6 cat. 118, B. burial 2 cat. 74, C. burial 102 cat. 1399

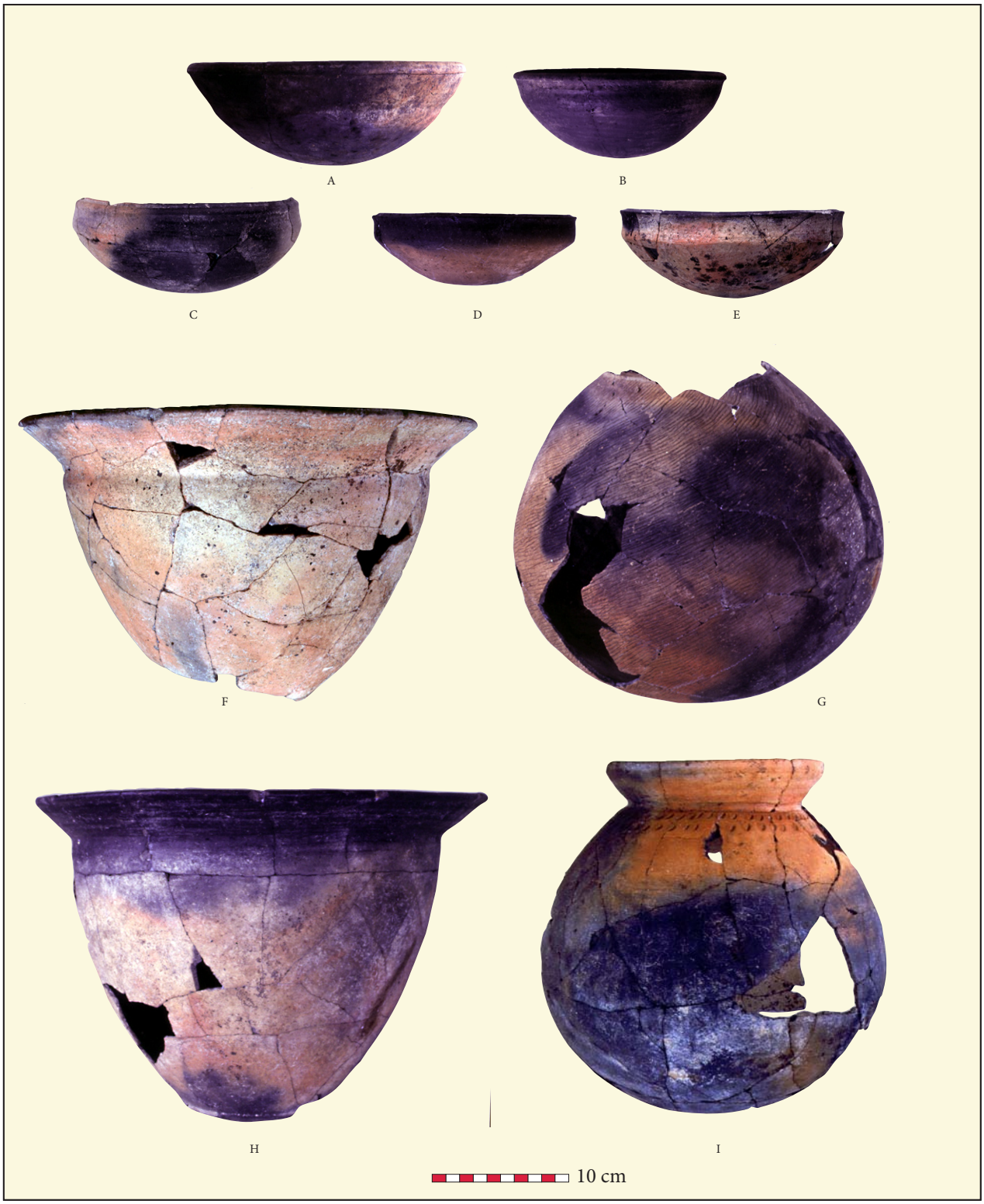


FIG. 16:22 Pottery vessels associated with mortuary phase 5 burials. A. burial 2 cat. 79, B. burial 2 cat. 80, C. burial 6 cat. 183, D. burial 6 cat. 183b, E. burial 12 cat. 163, F. burial 9 cat. 114, G. burial 4 cat. 133, H. burial 9 cat. 115, I. burial 12 cat. 162

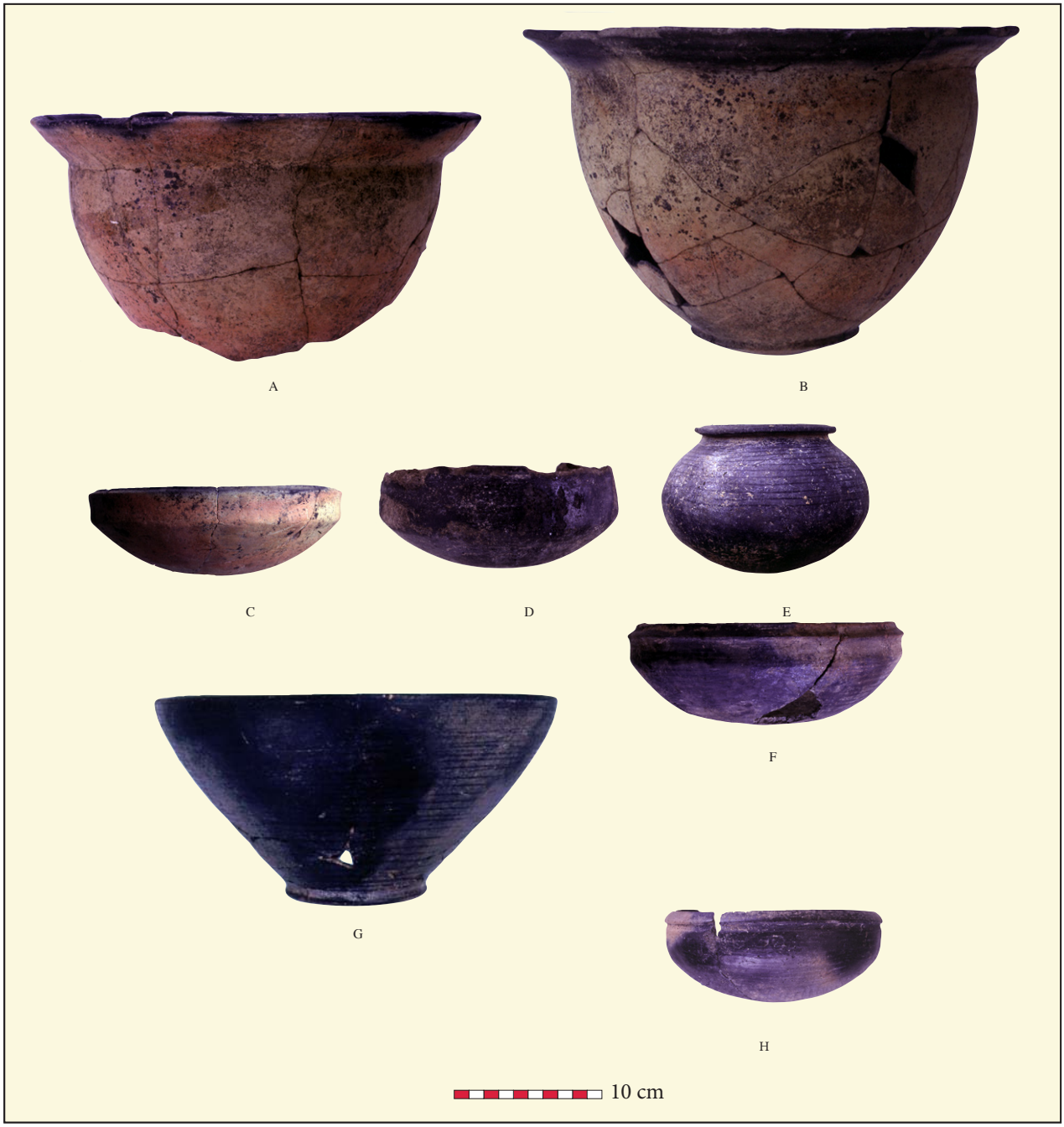


FIG. 16:23 Pottery vessels from mortuary phase 5. A. burial 58 cat. 841, B. burial 58 cat. 840, C. burial 59 cat. 876, D. burial 67 cat. 1024, E. burial 71 cat. 974, F. burial 73 cat. 1078, G. burial 102 cat. 1415, H. burial 116 cat. 1623



FIG 16:24 Agate ornaments from mortuary phase 5 burials.
A. burial 5 cat. 166, B. burial 73 cat. 1092, C. burial 4 cat. 100, D. burial 4, showing cat. 100 as found. Scale 2cm

XVII. THE PEOPLE OF NOEN U-LOKE

NANCY TAYLES, SIAN HALCROW AND KATHRYN DOMETT

Noen U-Loke has provided the largest and best-documented sample of human skeletal remains from the Iron Age in mainland Southeast Asia, with 120 individuals represented. This chapter presents the basic data on this skeletal collection and takes the opportunity to address the issue of whether there is evidence from human biology of the changes postulated on the basis of archaeological and ecological evidence to have occurred between the Bronze and Iron Ages (Higham 2002). This includes intensification of agriculture, changes in social organization resulting in the development of large settlements, increasing population density and the contact with a wider world evidenced by the presence of exotic artifacts. Such a society is assumed to have had the ability to produce more than enough food to allow the population to flourish and grow, sustaining increased settlement density. Countering the contribution to good health from adequate nutrition would be the potential for the introduction of pathogens following contact with the wider world through increased ability and desire to engage in exchange of manufactured goods. At least some of these infections are likely to have included the suite of infections that, although debilitating, are not fatal but result in the development of bone lesions. The settlement size and density would have enhanced the transmission of pathogens. The hypothesis being addressed is therefore that the population of Noen U-Loke would have been healthy compared with earlier populations in the region, but paradoxically would have had evidence of novel infections.

In order to address this question, evidence from the census of the cemetery sample will be considered as a basis for examining the demographic structure of the population. Health status will be examined using non-specific measures such as the growth of infants and children, stature of adults, growth disruption in the form of dental developmental defects and the prevalence of skeletal lesions other than those which permit a diagnosis of the aetiologic disease or injury. These parameters have the potential to provide a definition of the overall health status of the sample, whether healthy or unhealthy. Beyond the examination of non-specific evidence of health and disease, skeletal pathology, where a diagnosis is possible, will be used as an indicator of the possible introduction of novel infections into the region. These diseases could be introduced either by immigrants or by traders travelling beyond the region and returning with the infections.

As there are no universally applicable determinants of health status, in order to establish this, it is necessary to draw comparisons with at least one other skeletal sample. For this purpose we will use the sample from the nearby site of Ban Lum Khao. This cemetery is from an earlier period than Noen U-Loke but there is a slight overlap between the latest phase at Ban Lum Khao and the earliest at Noen U-Loke (chapter VIII p. 143). It is therefore an entirely appropriate comparison that has the potential to provide an indication of changes in health status in the region of the upper Mun River Valley over time. Kathryn Domett has published the evidence from the human skeletal remains of 110 individuals from the site (2001, 2004). A comparison of the two sites has been presented elsewhere (Domett and Tayles 2006 and in press) and will be summarised where appropriate in this chapter.

The environment and genetics are the two principal contributors to variation in human biology. The proximity of the two sites reduces the possibility of underlying environmental influences on health status, other than anthropogenic changes over time. It also increases the possibility of genetic homogeneity between the communities. It is not, of course, possible to eliminate these two variables from consideration but the proximity of the sites at least enhances the possibility that differences between the samples (and populations) are responses to economic, technological, socio-political, and anthropogenic environmental changes over time.

The issue of the homogeneity of the two populations is a question that is to be addressed in the future. The most obvious approach would be to use DNA but the problems with its recovery from skeletal remains buried in tropical environments are documented (Reed *et al.* 2003), in addition to universal problems with the analysis and interpretation of ancient DNA (aDNA). In order for this to be valid, it is necessary to recover both mitochondrial DNA, which can provide a measure of relationships through the maternal line, and the much more difficult nuclear DNA with the Y chromosome to measure relationships among males. Research on the methods of recovery and analysis is continually advancing and despite the potential difficulties there are plans for a pilot study to examine the possibility of recovery of any DNA, which will at the least show whether the method may be useful.

In addition to DNA, there are means of identifying individuals who were raised at another location and immigrated to the community through the analysis of chemistry of the hard tissues. This involves stable isotopes, in particular strontium but also oxygen and carbon. These isotopes are present in geological structures and become incorporated in hard tissues through ground water. The method is particularly valid where dental enamel is used as this does not remodel and therefore provides a record of the isotopic composition of local geology during the

development of the teeth during infancy and childhood, whereas bone and dentine remodels throughout life and the isotopic composition will therefore reflect the local environment. Research on this issue is currently being undertaken by Dr Alex Bentley of the University of Durham, in collaboration with Katharine Cox, PhD candidate at the University of Otago. Interpretations of the data presented in this chapter will, of course, be subject to reconsideration in the light of the outcomes of the research on genetics and enamel chemistry.

A cautionary point is made at this stage that despite the apparently adequate sample size, the poor preservation of many of the skeletons means that the interpretation of the evidence must be approached carefully. Interpretation will in most cases rely on simple observations, unable to be confirmed by statistical analysis.

This chapter will also provide raw data for the sample and describes features of burials which may be taphonomic or anthropogenic. Not all of these are explained here. As with most such research projects, time will bring deeper understanding, which will probably mean reinterpretation. In particular, the recent and ongoing excavation of a much larger skeletal sample (310 individuals at the time of writing) from the nearby site of Ban Non Wat will in the longer term permit a more confident interpretation of the bioarchaeological evidence from the upper Mun River Valley. That the Ban Non Wat sample covers more than 2.5 millennia from 2100 BC means that it will give a much more comprehensive context for the interpretation of Noen U-Loke.

THE NOEN U-LOKE SKELETAL SAMPLE

The sample of skeletons available for analysis differs from the number of burials identified during the excavation for a variety of reasons, including the failure of survival of bones in some graves and the identification of more than one individual in others. No bones that could provide age and/or sex estimates were identified from the earliest single 'Bronze Age' burial (B125) defining the first mortuary phase (MP1). Six burials from the earliest Iron Age mortuary phase (MP2) were cut into natural deposits and a seventh, a collection of child's teeth, was found in a pit. A total of 88 burials were identified, most in well-defined clusters, from the two subsequent mortuary phases (MP3 and MP4). The burials in two clusters (A and B) of MP3 provided 25 individuals and four clusters (A-D) in MP4 provided 50, with a further seven in isolated graves. The clusters range in size from 5 to 20 individuals, although three clusters were adjacent to the baulks and may continue beyond the excavation area. The final mortuary phase five (MP5) contained a total of 30 burials, representing 30 individuals. These were unclustered except for one group of six. During the excavation 126 burials were identified, with the final total 127 after the subsequent addition of one burial originally identified as a feature during the excavation (feature #7). The final number of individuals represented is 120, as discussed below.

FIELD METHODS

The recovery and curation of the human skeletal remains was under the control of a team of experienced biological anthropologists, ensuring that maximum data were preserved for analysis. The condition of the remains, as detailed below, dictated the manner in which they were treated at the excavation and during subsequent analysis. During the excavation, many of the skeletons were not identified by grave cuts, but only when the bones or accompanying artifacts, particularly ceramics, were revealed during the removal of spits and/or layers. This resulted in occasional damage to the skull vaults in particular, as the uppermost bone in the burial. The exceptions to this mode of discovery were firstly so-called 'rice' burials, where the grave infill was partly or completely unthreshed rice. Where these graves were undisturbed, the rice filling created a clear and easily recognised discontinuity with the surrounding matrix. Secondly, graves cut into natural deposits at the base of the site were clearly identified by the grave cut in the surrounding matrix. Graves were numbered consecutively as they were found. With two seasons of excavation in adjacent areas, and in the second season the retention of baulks until the end of the season, the numbering of the burials is not indicative of depth of burial or mortuary phase. This should be kept in mind while reading the chapter. The location and spatial relationships of each burial are detailed by mortuary phase in earlier chapters and summarised in the appendix to this chapter.

Regardless of the method or timing of discovery of the burial, the skeleton and associated artifacts were exposed *in situ* and a preliminary recording of skeletal completeness and preservation was made, using a paper Field Recording Form. Where possible, preliminary estimates were made of age at death and sex, long bones were measured *in situ* using sliding calipers, and any evidence of pathology or unusual burial or skeletal characteristics were recorded. Presence and location of artifacts were recorded where these were relevant to the condition or position of the skeleton. Evidence of human activity such as the digging of postholes, pits, or later graves, or of animal activity such as burrowing that could account for the condition or completeness of the skeleton was recorded. All burials were photographed. The bones were then lifted and any damp bones were dried in trays before being bagged individually by skeletal element and side where possible. Where bones were disturbed or secondary burials it was not always possible to identify immediately the burial number to which the bones belonged. In these cases the bones were bagged with details of location. There were a number of disar-

ticulated and/or fragmented human bones found during general excavation or bagged inadvertently with animal bones. These were recorded as 'loose human bone' and where there were nearby burials, consideration was given to whether they may have belonged to any of these burials. This exercise was infrequently successful. Skeletons were then bagged as separate units and stored in numbered and labeled boxes, initially at the Archaeological Laboratory of the Ninth Regional Office of the Fine Arts Department in Phimai. Later they were moved to storage at the Phimai National Museum, where they are currently located.

LABORATORY METHODS

During and after the 1999 'Laboratory season' of the project, the bones were cleaned manually using dental picks and brushes by NT, assisted by Natthamon Pureepatpong from Silpakorn University. Many of the bones, particularly the rice burials, were not robust enough to withstand washing but where possible this was carried out using water and brushes. Reconstruction was carried out using PVC glue, again where possible. Disarticulated bones were identified to skeletal element and side where possible and rebagged. Loose teeth were identified and bagged. A census of the skeletons was recorded in detail, including presence, completeness, and condition of skeletal elements (initially by NT, assisted by Natthamon Pureepatpong). Kirsten Nelsen recorded and reported on the teeth for her MSc thesis (Nelsen 1999). These data were modified following the addition of further teeth found during the cleaning of the skeletons in 1999. The data presented here therefore differ from those reported by Nelsen. All subadult skeletons were later re-examined and recorded by SH as part of her PhD research. The census of bones and teeth present was followed by a detailed estimate of age at death for all skeletons and of sex for adults. Long bone measurements were again recorded. As there were only three complete and undistorted crania, craniometrics were not recorded. All skeletal pathology was recorded, together with any distinctive or unusual characteristics of the skeleton such as post mortem treatment or taphonomic damage. Details of methods used are provided below in the relevant sections. Skeletons were then reboxed. All details were recorded in a FilemakerPro database and are stored in this format by NT. Following the laboratory analysis, the actual number of individuals was determined to be 120 after the elimination of burials with no remains recovered, the amalgamation of other burials, and the addition of further individuals where more than one person was represented in a burial. Details of the difference between the field numbering of graves and the final count of skeletons are provided in the appendix. In analyzing the data in this chapter, statistical tests used for nonmetric variables are χ^2 and Fisher's Exact tests (FET), and Student t-tests for metric variables. The critical p was set at 0.05.

BONE CONDITION AND SKELETAL COMPLETENESS

The condition of the skeletal remains varied from almost perfect to the virtual absence of bone. The only representative of MP1 (B125) was identified on the basis of a grave cut and pots accompanying what appeared to have been a pair of feet projecting from a baulk. As noted above, minimal identifiable bones were recovered. In contrast, the bone tissue in five of the six early Iron Age skeletons of MP2 was in almost perfect condition, as is often the case where graves have been dug in natural deposits. Four (B26, 27, 107, 108) of these five were complete with the fifth (B106) disturbed with lower limbs only remaining. The sixth (B114) was in contrast in very poor condition, although most bones were represented. The seventh burial from this phase, B51, was represented only by teeth.

The 26 burials identified in the field as MP3 provided 25 individuals, with an amalgamation (B23 with B22). The 62 burials in MP4 similarly provided 57 individuals with amalgamations of pairs of burials (B20 with B15; B95 with B96; B109 with B113) and the absence of bone in two burials (B80, B83) that had been identified on the basis of grave cuts and artifacts. The status of the bone in one further burial (B124) was unable to be confirmed in the laboratory. One additional burial was identified as a second individual, a child, mixed with B118. This has been designated as B118.2.

Bone tissue preservation was very poor in some of the individuals from MP3 and MP4. In particular, the skeletons from the interments in graves filled with unthreshed rice were in singularly poor condition. The rice has become silicified over time, and through an as-yet unidentified chemical reaction between the grain and the skeletons, resulted in the demineralisation of the bone tissue. The organic fraction of the tissue that survived was so lacking in structure that in the worst cases it was impossible to recover anything for further analysis. These burials have been referred to throughout this chapter as 'rice burials'. The burials involved and the totals do not necessarily correspond with those identified in earlier chapters as for our purposes only those with sufficient rice in the grave to have affected the bone condition were recorded as 'rice burials'. The earliest are in MP3, where there are ten, in cluster B. In MP4 there is a total of 18 spread in clusters A-C. This gives a total of 28, comprising almost one third of the burials in these mortuary phases and almost one quarter of the sample as a whole. This has a significant impact on the quality of the collection, particularly on the adult component as most of the rice burials were in this age range.

The clustering and superpositioning of graves was responsible for further destruction during these phases, with much intercutting of graves resulting in disturbance of earlier skeletons.

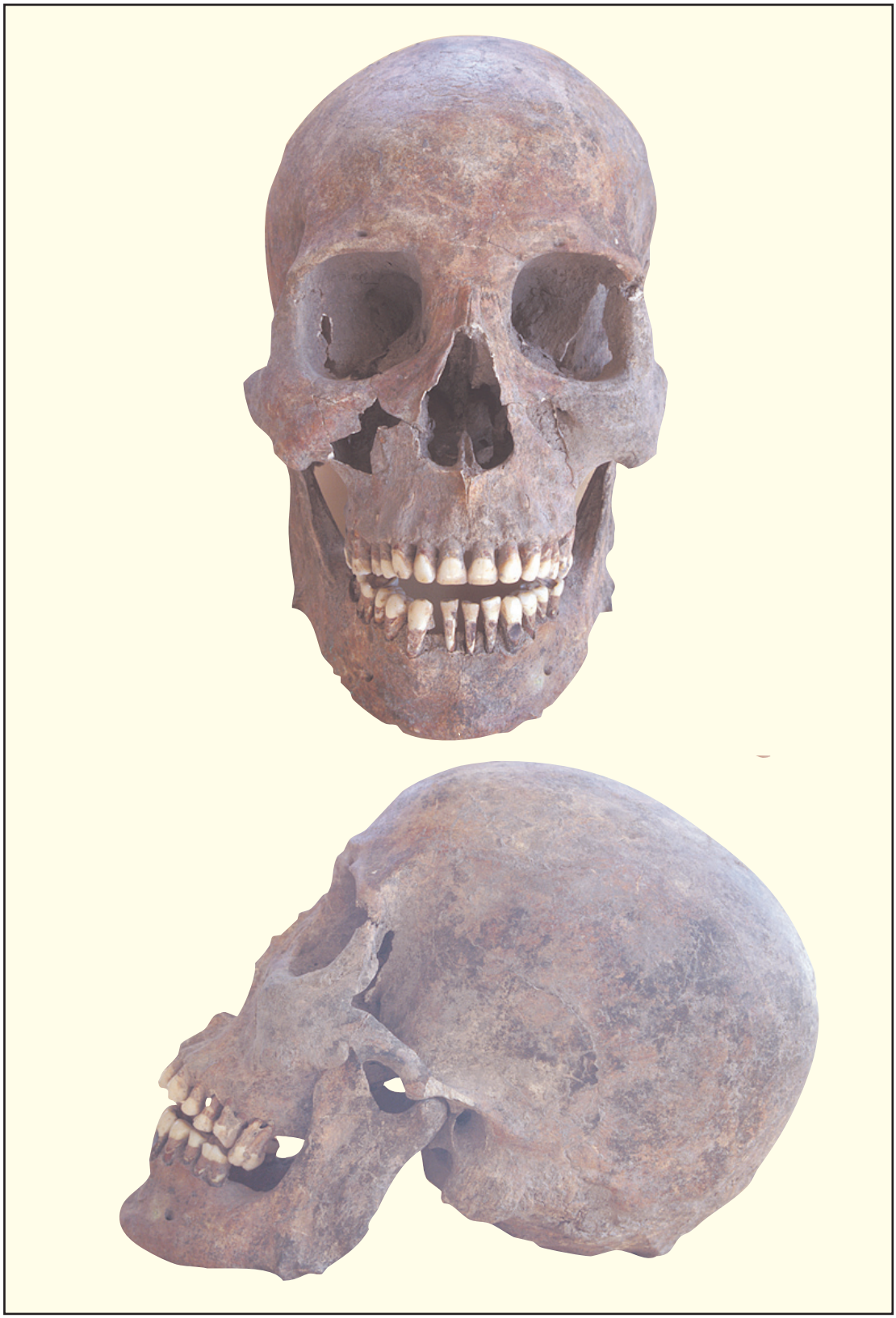


FIG. 17:1 The cranium of burial 27

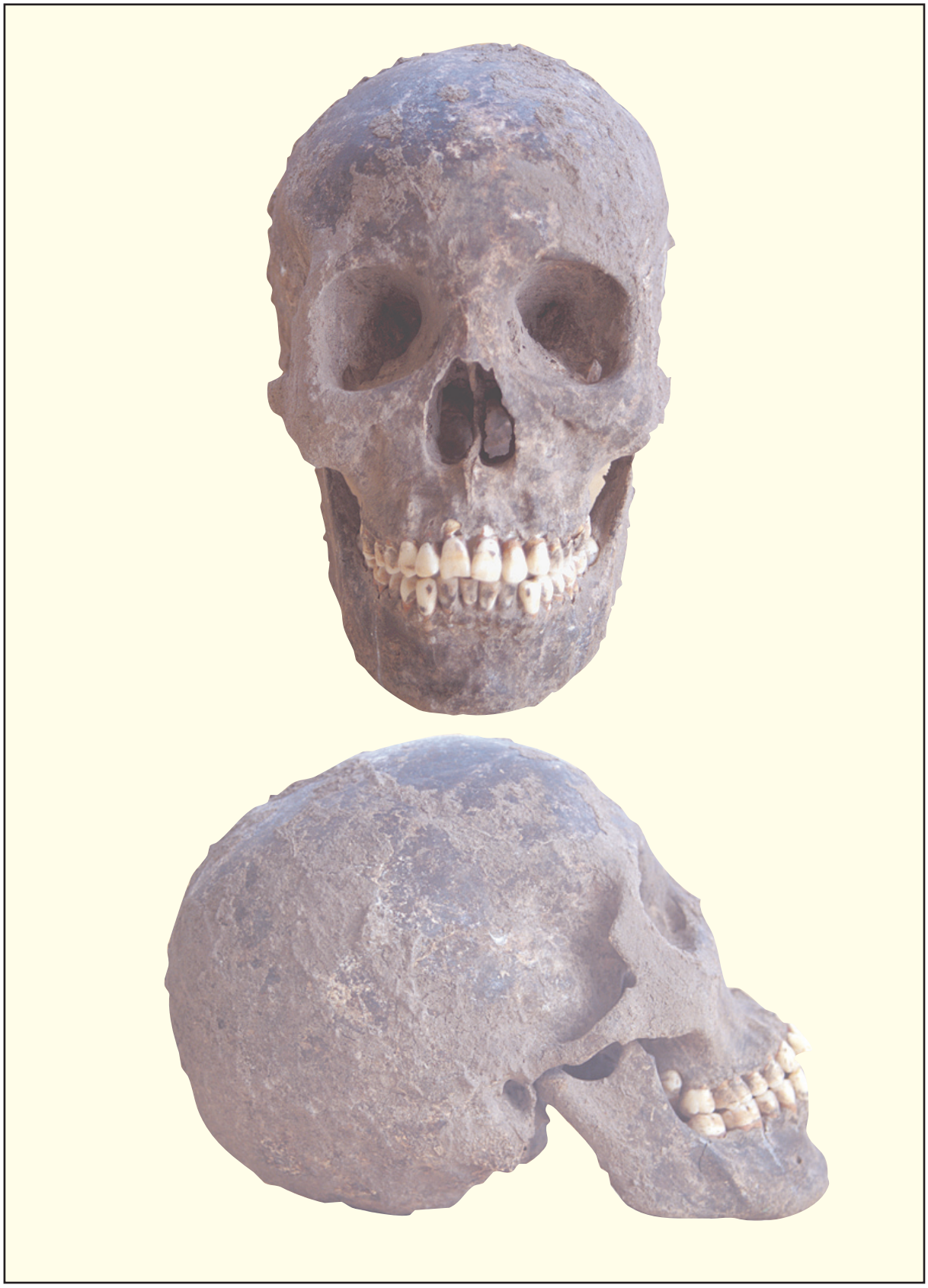


FIG. 17:2 The cranium of burial 107



FIG. 17:3 The cranium of burial 108

The 30 skeletons in the uppermost MP5 are also mostly poorly preserved, despite the graves not having been filled with rice, reflecting their proximity to the modern ground surface. The damage was collectively the result of subsequent human activities, animal burrowing, and growth of tree roots.

Of the 120 individuals, less than one-third (39) are classified as more-or-less (>75 percent) complete. The completeness of the remainder varied from a few bone fragments (mainly but not exclusively from 'rice' burials or infant jar burials) to partial skeletons with bones in excellent condition. Of the crania, only three (B27 Fig. 17:1, B107 Fig 17:2, and B108 Fig. 17:3) are complete and undistorted. Others are relatively complete but distorted and fragmented (B36, B44, B37 and B42, Fig. 17:4A-D) with many held together by soil filling the cranium. Where the bone is fragmented the edges are abraded so there would be no, or very minimal, chance of reconstructing the crania if the soil was removed.

The majority of the articulated child and adult burials were extended and supine. Three young males (B44, 61, 107) were buried prone. There were four classified as secondary burials (three adults and a three year-old child) on the basis of apparent placement of disarticulated bones, and five scatters of bone. Most very young infants (n =20) were buried in pottery jars. These were all full-term neonates except one three month old and one aged only as 'infant'. Some of the remaining 24 infants (defined as < 5 years) were articulated and supine, others were disturbed. The majority were 3 months or older, with only five late foetal or full-term neonates not buried in jars. Details are provided in the burial descriptions at the end of this chapter.

CENSUS: INDIVIDUALS

The first step in the examination of the skeletons was to establish who they represented by estimating age at death and sex where possible. Infants and children (subadults) are defined throughout as those less than 15 years of age at death.

Age at death of infants and children was estimated using dental formation stages (Harris and Buck 2002, Moorrees *et al*. 1963a, Moorrees *et al.* 1963b) with assistance of the resources of Duterloo (1991), Van der Linden (1983: 166-8) and Van der Linden and Duterloo (1976),

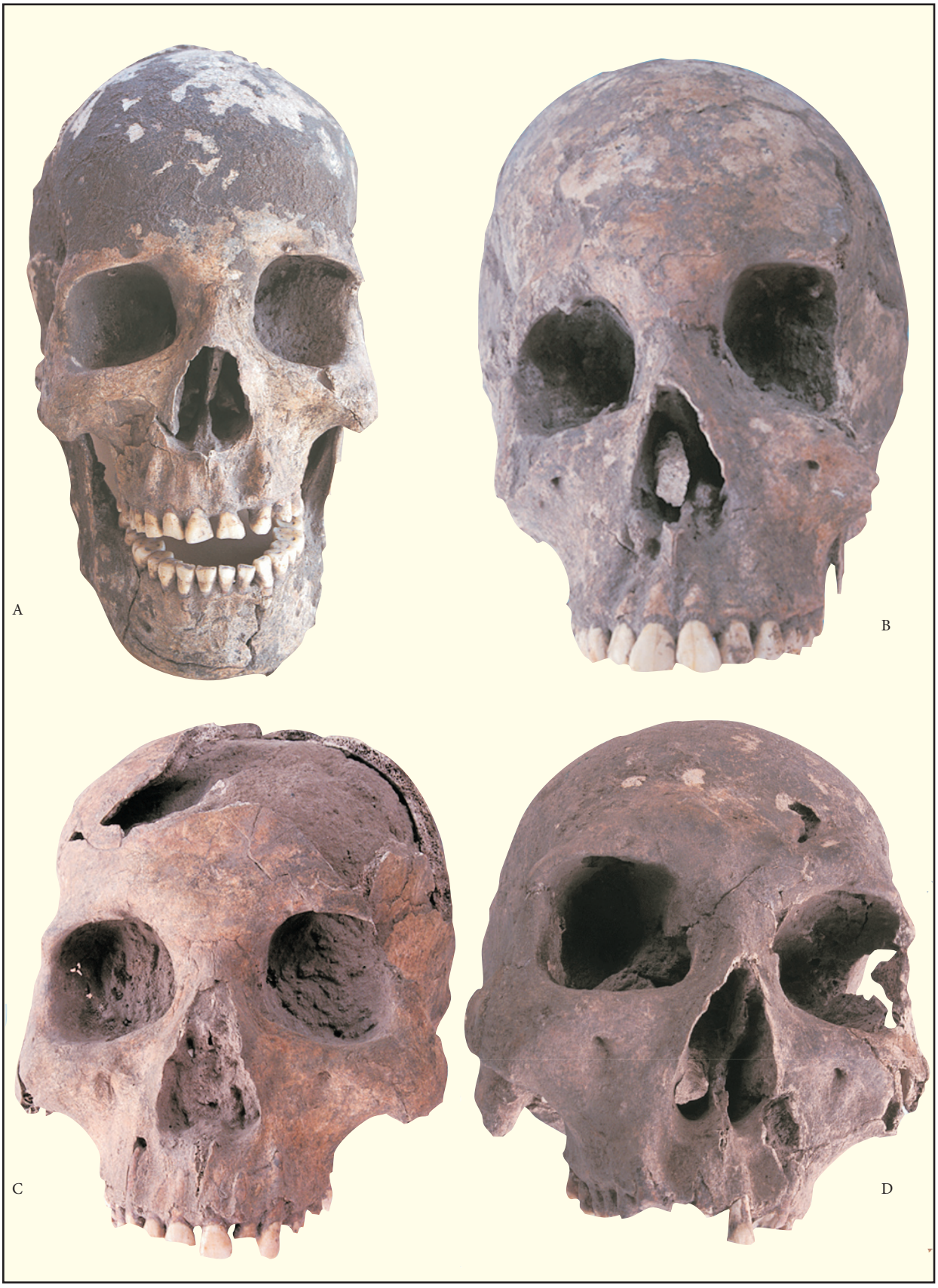


FIG. 17:4 The crania of A: burial 36, B: burial 44, C: burial 37 and D: burial 42

dental eruption stages of Ubelaker (1999) adapted with modifications from Kamalanathan, Huack and Kittiveja (1960), epiphyseal fusion (Buikstra and Ubelaker 1994) and diaphyseal length. Because dental methods for age estimation are most accurate these were given preference. So that these methods are more applicable to the Noen U-Loke sample a modified standard based on dental formation data of modern Thai children was used (Halcrow *et al.* in prep, Raungpaka 1988). Radiographs were taken of all teeth held in their crypts to assist age estimation by dental formation. Where there is insufficient dental material other methods based on skeletal development and size of skeletal elements were used. This involved comparing the length or size of bones with those individuals already aged by dental formation methods in the sample, or using non-population specific standards (Maresh's (1970) adapted in Scheuer and Black 2000). The protocol for measuring diaphyseal lengths followed Buikstra and Ubelaker (1994). Twenty-nine subadults were aged using dental methods, five using diaphyseal lengths, 14 by comparative size of bone elements and one using dental and size methods. In the case of four individuals not observed by SH (B28, 29, 34 and 46) the age estimates are based on field notes.

Age of adults was estimated using epiphyseal fusion of long bones in younger individuals (Buikstra and Ubelaker 1994:43), pubic symphysis morphology based on seriation, using the Brooks and Suchey illustrations as published in Buikstra and Ubelaker (1994:23-4), or relative rates of tooth wear, based on seriation. Tooth wear was graded using the system of Molnar (1971). Age estimates were presented in broad relative age ranges of young, middle-aged, and old, rather than specific age ranges. Although it is reasonable to suggest that the 'young' adults were aged between 20-30 years at death, the range of ages represented by the mid age and older adults is elusive and the suggestion of absolute age ranges would represent no more than an educated guess. We have chosen to avoid this temptation.

Sex of adults was estimated where possible using pelvic characteristics including the greater sciatic notch and the 'Phenice' features on the pubic bone as illustrated by Buikstra and Ubelaker (1994:17-8). This was either in conjunction with cranial characteristics (Buikstra and Ubelaker 1994:20), or replaced by them where no pelvic remains were available. The cranial and pelvic evidence was supplemented by long bone dimensions, using standards developed from the subsample with estimates of sex based on the pelvis or cranium. The dimensions used were clavicle length (male range 138-154 (ignoring the very short clavicle of an adolescent, B107); female range

TABLE 17:1 *Individuals with age estimates independent of tooth wear, used to form the basis for the assessment of age based on tooth wear*

Burial	Sex	Basis of age estimate	Age estimate	Tooth wear grades (all teeth)
5	Male	Pubic symph.	Young adult	2-3
26	Male	Epiph. fusion	Young adult	2-4
39	Male	Pubic symph.	Young adult	2-4
40	?Female	Epiph. fusion	Young adult	2-3
44	Male	Epiph. fusion	Young adult	2-4
50	Male	Pubic symph.	Young adult	2-3
75	?	Epiph. fusion	16-20 years	2-4
107	Male	Epiph. fusion	Young adult	2-4
113	Female	Epiph. fusion	Young adult	2-4
37	Female	Pubic symph.	Old adult	4-8 (3-8)*
108	Female	Pubic symph.	Old adult	5-8 (2-8)*

*the number in brackets represents the range of grades in all teeth, including those where the occluding teeth had been lost antemortem

131-140), the antero-posterior diameter of the tibia at the nutrient foramen (male range 35.4-38.7; female range 32.1-34.5) and the width of the distal humerus (male range 60.5-66.4mm; female range 51.2 – 58.5mm). The estimates were qualified as '?' where the evidence was suggestive but inadequate for a confident estimate to be made. The estimations based on cranial characteristics were modified slightly to allow for the observed relative gracility of prehistoric Southeast Asian populations. On the Buikstra and Ubelaker (1994) scale of 1 (most gracile) to 5 (most robust), grade 3 is deemed to be equivocal. In the Noen U-Loke sample, cranial characteristics of grade 3 were seen in males where confident estimates of sex were made from pelvic characteristics. On this basis, it was deemed appropriate that grade 3 cranial characteristics be taken as indicative of a male. This principle was applied only where

TABLE 17:2 *Census of the complete skeletal sample by age at death and sex*

	Female (including 2?)		Male (including 11?)		Sex not estimated		Total		% of total
Infants and children	n	%	n	%	n	%	n	%	
Foetal	-	-	-	-	-	-	2	3.8	1.7
0	-	-	-	-	-	-	24	45.2	20.0
<1y	-	-	-	-	-	-	11	20.7	9.1
1-4y	-	-	-	-	-	-	9	17.0	7.5
5-9y	-	-	-	-	-	-	2	3.8	1.7
10-14y	-	-	-	-	-	-	3	5.7	2.5
? age	-	-	-	-	-	-	2	3.8	1.7
Total subadults	-	-	-	-	-	-	53	100	44.2
Adults									
15-19y	0	0	2	8.3	2	10.5	4	7.4	3.3
Young	7	36.8	13	54.2	4	21.1	24	44.4	20.0
Mid	6	31.6	5	20.8	3	15.8	14	25.9	11.7
Old	7	31.6	4	16.7	1	5.3	12	22.3	10.0
Subtotal adults	20	100	24	100	10		54	100	45.0
Adults unknown age	1	0	3	6.3	9		13	19.4	10.8
Total adults	21		27		19	28.4	67	100	55.8
Total							120		100.0

the cranial characteristics were graded at least 3, and these individuals are identified as 'possible' males.

Eleven adults, including nine 'young' with age estimates based on epiphyseal fusion or pubic symphysis morphology formed the baseline for tooth wear, with two 'old' adults with age estimates based on pubic symphysis morphology forming the upper end of the scale (Table 17:1).

Apart from the 11 individuals listed in table 17:1, the most used basis for age estimation was tooth wear (42 cases), supplemented by pubic symphysis morphology (three cases) and skeletal maturation (three cases). Antemortem tooth loss formed the basis for estimation in one adult and was taken into consideration in two cases where this was sufficient to have significantly influenced tooth wear. The estimates for the 13 individuals listed as 'unknown' adults were based on a visual assessment of the size of the bones, which were fragmented.

Sex estimates were most frequently based on cranial morphology (33 cases) together with the pelvis (seven cases) and the sciatic notch (10 cases). The remainder of the estimates were based on various combinations of mandibular morphology, degree of robusticity (visually assessed) or long bone dimensions. Burial descriptions at the end of the chapter detail the basis for each individual. Seven individuals assessed as young males on the basis of pelvic characteristics or long bone lengths had cranial features that overlapped the female range. These were deemed to be over-ridden by the degree of 'masculinity' of the postcranial features. In a further four cases where there was disagreement between the cranial and postcranial features no estimate was made as neither was convincing.

CENSUS AND DEMOGRAPHY

The census of the sample is provided in table 17:2. Individual age and sex estimates and the basis for these are presented in the appendix.

Fifty-three individuals, or 44.2 percent of the total sample, were subadult. Most (n = 46) were infants under five years of age, with a peak in mortality of full-term neonates. There were only five children aged between five and 15 years and four adolescents between 15 and 19 years. There were two that were clearly subadult but no more specific age estimate could be made.

Adults were predominantly estimated as young, although it is possible that older adults are disproportionately represented among the 13 adults without age estimates.

Having estimated the age and sex of individuals where possible, the next question to be addressed is whether the sample might be representative of the population of the cemetery. There are three parameters that can be examined as evidence. One of these is the proportion of subadults in the skeletal sample. In pre-industrial societies the subadults make up a substantial percentage. Waldron (1994) estimates that this percentage should be approximately thirty percent of the sample. Weiss (1973) argues, based on a number of literary sources that subadult mortality rates of 30 to 70 percent are expected in preindustrial societies (Weiss 1973). Noen U-Loke has subadult mortality within this expected rate. Secondly, the sex ratio, which should be close to parity (Waldron 1994), shows males are disproportionately represented with a male:female ratio of 1.29:1.00. Thirdly, the sample of adults is expected to be spread across the age range from young to old. Although there are individuals in the three age groups, there is an imbalance of young adults. Males account for most of the imbalance, as over 50 percent of them are young. With more than one quarter of the adults with no age and/or sex estimates able to be made, it is possible that the sample of adults as a whole is representative despite the failure to meet the adult sex ratio and age range criteria.

Given this assessment, the census data can be used to address the question of population status. Do the data indicate that the population was growing? This would be indicated by a high level of fertility and/or low mortality, although these parameters are vexing to identify from the evidence of cemetery samples. This is partly because of the question of whether the excavated sample could be truly representative of the cemetery population. There are multiple factors influencing this, including subdivision of the cemetery area by age, sex, family or any one of a large number of other parameters. In these circumstances the area chosen for excavation could easily produce a biased sample. The cemetery itself may not contain the burials of all community members. A sector of the society may be buried elsewhere. A second influence is taphonomy; the postmortem influences on bone preservation can vary dramatically across even small distances, affecting particularly the preservation of poorly-mineralised infant skeletons. Clearly a non-representative sample will produce a very different image of the demography of a society. A markedly non-representative sample might be recognizable by its extreme composition but one that is slightly non-representative will not be identifiable but will have a significant effect on the interpretation, particularly where the samples are small.

The interpretation of even good samples is far from simple. There is a paradox that a change in infant/child mortality over time reflects a change in fertility rather than change in mortality at this age range. This is counter-intuitive but reflects the fact that, in populations with high subadult mortality rates (i.e. in virtually all pre-antibiotic societies), the more children born in a community, the higher their representation in the community's cemetery sample (Horowitz *et al.* 1988, Sattenspiel and Harpending 1983, Jackes 1994).

Approaches to the difficulties of interpreting data from small and possibly skewed prehistoric sites have been

developed as alternatives to the use of life tables, which requires the complete recovery of infant skeletons and accurate adult age estimates (Jackes 1992:215). The juvenile: adult ratio (JA) and the mean childhood mortality (MCM) are alternative indicators of fertility and the level of population growth (negative, positive or stationary) (Jackes 1992). The JA ratio is measured as the ratio of individuals aged between five and 15 years divided by the number of individuals over the age of 20 years. MCM is calculated by averaging the mortality rates (ironically, the 'q' values from a life table) from five to 15 years (5q5, 5q10, 5q15).

At Noen U-Loke the JA ratio is 0.111 (7/63) and the MCM rate is 0.05219 ([0.0270+0.0694+0.0597]/3). These statistics indicate a low rate of fertility. Plotting the two statistics (JA ratio and MCM) against each other as recommended by Jackes (1992, 1994) and comparing with the range of archeological populations used by Pietrusewsky and Douglas (2002), suggests that the Noen U-Loke population was increasing slowly or was even stationary. If the two subadults without age estimates are excluded, the JA ratio is 0.079 (5/63) and the MCM rate 0.052 ([0.027+0.043+0.060]/3), plotting these results shows a seriously declining population. This illustrates the extreme sensitivity of these statistics to sample size when two individuals can change the result so dramatically. They also ignore the high proportion of infant mortality in the sample. Both of these factors argue against the use of these statistics for Noen U-Loke.

Regional comparison

The earlier Ban Lum Khao population has a JA ratio of 0.296 (16/54) and MCM of 0.10 ([0.1467+0.0781+0.08 47]/3), which would be seen as indicating an increasing population, although the interpretation of the evidence is complicated by the relatively high levels of child mortality at this site. These are not matched by high levels of infant mortality, as would be expected in a rapidly growing population. The ratio of infants (<5 years) to children (5-15 years) at Ban Lum Khao is 35:16 or 2.188:1, compared with 46:7 or 6.57:1 at Noen U-Loke. The low proportion of infants at Ban Lum Khao could indicate under-representation of infants in the sample, although small infants were found in graves as well as in burial jars so there is no evidence that they were not mostly, if not fully, recovered from the excavation area. We cannot, of course, discount the possibility that very young infants were not buried in this area. Alternatively, it may be that the proportion of infants is indeed representative of the population. If that is the case, then something extraordinary may have elevated the proportion of child mortality, again raising the issue of the value of the JA ratio and MCM as fertility estimators.

What is the alternative? If we assume that the infant mortality rate is representative for both sites, we can try a modification of the JA ratio by including infants with the juveniles (I+JA ratio). For Noen U-Loke this would be 0.905 (57/63) and the modified MCM rate is 0.134 ([0.383+ 0.0270+0.0694+0.0597]/4) and at Ban Lum Khao the I+JA ratio would be 51/54, or 0.944 and the modified MCM rate 0.156 ([0.3182+0.1467+0.0781+0.0847]/4). This places Ban Lum Khao slightly above Noen U-Loke, as a slightly more rapidly increasing population. The implication of this is that if the proportion of infants in the Ban Lum Khao sample is actually less than that in the population, then the growth at Ban Lum Khao would have been very much more rapid than at Noen U-Loke. Higher levels of mortality in young adult females at Ban Lum Khao is consistent with the suggestion of greater pressure on population growth, as it is possible that a proportion of these deaths could be attributed to birth complications (Domett 2001). Overall the Bronze Age appears to have been a period of significant population growth but perhaps from a small base. There is evidence of unusually high fertility in populations 'in transition' (Bentley *et al.* 1993), where factors such as the availability of weaning foods results in increased fertility through reduction in length of the contraceptive effect of lactation. Regardless of whether the infants at Ban Lum Khao were under-represented, this would suggest that this was in fact such a population. This growth may have continued in the later Iron Age, as at Noen U-Loke, at a less rapid rate but as it was from a larger base, it would have nevertheless resulted in a larger population, compounding the population density and resulting in the density of large settlements identified in the archaeological record.

Summary of demography

The status of the population at Noen U-Loke appears *prima facie* to have been that of stability or slow growth. This would be surprising, given the evidence of the large and numerous settlements in the upper Mun River Valley during the period in question, which imply that the population was rapidly growing. It is even more surprising when compared with the apparently relatively rapid growth of the earlier Ban Lum Khao population. However, these interpretations need to be approached cautiously because of two factors, as outlined above. These are firstly whether the samples could be representative of the population, which seems more likely with Noen U-Loke than Ban Lum Khao with its low proportion of infants and relatively high proportion of children. Secondly there is the issue of whether the statistics available are skewing the evidence for Noen U-Loke, by disenfranchising the high infant representation in the sample. If these are taken into account the picture appears more logically to be one of significant growth. This is in accord with the archaeological evidence of multiple large settlements in the region.

TABLE 17:3 *Infant mortality (<5 years) at Noen U-Loke and Ban Lum Khao*

	Noen U-Loke		Ban Lum Khao	
Age (months)	n	%	n	%
1 (neonate)	26	70.3	14	66.6
2	1	2.7	0	0.0
3	1	2.7	0	0.0
4	3	8.1	1	4.8
5	1	2.7	1	4.8
6	0	0.0	0	0.0
7	2	5.4	1	4.8
8	1	2.7	0	0.0
9	0	0.0	1	4.8
10	0	0.0	3	14.2
11	0	0.0	0	0.0
12	0	0.0	0	0.0
?< 12 months	2	5.4	0	0.0
Total < 12 months	37	100	21	100
Age (years)				
1.0-1.9	1	11.1	3	18.8
2.0-2.9	3	33.3	8	50.0
3.0-3.9	4	44.5	5	31.2
4.0-4.9	1	11.1	0	0.0
Total 1-4.9 yrs	9	100	16	100
Total < 5 years	46		37	

HEALTH AND DISEASE: INFANT AND CHILD MORTALITY

Infant mortality is often used by anthropologists as a measure of a population's adaptability to challenges in their environment (Baker and Dutt 1972, King and Ulijaszek 1999, Little 1989). The usefulness of infant mortality is accepted to the extent that patterns of infant and child mortality, suggested by Mensforth *et al.* (1978) as a useful measure of health in past populations, is now widely used for both past and present populations. The pattern of infant mortality in a population is important in determining the relative contribution of the environment and human biology to their death (Wiley and Pike 1998). Demographers and clinicians make a distinction between neonatal mortality, which is seen as a consequence of endogenous causes including low birth weight and trauma, compared to exogenous causes that result in death after the neonatal period and are often attributable to environmental factors (Wiley and Pike 1998:318).

Mortality of infants in their first year (n=37) accounted for 69.8 percent of the subadult sample. It includes two burials (77 and 89) that are late foetal. Data are presented in monthly intervals in table 17:3. This pattern of high mortality in the first year and relatively few deaths later in childhood is consistent with patterns of mortality in other prehistoric populations and represents the vulnerability of infants to stress and the increasing resistance or resilience children acquire when they mature (Waldron 1994).

A statistically significant majority (χ^2 p=0.0005) of these deaths occurred at the time around birth, with the rest spread over the first eight months and none from the ninth month. Where the age estimate is a range (for example, burial 13 is aged from 0 to 0.25 of a year) the upper limit of the range is used for this analysis. This pattern of neonate mortality is well known and has been reported for many extant populations (Mosley 1984, Mosley and Chen 1984). To understand the high level of neonate mortality it is important to consider the intrinsic and extrinsic factors that affect the newborn. An attribute of newborns that makes them susceptible to illness and death is their state of biological immaturity. Infants are born with very immature immune systems and because of this are unable to rally against stressors that only have a mild effect on older individuals (Chandra 1975, Goodman and Armelagos 1989:226-7). The birth transition from life *in utero* to life independent of the uterine environment support system is critical. Unlike the foetus, the newborn is subjected to more environmental imbalances and deprivation of factors such as warmth and nutrition (Bornstein and Lamb 1992:125). It is also noted that throughout gestation, the infant is usually protected from bacterial infection (Cole 1998:491).

It is useful to assess not just how many full-term neonates were dying but also the mortality in the first year of

life (Wiley and Pike 1998:316). For those who survived the neonatal period at Noen U-Loke, all died before the age of nine months. This pattern of mortality at 4-8 months is proposed by Gray (1996) to have an association with the diminution of the acquired immunity from the mother at around 6 months.

Regional comparison

Infant mortality under one year of age is statistically significantly greater (χ^2 p =0.0405) at Noen U-Loke (37/120) than at Ban Lum Khao (21/110). The pattern of infant deaths at Ban Lum Khao shows a high proportion are full-term neonates as at Noen U-Loke but a wider spread of older infants through the first year with a minor peak at 9-10 months. On the basis of this evidence it could be argued that the Noen U-Loke subadults were weaker and dying earlier than the Ban Lum Khao subadults.

Of the total skeletal sample there is a greater proportion of infants dying between 1 and 4.9 years of age at Ban Lum Khao (16/110) compared to Noen U-Loke (9/20) (χ^2 p=0.0864) (Table 17:3). This is interesting given the similar proportion of infants in total at Noen U-Loke (46/120) compared to Ban Lum Khao (37/110) (χ^2 p=0.4587). Also a higher proportion of the 1-4.9 year old infants were dying at an earlier age at Ban Lum Khao compared to Noen U-Loke. In terms of health this may indicate that the infants at Noen U-Loke were stronger than at Ban Lum Khao.

How can the high neonatal death at Noen U-Loke and higher mortality at Ban Lum Khao in the 1-4.9 year olds be explained? Given the high neonatal mortality at Noen U-Loke compared with Ban Lum Khao, were the Noen U-Loke neonates subjected to more environmental stress, or is the higher neonatal mortality an indication of a higher fertility rate that the demographic indicators discussed above do not reflect? Fertility rates do not seem to be the explanation, as it would not only affect neonates. A further alternative explanation, briefly discussed above, is that the neonate sample from Ban Lum Khao is not representative but underestimates the mortality rate. If this was the case, the interpretation of the evidence would be completely reversed. We will probably never know the answer to this.

Were those at Noen U-Loke who survived the stresses of the neonatal period stronger than the infants and children in the sample who survived the neonatal period at Ban Lum Khao? The higher level of mortality (and morbidity in the form of linear enamel hypoplasia as discussed below) in late infancy and early childhood suggests that the Ban Lum Khao subadults were subjected to chronic disease, and were therefore more frail so they ultimately succumbed in the difficult "weaning" environment of early infancy or to other illnesses later in childhood.

Another estimator that has been used to compare weaning juvenile mortality is D(Deaths)(1-5)/D(1-10) (Buikstra *et al.* 1986). For Noen U-Loke this is 0.833 (10/12) and for Ban Lum Khao 0.56 (14/25). The higher figure at Noen U-Loke suggests that more infants were dying at Noen U-Loke during the weaning stage compared to the post-weaning stage but the more detailed consideration of the evidence for this period raises a question about the appropriateness of the weaning juvenile mortality estimator. It seems that the use of this estimator for the Ban Lum Khao sample with an unusually large proportion of individuals in the 5-10 year old category may be inappropriate.

The comparative infant and child mortality rates at the two sites cannot be confidently interpreted because of the uncertainty introduced by the pattern at Ban Lum Khao. If we accepted that the samples were representative the interpretation would be that frail Noen U-Loke individuals died in infancy, whereas frail Ban Lum Khao individuals survived the neonatal period but ultimately something, either chronic or acute, compromised their survival so they died later in infancy or during childhood.

ADULT LONGEVITY/LIFESPAN

Beyond the use of demographic data as a measure of population growth status, the adult age at death data can also be used to compare the evidence for lifespan between the sexes and in comparison with other samples. This is, of course, not independent of the influences of population growth as noted above; nevertheless it is worth considering the age and sex composition of the sample.

With those of unknown age excluded, just over half of the adults (28/54) are classified as young (<30 years of age at death) and the rest equally distributed in the mid and old age groups. Females are almost equally distributed across the age groups so that the high proportion of young adults is reflective of the proportion of young males. Despite this, the sex difference in the age structure of the samples is not significantly different (χ^2, p = 0.2231). This may be simply sampling error, although the possibility exists that females are disproportionately represented among those where no age and/or sex could be estimated.

Regional comparison

There are no significant differences in total adult mortality by age category at Noen U-Loke and Ban Lum Khao but there are differences when these data are compared for males and females (Table 17:4). This is particularly so for the young adults, where there are significantly fewer females in the Noen U-Loke sample than in the Ban Lum Khao sample (FET p = 0.042), partially balanced by the higher (but non significant), proportion of males at Noen U-Loke. These young females at Ban Lum Khao account for a significantly higher proportion of females overall at Ban Lum Khao.

What do these data say, if anything, about the mortality rates at the two sites? There are several alternative explanations. It is certainly possible that the differences again reflect the vexing problem of sampling, previous-

ly discussed in the section on demography. The ratio of males to females at Noen U-Loke is 1.0:0.8, compared with a ratio of 1.0: 1.2 at Ban Lum Khao. Given that the same methods of sex estimation were used at both sites, the chances of this reflecting estimation error are reduced but cannot of course be completely discounted. Assuming, however, that the estimates are valid, the difference may reflect an under-representation of one sex in each sample with young females buried either elsewhere in the site or away from Noen U-Loke (or as mentioned above, their skeletons being disproportionately excluded because of poor preservation) and the same possibilities applying to males at Ban Lum Khao. Taking the assumptions one step further and accepting the validity of the samples as representations of the cemetery populations there are yet further complications in that the differential representation of young females at Ban Lum Khao may be a correlate of the higher fertility discussed previously as one of the possible demographic interpretations of the mortality data. It is possible that these young women represent mortality with pregnancy or birth complications. Given all these possible explanations for the sex differences, the only inference that can be comfortably drawn from the data is that there is no evidence of significant differences in the length of adult life at the two sites.

GROWTH

Growth is a sensitive barometer of a population's health (Eveleth and Tanner 1990). As evidence of growth from infants and children, all complete diaphyseal lengths were measured using the Buikstra and Ubelaker (1994) standards. Those under 150mm were measured with Mitutoyo digital calipers in millimetres rounded to 0.1mm. Longer bones were measured using large sliding calipers and rounded to the nearest 1.0 or 0.5 of a millimetre.

The diaphyseal lengths from the fourteen infants and children with measurable diaphyses are listed in table 17:5. These were mostly very young foetal or full-term neonates, with only two older subadults. This precluded the comparison of bone growth with dental development. Bone growth is more strongly influenced by the environment than dental development so the comparison of the two measures is a valuable indicator of environmental influences on population health (Saunders 2000).

Regional comparison

The diaphyseal lengths from the Ban Lum Khao infants and children are provided in table 17:6. There is a larger sample of all ages.

The mean diaphyseal lengths for the neonate samples suggest that babies at Ban Lum Khao were larger than those at Noen U-Loke but the sample is too small for any firm conclusions to be drawn. Little can be said about older infants and children, because the samples are even smaller in this group.

ADULTS

Evidence of growth from adults is in the form of stature. All complete long bones were measured using sliding calipers (no osteometric board was available to us in Thailand at the time the data were collected). Maximum lengths were recorded using the standard methods (Buikstra and

TABLE 17:4 *Adult mortality*

	Noen U-Loke								Ban Lum Khao					
	Females		Males		? Sex		Total		Females		Males		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
15-19 y	0	0.0	2	1.7	2	1.7	4	3.3	2	1.8	3	2.7	5	4.5
young	8	6.7	13	10.8	4	3.3	25	20.8	17	15.5	7	6.4	24	21.8
mid	7	5.8	5	4.2	3	2.5	15	12.5	7	6.4	9	8.2	16	14.5
old	6	5.0	4	3.3	1	0.8	11	9.2	4	3.6	7	6.4	11	10.0
?age	0	0.0	3	2.5	9	7.5	12	10.0	2	1.8	1	0.9	3	2.7
Subtotal	21	17.5	27	22.5	19	15.8	67	55.8	32	29.1	27	24.5	59	53.6
Total							120	100					110	100

TABLE 17:5 *Diaphyseal lengths: Noen U-Loke infants and children*

Burial	Age (years)	Humerus	Ulna	Radius	Femur	Tibia	Fibula
B77	foetal	54.3	-	44.5	-	-	-
B89	foetal	-	-	-	53.4	47.4	-
B18	0	-	-	-	-	-	60.2
B19	0	66.7	-	-	-	-	63.7
B24	0	-	-	-	70.5	63.3	-
B38	0	62.9	59.6	52.0	72.2	64.2	60.5
B43	0	67.4	64.3	55.8	77.1	68.5	-
B81	0	59.5	-	-	-	60.0	-
B88	0	64.6	61.7	54.9	75.4	-	-
B100	0	65.7	60.3	53.0	75.7	66.3	62.1
B103	0	-	-	-	77.5	-	-
B106	0	-	-	-	68.0	-	-
Mean: full-term neonates (n)		*64.5 (7)*	*61.5 (4)*	*53.9 (4)*	*73.8 (7)*	*64.5 (5)*	*62.1 (4)*
B22/23	3	-	-	115.7	-	-	-
B41	11	218.5	-	-	-	-	-

Ubelaker 1994).

Only 13 adults (nine males, four females) had complete or reconstructed long bones that were measurable. Stature was estimated using equations derived from modern Thai and Chinese cadavers (Sangvichien *et al*., n.d.; Sangvichien *et al*., 1985). The Thai/Chinese equations produce the least variation in stature estimates for different long bones for individuals from prehistoric Thai skeletons compared with other stature equations such as those by Trotter (1970) (Tayles 1999). The long bone lengths, the estimated statures and the bones used in the estimates are listed in table 17:7.

Regional comparison

The summary data are presented in table 17:8. Comparative data from Ban Lum Khao are also presented (Domett 2004). The mean stature of females is identical to that of the larger sample from Ban Lum Khao. In contrast, the mean from the sample of males at Noen U-Loke is 5cm taller than that at Ban Lum Khao, but there is a much greater variation in the range at Ban Lum Khao. This is a statistically significant difference (t-test p = 0.049).

The level of sexual dimorphism in stature at Noen U-Loke is 8.7 percent of male stature. This compares with the slightly lower level of 6.1 percent of male stature at Ban Lum Khao, reflecting the shorter mean male stature in this sample. Both are within the normal range of 5-10 percent found in human populations (Molnar 1992).

Accepting that the small sample at Noen U-Loke is representative, the first implication is that the Noen U-Loke population was healthier. It is recognized that males have a greater response to environmental conditions than females (Stinson 1985), so the taller males at Noen U-Loke suggest a healthier population. The interpretation of this evidence is of course subject to caveat because the sample from Noen U-Loke is small and may well be biased. The

TABLE 17:6 *Diaphyseal lengths: Ban Lum Khao infants and children*

Burial	Age (years)	Humerus	Ulna	Radius	Femur	Tibia	Fibula
B14	foetal	54.9	-	-	64.1	-	-
B103	foetal	47.1	-	-	51.2	47.0	-
B3	0	70.0	65.0	58.4	-	-	-
B9	0	-	-	-	-	68.4	-
B50	0	-	-	-	81.7	68.4	-
B58	0	65.8	-	-	-	-	-
B62	0	81.0	-	-	-	-	-
B70	0	-	52.7	-	66.5	-	-
B104	0	60.2	-	-	-	-	-
B107	0	-	61.9	-	-	-	-
Mean: full-term neonates (n)		*69.3 (4)*	*59.9 (3)*	*58.4 (1)*	*74.1 (2)*	*68.4 (2)*	-
B84	0.25	79.3	-	-	-	-	-
B76	0.75	-	-	-	109.6	94.1	-
B105	0.75	93.0	86.0	75.3	-	-	-
B91	1	-	-	-	115.2	-	-
B78	1.5	-	97.9	87.1	150.2	-	118.0
B4	2	-	-	-	133.4	-	-
B11	2	108.2	-	-	142.7	119.8	-
B87	2	-	-	-	148.5	123.3	-
B26	2.5	126.9	-	-	-	-	-
B68	2.5	-	-	-	169.0	-	-
B83	2.5	113.2	-	-	-	-	-
B106	3	129.6	-	101.0	-	-	-
B110	3	-	-	-	-	160.0	-
B108	7	-	-	-	243.0	203.0	-
B41	8	176.0	-	-	-	-	-
B90	10	-	186.0	-	-	-	-

TABLE 17:7 Long bone lengths, stature estimates and bones used in the estimates

Burial	Sex	Stature estimate	Clavicle		Humerus		Ulna		Radius		Femur		Tibia	
			L	R	L	R	L	R	L	R	L	R	L	R
5	male	170.9H	-	-	-	334	-	-	-	-	-	-	-	-
26	male	168.1F+T	138	-	315	-	286	287	259	259	459	461	376	372
27	male	165.3F+T	142	154	308	307	266	-	-	244	450	-	364	364
32	male	166.3U	-	-	-	-	267	-	-	-	-	-	-	-
33	male	167.0R	-	-	-	-	-	-	254	-	-	-	-	-
37	female	153.3H	-	131	291	284	-	-	-	-	-	-	-	-
40	female	151.5U	-	-	-	-	238	-	-	-	-	-	-	-
42	male	173.5F	-	-	340	341	-	-	-	-	494	-	-	-
44	male	167.5F	-	-	319	-	-	-	-	-	-	459	-	-
50	male	171.2H	-	-	335	-	-	-	-	-	-	-	-	-
99	female	151.9R	-	-	-	-	-	-	222	-	-	-	-	-
107	male	173.7F+T	122	-	317	315	-	-	-	-	470	-	403	-
108	female	161.6H+R	-	138	312	308	-	-	254	252	-	-	-	-

second possible implication is that the greater range of male statures at Ban Lum Khao indicates a greater degree of equality in access to resources at Noen U-Loke.

TABLE 17:8 *Statures of adults from Noen U-Loke and Ban Lum Khao*

Noen U-Loke	n	Mean (cm)	Standard deviation (cm)	Range (cm)
Females	4	154.6	4.7	151.5-161.6 (10.1)
Males	9	169.3	3.1	165.3-173.3 (8.0)
Ban Lum Khao				
Females	25	154.7	3.8	147.9-162.2 (14.3)
Males	18	164.7	6.2	152.4-174.9 (22.5)

GROWTH DISRUPTION:

Enamel Hypoplasia

Linear enamel hypoplasia (LEH) was identified macroscopically as a transverse line or groove across the tooth enamel (Hillson 1996). These are identified as one or more linear hypoplastic defects per tooth. All teeth were included. Data are reported per individual and per tooth.

Subadults

No deciduous teeth in the Noen U-Loke sample have LEH, which is the usual finding for prehistoric skeletal samples. In the permanent teeth, 7.0 percent (4/57) are affected. This represents 80 percent (3/5) children with permanent teeth.

Circular enamel defects or localised hypoplasia of the primary canine (LHPC), are characterised by roughly circular areas of defective or thinned enamel in the form of a flattened pit

TABLE 17:9 *Linear enamel hypoplasia: adults, Noen U-Loke and Ban Lum Khao*

	Noen U-Loke				Ban Lum Khao				
	Teeth		Individuals		Teeth		Individuals		χ^2 P value NUL cf BLK
	a/n	%	a/n	%	a/n	%	a/n	%	
Females	39/258	15.1	12/20	60.0 a	54/429	12.6	11/24	45.8	0.35 teeth 0.38 indiv
Males	20/304	6.6	10/22	45.5 b	35/308	11.4	6/18	33.3	0.04 teeth 0.53 indiv
?sex	13/114	11.4	6/10	60.0	-	-	-	-	
Total	72/676	10.7	28/52	53.8	89/737	12.1	17/42	40.5	0.40 teeth 0.197 indiv

a= affected with LEH, n= total number of teeth (wear grade <6) or individuals observed

on the midlabial surface of deciduous canines (Skinner and Newell 2003:61). This defect was present on 3/8 (37.5 percent) of deciduous canines present, affecting two of the three subadults with these teeth.

The clinical and epidemiological literature records the occurrence of this defect in between 0.5 and 50 percent of individuals (Guatelli-Steinberg and Lukacs 1999:97). Most studies find a negative association between socio-economic status (SES) and the appearance of this defect (Guatelli-Steinberg and Lukacs 1999). A number of studies undertaken in areas of the world with children of comparatively low SES and nutrition status generally have a LHPC prevalence of between 30 and 50 percent (Guatelli-Steinberg and Lukacs 1999: 97). The high prevalence in the Noen U-Loke sample cannot be assumed to indicate that the children had similar health status to children from modern low SES populations because of the small sample size but nevertheless it hints at poor health in this sample of non-survivors. Given that they are in the cemetery sample, this is not necessarily indicative of the health status during childhood of those who survived to at least the age where the deciduous canines are lost.

Regional comparison

It is accepted that canines and incisors may form hypoplasia at higher frequencies than other teeth (Goodman

TABLE 17:10 *Mean stature of Noen U-Loke and Ban Lum Khao adults with and without linear enamel hypoplasia*

	Mean stature (cm) with LEH				Mean stature (cm) without LEH			
	Males	n	Females	n	Males	n	Females	n
Noen U-Loke	169.4	4	151.7	2	169.9	4	157.5	2
Ban Lum Khao	162.8	5	153.9	7	165.5	9	154.3	12
t-test p =	<0.01		0.07		0.222		0.585	

LEH = linear enamel hypoplasia

et al. 1980). Therefore, to ensure that one sample does not have a significantly higher proportion of these teeth, the percentage of anterior teeth was compared between the samples. Both samples had very similar percentages of canines and incisors, both mandibular and maxillary, of 44-45 percent. Therefore we can assume that the data presented in table 17:9 are not biased.

No deciduous teeth in the Ban Lum Khao sample have LEH but LHPC are present on 7/35 canines (20 percent), affecting 4/15 individuals (26.7 percent). Although the rates of this dental defect appear to be much higher at Noen U-Loke than at Ban Lum Khao, the differences are not statistically significant (χ^2, FET p = 0.245), no doubt reflecting the very small sample size at Noen U-Loke rather than indicating that the rates are truly comparable.

In the permanent teeth of the Ban Lum Khao subadults, 30/106 (28.3 percent) of teeth have LEH, affecting 6/9 (66.7 percent) individuals. These results indicate a very much higher proportion of the permanent subadult teeth in the Ban Lum Khao sample were affected by episodes of growth disruption than at Noen U-Loke. This difference in the proportion of teeth affected is statistically significant (χ^2 p = <0.01) but the proportion of individuals does not differ statistically significantly between the sites. This suggests that the children at Ban Lum Khao with LEH died of chronic problems as there had been time for stress to affect the development of the dentition, although the events that resulted in the LEH were not necessarily the cause of death. According to the osteological paradox (Wood *et al.* 1992) this indicates that this population was able to survive the insults and therefore was immunologically 'healthy', although possibly miserable in their daily lives. The children at Noen U-Loke were more likely to have died of acute illness at an earlier age.

Adults

The sample has a high level of advanced attrition (grades 6-8 on the Molnar scale) at 15 percent of teeth (see the dental pathology later in this chapter) which may have eliminated some evidence of LEH. The proportion of LEH in adults is therefore calculated excluding these highly worn teeth to enable comparison between the samples.

In adults, just over 10 percent of teeth and half of individuals were affected. The prevalence is higher in the females than in males, with the differences per tooth highly statistically significant (FET, p = 0.0031) but differences per individual are not significant (FET, p = 0.599). This shows that of those adults with hypoplasia, females had more hypoplastic teeth than males.

Regional comparison

As with subadults, both samples had very similar percentages of canines and incisors, both mandibular and maxillary, of 35 percent and 38 percent.

Neither the proportions of teeth nor the proportions of individuals affected in the adult samples differs significantly between Noen U-Loke and Ban Lum Khao. The proportions also do not differ significantly in the female samples, even though teeth in Noen U-Loke females have more LEH than the teeth in Ban Lum Khao females. The proportion of affected teeth in Noen U-Loke males is almost half that in Ban Lum Khao males and this difference is significant but the proportions of individuals affected do not differ significantly. This means that the evidence from the adult dentition suggests that overall the adults at Noen U-Loke and Ban Lum Khao were similarly affected by episodes of growth disruption during early childhood, despite a proportion of the males at Ban Lum Khao being particularly subject to episodes. This possibly indicates chronic ill health in these individuals, that nevertheless did not compromise their survival to adulthood.

It is possible that an individual with enamel hypoplasia, as an indication of stress in childhood, may be affected long term. Depending on the individual's ability to catch-up in growth after the stress period (Stini 1985), those with enamel hypoplasia may not reach their genetic potential for stature. The correlation between low stature and high levels of enamel hypoplasia has been demonstrated elsewhere (Pechenkina *et al.* 2002, Stodder and Douglas 2003).

A comparison of the mean stature of adults with LEH with those without LEH shows that within both samples, individuals with LEH have lower mean statures than those without (Table 17:10) but the differences are not statistically significant for either males or females.

Comparison of the two samples with LEH shows that Noen U-Loke males were significantly taller than Ban Lum Khao males although sample sizes are small. This follows the pattern seen in the complete samples (Table 17:8). The differences in mean stature between the females with LEH from the two sites are close to being statistically significantly different, with females at Noen U-Loke shorter than at Ban Lum Khao and considerably shorter than females from Noen U-Loke without LEH.

The significant difference between males from the two sites suggests that the Ban Lum Khao males with LEH had been severely affected by childhood illness to the extent that they did not catch-up the lost growth potential. As a consequence they did not attain their genetic potential for height. In contrast, the Noen U-Loke males, although showing signs of growth disturbance, were either not badly enough affected to have growth disrupted for any length of time or else recovered sufficiently well to catch-up lost growth. This correlates with the evidence from the complete sample of stature estimates.

SUMMARY OF HEALTH

The infant and child mortality rates at Noen U-Loke follow the pattern generally expected in pre-antibiotic populations, with relatively high death rates early in infancy but very much lower mortality during childhood. This is suggestive of good health during childhood, and consistent with few episodes of growth disruption in the adult dentitions and hints of achievement of growth potential from the small sample of adult males. Adults of both sexes appear to have lived lives of 'reasonable' length for a prehistoric population.

This compares with the picture from Ban Lum Khao of relatively low neonate mortality but higher rates later in infancy and during childhood with these infants and children having experienced multiple episodes of growth disruption. Those who survived to adulthood had fewer episodes of growth disruption than the children but the males had experienced more than the adult males at Noen U-Loke, and were on average of shorter stature. Females at Ban Lum Khao did not show that same relatively poor health but there was a higher proportion of young adult female mortality.

Under the osteological paradox (Wood *et al*. 1992), the Ban Lum Khao children and males could be said to have been 'healthy', as they survived multiple insults, at least for some time. 'Health' in this context refers to the immune status of the child and does not imply that they had a good quality of life. It does not mean, however, that the Noen U-Loke children were not healthy, or did not experience a better quality of life, as it depends on the frailty of the children and the hidden heterogeneity of risks, or in other words their exposure to disease. Without any evidence of the respective causes of death in the two samples of children, and in the absence of an assurance that the samples of both infants and children were representative, it is difficult to interpret the significance of the comparative evidence from the two sites.

The adults at Noen U-Loke may have been healthier than those at Ban Lum Khao as there was no peak of mortality among young adult females, the males were on average taller, and they did not suffer so many episodes of growth disruption.

The limited range of statures in Noen U-Loke males may also indicate a more egalitarian society, although the small sample limits the value of this interpretation and does not accord with the considerable mortuary wealth found with some men and women. The possibility of different genetic potentials because of differences in the gene pools cannot be discounted. This could reflect immigration of taller individuals at Ban Lum Khao.

DISEASE

All bones from all skeletons, regardless of preservation, were examined macroscopically for pathological bony

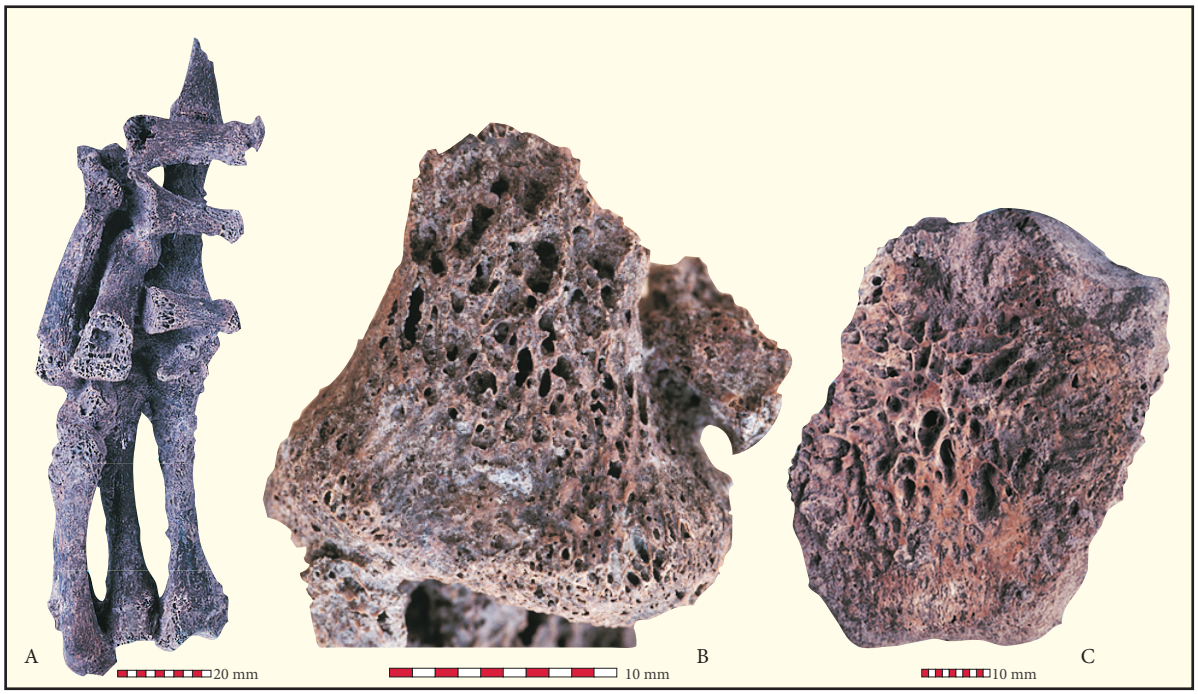


FIG. 17:5 Changes in bones from burial 107. A: The partial right hand, showing the position of the bones described in the text. The proximal interphalangeal joint malformations and resorption of the middle phalanx of the index finger are visible. There is postmortem damage exposing cancellous bone on the proximal ends of the phalanges in particular, B: Distal first foot phalanx, plantar aspect, with resorbed tuft and shaft and diffuse cortical porosity, C Posterior aspect of the manubrium, showing abnormal cortical bone

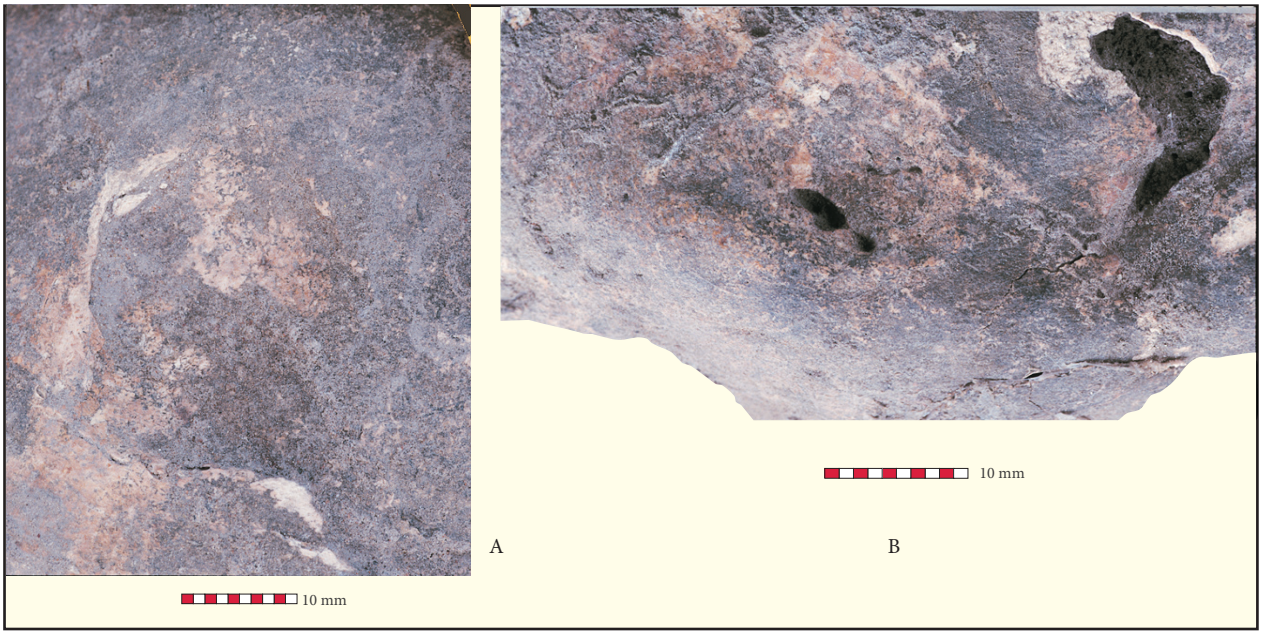


FIG. 17:6 The changes in the cranial bones of burial 42 described in the text. A: possible healed depression fracture on the right parietal, B: The lesions in the frontal bone (the nasal bone is towards the bottom of the image)

change. Any changes observed were examined under a low-power binocular microscope to confirm the initial observation. Lesions were recorded using the terminology advocated by Ortner (2003). Although ideally radiography would be used to further clarify the nature of the lesions, unfortunately access to facilities was not possible at the time the data were collected. Also, as the interstices of virtually all bones were filled with soil, the value of radiographs would have been limited. The skeletons with changes are presented here as a series of case studies as the preservation of the skeletons prevents meaningful epidemiological data being calculated for the whole sample. For the same reason, even the one ubiquitous disease that is certain to have been present, osteoarthritis, was not able to be recorded in any systematic way because of the condition of most of the joints.

Osteoarthritis in the synovial joints manifests as marginal and intra-articular osteophytes, pitting of the articular surface, and eburnation of the articular surface in extreme cases. On the cartilaginous joints between vertebral bodies degeneration of the intervertebral discs results in the formation of marginal osteophytes. In the five individuals with multiple intact joints, only one, B108, an old woman, has polyarticular joint degeneration such



FIG. 17:7 The superior aspect of the clavicles of burial 42, showing the changes described in the text



FIG. 17:8 Changes in the hand of burial 42. A: Lateral view of the phalanges of the right thumb, showing the alteration in shape of the shaft of the distal phalanx and the enlarged dorsal aspect of the articular surface. This suggests habitual hyperextension of the thumb, B: An example of the ossification at the attachments of the fibrous sheath on the margins of the palmar aspect of the phalanges. The sheath acts to hold in place the tendons of the extrinsic finger flexors and therefore the ossification suggesting extreme habitual flexion of the fingers

that might be classed as osteoarthritis. The details of these five are:

B26 Young male. No changes or slight marginal osteophytes on most joints, with the exception of the patellae, where in addition to slight marginal lipping there are discrete osteophytes on the articular surfaces, with marked pitting. These are not matched by changes on the distal articulating surfaces of the femora.

B27 Mid male. No changes or slight marginal osteophytes on most appendicular joints. The joints on the vertebrae also have either no changes or slight marginal osteophytes.

B42 Old male. No change or slight marginal osteophytes on most appendicular and vertebral joints. Note description of lesions related to infectious disease below.

B107 Young male. No change on most appendicular and vertebral joints. Note description of lesions related to infectious disease below.

B108 Old female. Many appendicular joints and vertebral joints with severe marginal osteophytes and pitting of articular surfaces, including hands and feet. This is the only individual with evidence of significant polyarticular osteoarthritis.

Other individuals had survival of individual joints but these showed no or minimal evidence of degeneration. Cases where joints have changes other than those of osteoarthritis are included in the list of pathologies in table 17:11.

SYSTEMIC INFECTIOUS DISEASES

Evidence for other forms of skeletal pathology is reported as case studies for three individuals with significant lesions suggesting systemic infections. Full details have been published in Tayles and Buckley (2004).

Case one

The first individual is a young male (B107) whose age at death was estimated at 16-20 years. His bones are very well preserved and his skeleton is largely complete. He was estimated to have been 173 cm in stature, which is well above average for prehistoric Southeast Asian males

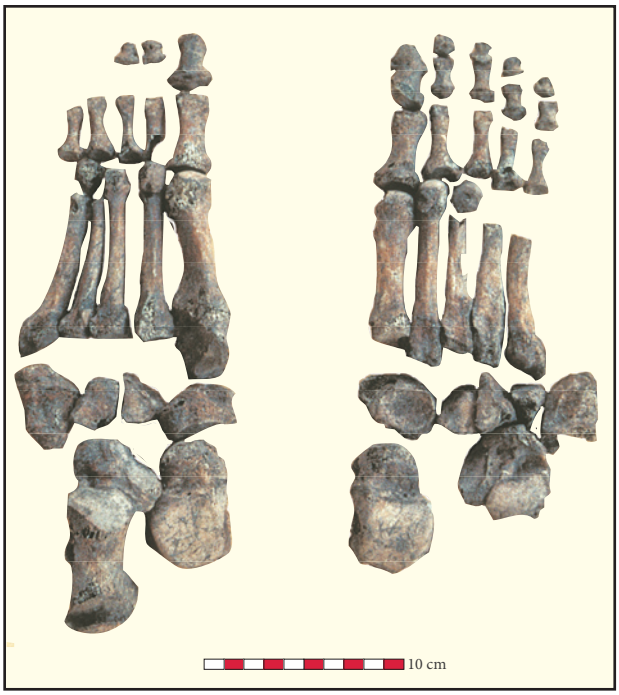


FIG. 17:9 The superior view of the feet of burial 42, showing the changes described in the text.

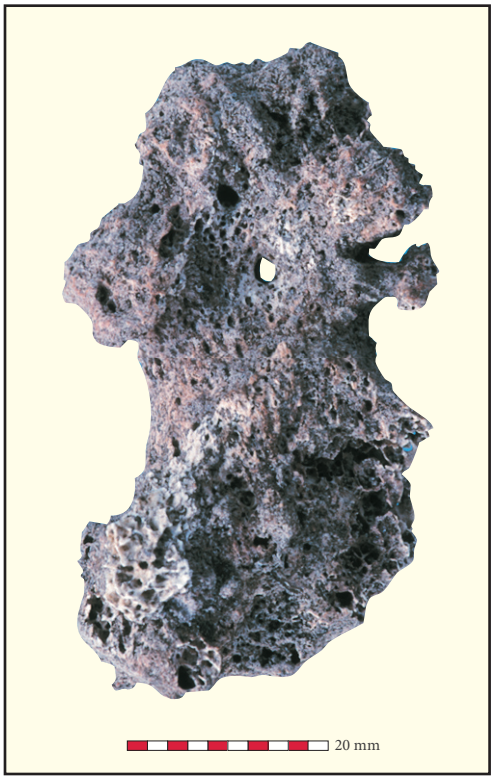


FIG. 17:10 The plantar aspect of the first distal foot phalanx of the left foot of burial 42, showing a remodeled hole through the shaft and the unusual development of the distal tuft. The proximal third of the bone has been damaged postmortem but there are hints of remodeling of the attachment of the long flexor (*flexor hallucis longus*)

(Pietrusewsky and Douglas 2002).

He has pathological bony changes on his hands and feet, tibiae and fibulae and manubrium. The most obvious lesions are on his hands and involve woven bone on shafts, joint destruction with possible ankylosis and resorption of distal phalanges. His right hand was excavated in the position shown in figure 17:5A. On his feet, one metatarsal shows concentric atrophy, with woven bone and porous proliferative periostitis on other metacarpals and phalanges. One first distal phalanx has resorption of the tuft and part of the shaft and diffuse and extreme cortical porosity on the plantar aspect (Fig. 17:5 B). Subperiosteal woven and sclerotic bone is present on the distal shafts of both tibiae and fibulae. There is abnormal bone on the posterior aspect of the manubrium (Fig. 17:5 C). There are no visible lesions around the nasal aperture or on the palate.

Case two

The second individual is an older male (B42). Most bones are represented but many are fragmented or damaged.

He has lesions throughout his skeleton, although some of these are consistent with pre-symptomatic joint degeneration and are not surprising in an older person (Resnick 1995:1265). One appears to be a healed depression fracture on the cranium on the right parietal, 20x30mm in diameter (Fig. 17:6A). To summarise the remaining extensive lesions, these are a mix of resorptive, proliferative, and deformative. In the axial skeleton, there are remodelled lesions on the frontal and parietal bones. These are shallow depressions, 30x20 mm in size. The frontal lesion has a small, uneven, fenestration through to the frontal sinus (Fig. 17:6B). In the appendicular skeleton there is a variety of lesions. These are on the clavicles, hands, legs and feet and are mostly bilateral. On the clavicles they are mixed lytic and proliferative (Fig. 17:7). Other changes in the hand affect the distal interphalangeal joint of the thumb and the proximal hand phalanges (Fig. 17:8). These changes suggest hyperextension of the thumb and habitual flexion of the fingers, at the proximal interphalangeal joints (Ortner 2003). On the tibiae and fibulae, there is abnormal woven and sclerotic bone on the distal half of the shafts. In the feet the lesions are more complex with a mixture of proliferative, lytic and deformative. These are mainly on the right foot, where the medial cuneiform and first metatarsal have ankylosed and there are marginal osteophytes at the articulation between the third and fourth metatarsals with the shafts superiorly broadened and flattened (Fig. 17:9). The distal first phalanx has a variety of changes as illustrated in figure 17:10. On the left foot, the fourth metatarsal shaft is narrow with possible concentric atrophy of the cortex.

DIFFERENTIAL DIAGNOSIS

As these two individuals have types and patterns of le-



FIG. 17:11 The maxilla of burial 36, showing the 'gap' on the midline, inferior to the anterior nasal spine. This image also shows the probable ablation of the left lateral incisor and a deep depression at the position of the missing tooth, discussed below in the section on tooth ablation

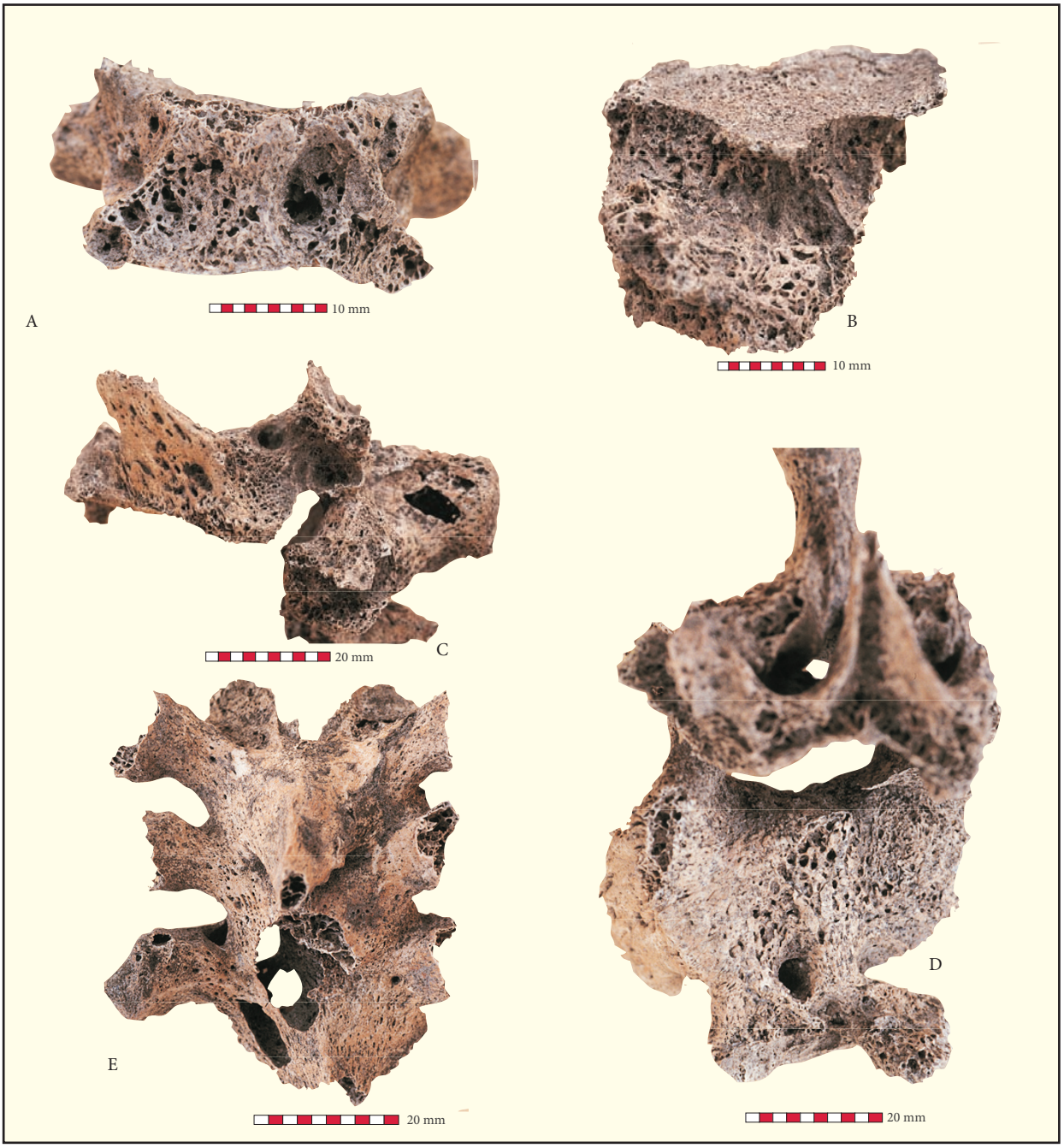


FIG. 17:12 The vertebrae of burial 36. A: The first thoracic vertebra showing a large lytic lesion on the anterior aspect of the body, B: the body of a thoracic or lumbar vertebra, showing almost complete destruction with scalloped lesions. C. and D: The twelfth thoracic vertebra from the left lateral aspect in C. and the inferior aspect in D (spinous process at top of image). The inferior view shows the complete destruction of the vertebral body, with sclerotic remodeling of the inferior aspect of the surviving superior endplate, a lytic lesion and marginal osteophyte. The lateral view shows the marginal osteophyte and the surviving fragments of the posterior elements, E: The fused posterior elements of T3-5 with periosteal porosity and possible lytic lesions, although the holes visible are in part postmortem damage

sions in common, the differential diagnosis for them both can be considered jointly, with the exception that the malformation of the joints in the younger man, B107, implies a chronic condition that was active during the development of the affected joints. A detailed differential diagnosis is discussed in Tayles and Buckley (2004). To summarise, this excludes non-specific osteomyelitis and suggests that rheumatoid arthritis and psoriatic arthritis cannot be completely discounted, particularly in the case of B42, but are unlikely on epidemiological grounds. On

the basis of the skeletal pathology in both cases, leprosy is the most compelling diagnosis. The recent isolation of DNA from the infecting organism, *Mycobacterium leprae*, from a hand phalanx from B107 (Ward pers. comm.) has strongly supported the diagnosis.

Leprosy is a complex bacterial infection with the effect on an individual being dependent on their immune response (Meyers 2000). Skeletal lesions can reflect secondary reactions to neural infection or direct reactions to the bacilli (Aufderheide and Rodriguez-Martin 1998). In infection of the peripheral nervous system, denervation and subsequent disuse results in resorption with concentric atrophy of distal hand phalanges, metatarsals, and foot phalanges (Andersen *et al.* 1992) and changes to the joints (Resnick 1995:2488). These skeletal changes can be complicated by osteomyelitis from infections following trauma to the desensitised areas. Joints can be involved from infection secondarily to neural infection, when the changes can simulate those seen in psoriatic arthritis. The bacterium prefers cooler areas of the body such as the hands and feet and osteomyelitis and osteitis can also develop directly from overlying dermal infection in the absence of trauma. The small facial bones can be directly infected from mucosal lesions, with resorption of the anterior nasal spine and the maxillary alveolar process. Haematogenous spread of the infection can result in the involvement of distal long bones, particularly the tibia, fibula and ulna, with symmetrical porous proliferative periostitis.

In both B107 and B42 the disease appears to have been at the so-called 'tuberculoid' end of the spectrum of manifestations. This involves peripheral nerve infection in the hands and feet but no involvement of the nasal mucosa and hence no classical '*facies leprosa*' (Andersen and Manchester 1992). The ulnar nerve is commonly affected, with consequent denervation of the medial side of the hand, causing development of a characteristic 'claw hand' (Enna *et al.* 1971) suggested by the position of the hand of B107 and the deformity of the hand of B42. In the feet, the concentric atrophy of a metatarsal and the involvement of the foot phalanges are also consistent with neuropathy of leprosy. Reports of clavicular involvement such as seen on B42 have not been located in the literature on leprosy. However, given the predilection of the mycobacterium for cooler regions of the body, and the subcutaneous location of the clavicles, the periostitis may be explicable as secondary to infection of the overlying soft tissues. Carrying of loads on a pole over the shoulder (a yoke) is common in Southeast Asia. This practice could have caused local trauma with consequent opportunity for infection by the bacterium.

Leprosy could not account for the cranial vault lesions of B42, as it does not produce lytic lesions of these bones. The cranial lesions may be indicative of traumatic injury, such as blows to the skull, with subsequent infection having resolved but leaving a permanent opening to the sinus. The most probable explanation is that in addition to leprosy and age related osteoarthritis, this individual suffered from trauma to the cranium.

Case three

The third individual is a young adult female (B36). She was buried in the same cluster in MP3 as B42. Although the bone tissue is in poor condition, elements of most bones are present, except part of the lower limbs.

There are possible lesions in the facial bones. There is a *c.* 1mm wide gap between the alveolar processes of the maxillae, with cancellous bone visible (Fig. 17:11). There are no lesions on the palate.

The principal lesions in this individual are on fragments of thoracic vertebrae (Fig. 17:12 A-B). These are described in detail in Tayles and Buckley (2004) and are in the form of lytic lesions on bodies of thoracic and upper lumbar vertebrae and ankylosis and proliferative periostitis of

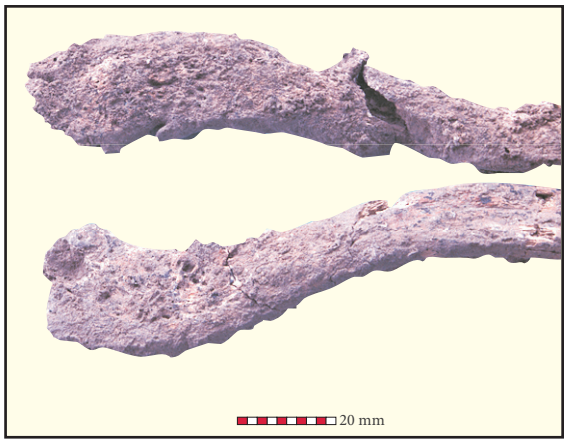


FIG. 17:13 The superior view of the clavicles of burial 94. These have a calcareous coating but show similar changes to those of burial 42, illustrated in figure 17:7

posterior elements. The lesions on the bodies vary from complete destruction (Fig. 17:12 C-D) to relatively minor. In all cases the endplates appear to be normal. Twelve thoracic vertebral arches are present but fragmented. The arches of T3-T5 are identifiable, with complete ankylosis of the laminae on the posterior aspect but not on the anterior (Fig. 17:12E). The laminae and pedicles have extensive porous periostitis and possible lytic lesions. These may reflect a mixture of lysis and post-mortem damage but poor preservation prevents definite identification. The vertebral body fragments with lytic lesions may belong to the same vertebrae. On adjacent vertebrae (T2 and T6) the laminae are also affected by porous proliferative periostitis and the zygapophyseal joints are porous with marginal osteophytes. Her spine was found with a marked bowing towards the left, which would be consistent with kyphosis but may also reflect post-depositional processes.

The differential diagnosis of the vertebral lesions in this individual includes non-specific osteomyelitis, infec-



FIG. 17:14 Two ribs of burial 26, showing the ossification of the costal cartilages described in table 17:11

tion from *M. tuberculosis*, brucellosis, and certain fungal infections. Sarcoidosis is considered, as is infection with brucellosis, actinomycosis and the fungi *Aspergillus* and *Cryptococcus* is considered but on the basis of the nature and distribution of the lesions and/or epidemiology, these are not favoured over non-specific osteomyelitis or tuberculosis. Infection with *M. tuberculosis* affects the spine in up to 60 percent of cases (Resnick 1995:2463). The lesions typically affect the first lumbar vertebra and those in either direction from this, with more than one vertebra affected and the anterior aspect of the bodies most frequently affected. The pattern of lesion distribution in the spine of B36 is consistent with tuberculosis.

The alternative diagnosis for B36 is non-specific pyogenic osteomyelitis. This is caused by ubiquitous bacteria, mainly *Staphylococcus aureus* (Aufderheide and Rodriguez-Martin 1998). The presence of bone lesions would indicate that her immune system was able to contain the infection but not to prevent it becoming chronic. It may ultimately have contributed to her early death. Given her young age at death, an infection related to pregnancy is possible.

Summary of the cases

There is no common disease included in the differential diagnosis for these three cases. The diagnosis in the two men (B107 and B42) is limited to leprosy. Unlike many infectious diseases, leprosy does not infect the spine and therefore is not included in the differential diagnosis for the third individual (B36). This strongly suggests that B36's lesions have a different aetiology. They may be diagnosed as non-specific osteomyelitis or tuberculosis. Non-specific osteomyelitis was considered in the differential diagnosis of B107 and B42 and discarded. Tuberculosis can affect extraspinal locations but both the pattern of lesions and the distribution is quite different from that of the lesions in the two men.

OTHER PATHOLOGY

Of the remaining 117 skeletons in the Noen U-Loke sample, there are six with pathological lesions other than minor degenerative joint conditions such as slight marginal osteophytes or minor pitting of the subchondral articular surface. Only one of the six individuals has a possible systemic infectious aetiology. In this individual, an older adult male burial 94, lesions of the lateral anterior-superior surface of the clavicles (Fig. 17:13) are similar to those on the clavicles of B42. They have the same porous appearance with lytic lesions up to 5mm in diameter. The bone preservation is very poor and the skeleton is represented only by fragmentary and incomplete axial and right appendicular bones to the knee joint so a detailed diagnosis, in the



FIG. 17:15 Burial 27 A: The articular surface at the head of the left second metatarsal, showing the lesion and osteophyte described in table 17:11, B: the metatarsal and proximal phalanx in the position in which they appear to have been articulated during life

TABLE 17:11 *Individuals with lesions indicating trauma or non-systemic disease other than degenerative joint disease*

Burial	Age and sex	Completeness and preservation	Pathological lesions	Diagnosis
26	Young adult male	Complete, very good condition except skull	Costal cartilages calcified on L (6/12 ribs), R (8/12 ribs). Costo-vertebral articular surfaces porous with marginal osteophytes L 3/12 ribs R 4/12 ribs. R sterno-clavicular joint, large lytic lesions on both surfaces. (Fig 17:14)	Unknown. Differential diagnosis includes hyperthyroidism; Addisons disease, congenital adrenal hyperplasia (Resnick 1995)
27	Mid age Male	Complete, excellent condition	L second metatarsal head, discrete lytic lesion middle of the articular surface; 8mm diameter, covers ~25 percent of the joint surface. There is a severe osteophyte on the dorsal aspect of the head (Fig. 17:15A). The articulating surface on the proximal end of the proximal phalanx has an extensive, sharp osteophyte also on the dorsal aspect, suggestive of hyperextension of the joint. The adjacent medial margin of the first distal phalanx has a spicule of bone extending proximally (Fig. 17:15B). The lumbar vertebrae have a suite of changes that appear to be related and congenital. These include the presence of a sixth lumbar vertebra, possibly with a form of spondylolysis with the failure of ossification of the inferior right zygapophyseal joint process to the pedicle, and the complete fusion of L2-L3. The L3 body is malformed with an anterior height approximately half that of a normal vertebra (Fig. 17:16).	Polyarticular porosity and marginal osteophytes on vertebral column and appendicular skeleton suggests widespread but minor joint degeneration of unknown aetiology.
78	Mid age adult ? sex	Secondary burial; mixed bone preservation. Both tibial shafts present	L tibia shaft ant.-med discrete lesion 30cm length. Remodelled periostitis with porosity and thickened cortex	Unilaterality, location, and nature suggests a bony response to an overlying soft tissue lesion, probably traumatic
87	Adult ? sex	Fibulae and feet, poorly preserved	R foot, first proximal phalanx, discrete lesion, dorsal aspect adjacent to the proximal articular surface. Porous, area 3mm diameter, raised 2mm	Poor condition precludes diagnosis: most probably traumatic
108	Old adult Female	Complete, very good condition	Vertebra T12 body wedge shaped with fractures on superior endplate, no active lesions, other vertebrae normal (Fig. 17:17). Both feet subtalar joint, navicular, intermediate and lateral cuneiform, cuboid, base of 4th metatarsal, severe porosity, joint surface deformity, marginal osteophytes (Fig. 17:18). Left third metatarsal has a very narrow shaft (Fig. 17:19).	Vertebra: traumatic fracture Feet: Unknown diagnosis.

L: left. R: right. T: thoracic



FIG. 17:16 The left aspect articulated lumbar vertebrae 2-6 of burial 27, showing the fusion of L2-L3, and wedge-shape of L3

absence of pathognomonic lesions, is not deemed to be valid. Nevertheless the unusual location and similarity of the lesions hints at the same diagnosis as B42.

The lesions in the other five individuals do not appear to be caused by systemic disease and are briefly described in table 17:11. These include the remaining three of the four complete and well-preserved adult skeletons, hinting that the sample as a whole may have held clues to a much more extensive array of pathologies, had the bones been in better condition and the skeletons more complete. The individuals are listed with a differential diagnosis where possible.

UNUSUAL CASES

There were several individuals with unusual conditions of the bones that warrant detailed consideration. Two of these have been published in detail elsewhere (Tayles 2001, 2003) and will be summarized here. These are B97, an infant buried in an unusual position, and B99, a woman with a cut through her skull.

Burial 97

This burial was placed in an unusual position, as illustrated in figure 17:20. The upper limbs were fully flexed at the elbows and the left lower limb was externally rotated with the knee slightly flexed. The left foot appeared to have been in full plantar flexion. The cervical spine was

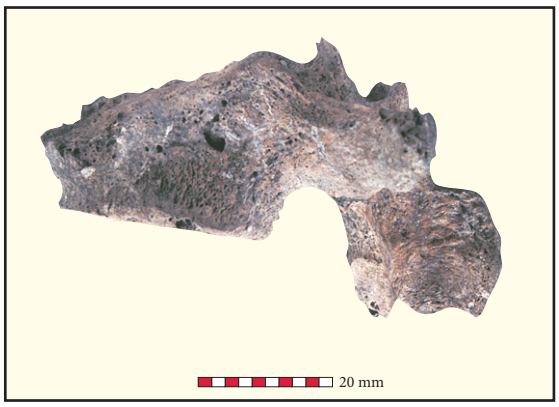


FIG. 17:17 Vertebra T12 (left aspect) of burial 108, showing the wedge-shape of the body described in table 17:11

flexed so that the head was oriented with the face looking down the body. The thoracic spine appeared to have both kyphosis and scoliosis, and the ribs to be asymmetrical, with those on the right having an abnormal curvature. Unfortunately the bone tissue was poorly preserved with very little mineral remaining so that there was little chance of identifying the detail of the vertebral morphology or any response of other joints to what may have been the continual adoption of this unusual posture during life. An exception is the left proximal femur which has a larger



FIG. 17:18 The right tarsals of burial 108, showing the changes in the subtalar and other joints described in table 17:11



FIG. 17:19 The left metatarsals of burial 108, showing the narrow shaft of the 3rd metatarsal described in table 17:11. The head is damaged postmortem, and there is postmortem damage exposing the cancellous bone on the heads and bases of the other metatarsals



FIG. 17:20 Burial 97 *in situ* showing the position described in the text. The child has ivory bangles on its wrists. The cranial vault has postmortem damage

neck-shaft angle than the right (Fig. 17:21).There was no discernible evidence on the skeleton of pathology.

Age at death of this infant was estimated at 1.5-2.5 years on the basis of dental formation. Diaphyseal lengths did not indicate retarded growth.

A suggested explanation for the burial posture and morphological features is that the child suffered from cerebral palsy. Children with quadriplegia from this condition commonly adopt an abnormal posture very similar to that of B97 because of muscle hypertonicity. It is acknowledged that bones in general, and particularly those of young children, can be deformed by post-depositional processes but it seems very unlikely that all the features observed in this



FIG. 17:21 Posterior view of the femora of burial 97, showing the differences in the neck-shaft angle

child would have resulted from these processes.

Cerebral palsy includes a group of conditions resulting from damage to the brain early in life. There are various manifestations of the condition, all of which result in some motor and balance disabilities, and can be associated with mental disability, respiratory problems, and epilepsy. There are complex and individually variable effects depending on the nature of the injury and the treatment of the child. The gross disability greatly increases morbidity and mortality rates in these children but life expectancy is difficult to define because of the variability in outcome. The aetiology ranges from prenatal malformations, prematurity, perinatal trauma resulting in anoxia



FIG. 17:22 The skull of burial 99. A: View from superior aspect, showing the straightness of the cut and the antero-posterior compression of the skull, B: Left lateral view, C: Close-up of the cut

(oxygen deprivation), or postnatal head trauma or infection such as meningitis and encephalitis (Menkes 1990). If the child had indeed had cerebral palsy, the care taken with the burial shows that the family and /or the community valued the child despite the disability.

Burial 99

This burial is distinguished by both the burial position and the condition of the skull. The burial was of an adult female, laid supine, in a 'rice bed' burial in the unusual position of having her head inside a large ceramic pot and her legs crossed at the ankles (Fig. 12:3). The condition of the skull was not obvious at the time of excavation but became clear during the cleaning of the skeleton. The skull is virtually complete, except for parts of the facial bones but it had been cleaved in the coronal (frontal) plane from side to side, so the anterior portion of the skull was separated from the posterior portion. Details are provided in Tayles (2003).

The damage to the skull is shown in figure 17:22. The cleavage appears to have been through the complete skull, including the mandible, and to have damaged the middle third of the skull. There is a very definite cut edge on the anterior margin of the damaged area. The surface of the cut is unfortunately coated with a calcareous deposit and the facilities and expertise available to us in Thailand did not allow the removal of this material, preventing a microscopic examination of the cut surface. At the vertex of the skull, there is a lunate-shaped fragment broken from the anterior margin of the defect. This has been replaced with a fragment of bone which is cemented in place and heavily coated but appears to be the frontal process from



FIG. 17:23 The skull of burial 99, showing the open mouth, indicating that the mandible was articulated at the time of burial



FIG. 17:24 The skull of burial 110. A: Anterior view showing the distortion of the skull, the two holes in the frontal and elsewhere in the facial bones, as described in the text, B: lateral view, showing the fragmentation of the posterior half of the skull

the right zygomatic bone.

The fact that the 'cut' through the cranium had also affected the mandible indicates that the damage must have occurred when the soft tissues were still in place rather than some time after burial, as the mandible had fallen forward as the tissues decomposed so the mouth appears to be wide open (Fig. 17:23). It seems very unlikely that the mandible would have been rearticulated perfectly if the cut was made some time after decomposition of the soft tissues. Such a massive injury would clearly have been fatal as the damage to the brain would have resulted in an immediate fatal shock, apart from the blood loss which would have occurred. However, it is not possible to determine whether the injury was the cause of death or occurred shortly after death. It can only be described as a perimortem injury.

It appears that this woman had her skull cleaved by a very sharp, heavy instrument, wielded from her left, with at least two blows across her vault and one or more to the left side of her head, including through the jaw. The remaining bone on the right side of her skull then appears to have been crushed or hit with a blunt instrument with such force that it has driven the bone fragments into her head. She may also have received a blow with a blunt instrument across her midface. The man interred in B27 was associated with a large and heavy iron spear, just the type of weapon that could have inflicted such damage (Fig. 8:9). The question is why this woman should have been subjected to such extreme violence and whether it caused her death or occurred after death. Unfortunately there is no definitive answer to the second part of the question, although the suggestion that she was upright when the first blow was suffered hints that it occurred at the time of death. That B99 was carefully buried with jewellery and other grave goods implies that she was held in high esteem. There is nothing to suggest that this woman was an outcast or of lower class than other people in the cemetery so there is no hint that the treatment may have been punitive. It is even possible that the reason for the placement of her head in the pot was a respectful masking of appalling injuries. However, if the blow in fact killed her, to suggest a reason for this would be pure speculation.

Burial 61

The only other burial where there is evidence of possible interpersonal violence is this young man from MP5. He was buried prone, and his skeleton was virtually complete but the bone variably preserved. An iron projectile was lodged to the left of the bodies of the twelfth thoracic and first lumbar vertebrae, medial to the transverse processes (Fig. 16:6). The angle and orientation of the projectile suggests that it entered the body from in front and was aimed upwards. The wound would have been fatal as the projectile would have penetrated vital organs and possibly major blood vessels, leading to massive internal haemorrhaging, blood loss and shock.

TAPHONOMY OR ANTHROPOGENIC?

Several burials had holes penetrating and/or depressions

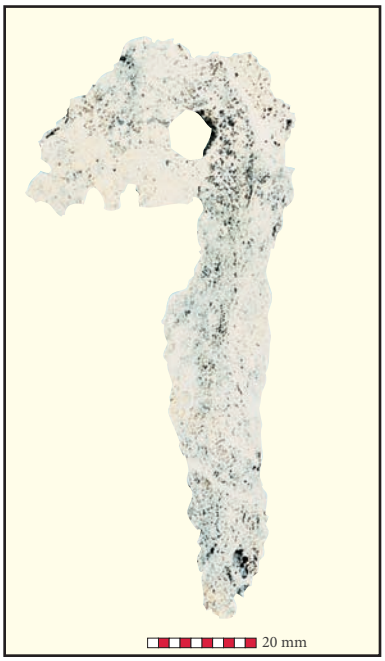


FIG. 17:25 The surviving fragment of the right scapula of burial 110, showing the circular hole through the blade at the base

aligned along the subperiosteal cortical bone. Some are completely circular, others irregular in shape. Although it is tempting to infer that those in cranial bones represent trephinations, the unusual locations of others, such as the blade of the scapula and the iliac crest are most unlikely to have been anthropogenic. These have remained enigmatic but on balance appear most likely to be postmortem damage inflicted by boring insects. A selection are described and illustrated below.

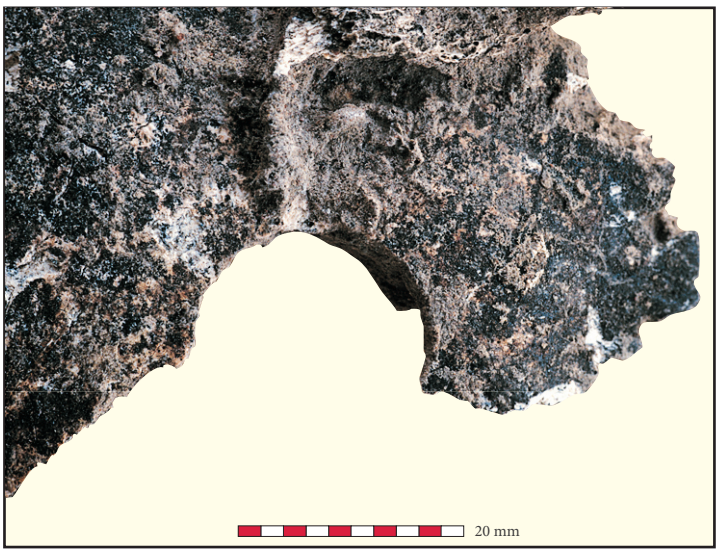


FIG. 17:26 The vault fragment from burial 15, showing the large circular hole and the fracture radiating from it towards to the top of the picture

Burial 110

This older woman has numerous holes of various shapes and sizes in the cranium and mandible, second cervical vertebra, scapula, pelvis and radius. At least two on the pelvis appear to be remodeled. The skull is significantly distorted in shape (Fig. 17:24A). This is a postmortem event, probably developed shortly after burial when the bone was still relatively organic and therefore plastic so the weight of the grave infill has been able to distort its shape before the cranial cavity filled with soil. The posterior half of the skull is very badly preserved with the bone fragmented (Fig. 17:24B). Two holes in the frontal bone vary in size and shape. One is almost circular (12.5mm diameter) and the second is large (37.5mm x 15-18mm, maximum width and height) and irregular in shape. There are a number of other smaller holes in the vicinity. All penetrate through the vault. A calcareous coating on the bone surfaces prevents close examination of the edges of the holes for evidence of cutting or drilling. The underlying bone is poorly preserved and partly demineralised so there is no means of removing the coating without damage. There are also holes in the orbits, the palate and the maxilla. The hole in the scapula is circular, approx. 7mm in diameter, through the blade just inferior to the base of the spine (Fig. 17:25).

Burial 5

This is a young adult male. There are holes/depressions on his skull, second cervical vertebra, and iliac crest. The area in question on the skull is on a small fragment of parietal bone. The outer table and part of the diploe is missing in an irregularly shaped area on the edge of the fragment. No fragments that might have been adjacent to this one were located. The area is ~ 9mm in the longest dimension, with an irregular floor and rounded edges, although as the whole fragment has been abraded on the edges this may not reflect the original form of the affected area. The ~ 10mm diameter hole on the vertebra penetrates the inferior aspect, removing a substantial portion of the body.

Burial 15

This mid adult female again has a hole in a fragment of cranial vault (Fig. 17.26). This hole penetrates through the full thickness of the vault, is ~ 20mm in diameter and appears to have sharp, well-defined edges and to be cut straight through the tables. Again a coating of calcareous material prevents a microscopic examination of the surfaces. There is a crack extending through the inner table radiating from the hole but as the bone is a fragment, this may be unrelated to the formation of the hole.

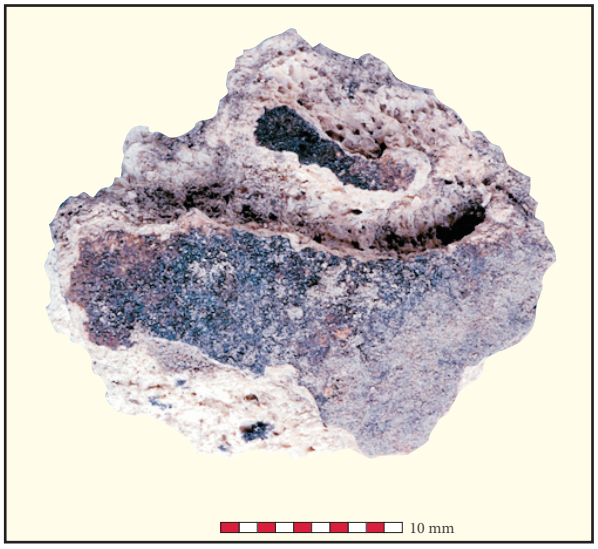


FIG. 17:27 The vault fragment from burial 104, showing the meandering track through the outer table and diploe, described in the text

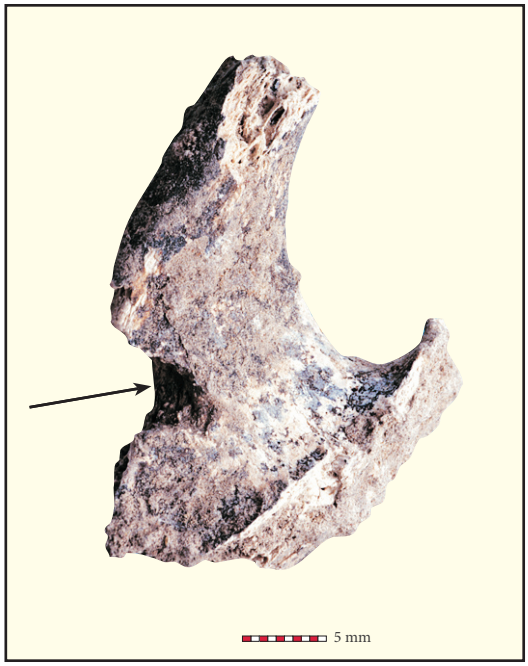


FIG. 17:28 The base of the acromion process from the scapula of burial 104, with a hole cutting across the bone (arrow)

Burial 104

This is a young adult female. Yet again, there is a skull vault fragment with evidence of activity. This example (Fig. 17:27) is very reminiscent of an insect burrow ~3.5mm in width. It has removed the outer table and runs on a winding course through the diploe but stops before the edge of the bone fragment. Again a search through other fragments of the skull failed to locate adjacent pieces. There is also a hole in the base of the acromion process of the scapula (Fig. 17:28) ~ 5mm in width.



FIG. 17:29 Fragment of right femoral shaft from burial 32, with a diagonal cut described in the text

Is this anthropogenic or taphonomic?

The issue here is whether these holes (using this as a descriptor for all the areas described above) are evidence of some ante- or postmortem 'treatment' of the body or whether they are the work of one or more species of burrowing insects or other small creatures. The round holes in skulls look compellingly like the effects of trephination, the surgical treatment of an individual during life. However the round hole in the scapula of B110 argues against this. The thickness of soft tissue overlying the area of the scapula is such that it is unlikely that this would be an area of choice for surgical treatment. Given that the person also had one of the round holes in the skull, the possibility that all, cranial and post cranial, were caused by a particularly precise drilling by some sort of tropical insect is the most parsimonious explanation. B110 also had numerous other, far less symmetrical, holes in the skull and elsewhere on the skeleton, further arguing that all were the result of taphonomic processes. In other individuals there are some cranial holes which also look as if they may have been surgical, such as B15, and others

TABLE 17:12 *Dental census*

Teeth	Deciduous	Children: permanent	Males	Females	? sex	Total adults
Present complete	64	44	439	394	160	833
Present broken	4	0	52	37	17	89
Lost am pathological	0	0	16	46	7	62
Missing/ lost am ablation/ agenesis	0	0	36	38	10	74
Lost postmortem	0	0	21	42	14	63
Erupting	22	10	5	0	0	5
Total	90	54	569	557	208	1126
Individuals						
Total	12	6	27	21	19	67
With teeth/ tooth positions	10	4	23	20	11	54
% with teeth/tooth positions	83.3	66.7	85.2	95.2	57.9	80.6
Mean teeth/ tooth positions per individual	9.0	13.5	24.7	27.9	18.9	20.9
Mean teeth per individual	5.3	13.5	19.1	19.7	14.5	15.4

am = antemortem

which are clearly animal tracks, such as B104. On postcranial bones, the holes are largely in areas of bone that are subcutaneous, such as the acromion process and the iliac crest. These may have been the work of a variety of small fauna feeding on the recently interred cadaver. There are others that are not subcutaneous, such as in the vertebra of B5, which could only have been created very much later, after the complete decomposition of the soft tissue. It is entirely possible that similar other postcranial 'holes' were not identified as they would not have been as obvious as

in the cranial vault.

Further work is necessary here, and particularly the examination of the sharp margins of holes such as that on the skull fragment of B15. In the meantime, the holes remain enigmatic.

One other individual with evidence of postmortem damage to a bone is B32, a mid age adult male. There is a ~1cm wide cut through the proximal half of the right femur at an angle (Fig 17:29). The cut is relatively straight on one edge but rough on the other. It extends approximately halfway through the shaft. As this was a disturbed and scattered burial the chances are very high that this cut occurred during whatever activity was responsible for the disturbance. There is no reason to believe it represents a fatal perimortem event.

DENTAL REMAINS: CENSUS, HEALTH AND DISEASE

The teeth were recorded in adults as being present and whole, present and broken, lost postmortem, lost antemortem (pathological), or missing antemortem (ablation or agenesis). In subadults there were two additional categories: unerupted or erupting.

Postmortem loss was identified by the presence of an unremodelled socket. Antemortem loss as a result of disease was identified where there was clear evidence of the tooth having been present, in the form of a space between surviving teeth and interproximal wear facets on surviving teeth. The differentiation of teeth 'missing' antemortem due to either ablation or agenesis from those lost antemortem from dental disease was based on the pattern of tooth loss. As detailed below, there was a significant number of individuals in this sample with missing lateral incisors but otherwise extant teeth. This is an unusual pattern of loss through dental disease and these teeth were therefore categorized separately from other teeth lost antemortem. The question of whether these teeth were lost through having been deliberately removed (ablated) or whether they had not formed (agenesis) is discussed below.

The dental census for the adult sample is summarized in table 17:12. The proportion of adults with at least one tooth present was 80.6 percent (54/67) . There were no individuals with only 'tooth positions' (i.e. with alveolar bone where teeth had been lost or missing ante- or postmortem). As is to be expected, a smaller proportion of individuals without sex estimates had teeth and the proportion per individual was lower than in those with sex

TABLE 17:13 *Summary of dental wear in adults*

				Anterior		Posterior	
	n indiv	n teeth	Mean wear grade	n teeth	Mean wear	n teeth	Mean wear
Females							
Young	7	152	3.14	48	3.56	104	2.94
Mid	6	113	4.52	38	4.71	75	4.43
Old	7	127	5.40	47	5.87	80	5.13
Mid/Old ("older")	13	240	4.99				
Males							
Young	15	304	3.06	92	3.49	216	2.87
Mid	3	46	3.98	18	4.22	28	3.82
Old	5	82	5.73	27	5.85	55	5.67
Mid/Old ("older")	8	128	5.10				

TABLE 17:14 *Summary of the proportion of teeth or tooth positions affected by dental conditions in adults*

	By individual			By tooth		
	All adults a/n (%)	Females a/n (%)	Males a/n (%)	All adults a/n	Females a/n (%)	Males a/n (%)
Caries	23/54	10/20	10/23	46/956	22/382	19/422
All adults	42.3	50.0	43.5	4.8	5.8	4.5
Young adults	13/28	4/7	7/15	20/581	5/153	12/308
	46.4	57.1	46.7	3.4	3.3	3.9
Older adults	10/25	6/13	3/8	26/373	17/229	7/114
	40.0	46.1	37.5	7.0	7.4	6.1
Alveolar lytic lesions	14/37	7/16	5/16	34/571	15/260	16/262
All adults	37.8	43.8	31.3	6.0	5.8	6.1
Young adults	5/19	2/5	2/9	5/307	2/106	2/153
	26.3	40.0	22.2	1.6	1.9	1.3
Older adults	9/19	5/11	3/7	28/264	13/154	14/109
	47.3	45.5	42.9	10.6	8.4	12.8
Antemortem tooth loss [a]	22/54	11/20	9/23	69/1334	46/557	16/569
All adults	40.7	55.0	39.1	5.2	8.3	2.8
Young adults	5/28	1/7	3/15	7/696	3/197	3/363
	17.9	14.3	20.0	1.0	1.5	0.8
Older adults	17/25	10/13	6/8	62/636	43/360	13/206
	68.0	76.9	75.0	9.7	11.9	6.3
Advanced wear				152/400	92/240	53/128
Older adults				38.0	38.3	41.4

a= affected, n= total number of teeth observed; [a] Excluding 'missing' lateral incisors as discussed in the section on tooth ablation

estimates. The proportion of teeth accounted for in males is lower than in females. The dentition was reasonably well represented in infants but less so in children, with 83.3 percent (10/12) with deciduous teeth and 66.7 percent (4/6) with permanen2t teeth (Table 17:12).

TOOTH WEAR

Tooth wear was recorded for all teeth, using the scale of Molnar (1971). The results for adults is summarized in table 17:13. Wear does not differ significantly between males and females. As tooth wear was used in the estimation of age, the progression with age has no interpretive value. The pattern of severity of wear around the dental arcade is similar in both sexes, with wear on anterior teeth greater than wear on posterior teeth. When age is considered, the differential between anterior and posterior wear is greatest in young adults and reduces with age in both sexes. This may indicate that all had a similar diet, although the possibility of males and females having different diets with equally abrasive effects cannot be ruled out.

DENTAL PATHOLOGY

Caries, evidence of infection in the form of lytic lesions on the alveolar bone, and antemortem tooth loss are reported here. These are presented both with the individual as the unit and with teeth as the unit, recognizing that both methods of quantification have advantages and disadvantages. The individual count method would be optimal in a perfect world where all dentitions were complete. This is rarely the case in any prehistoric sample and certainly not in the case of the Noen U-Loke sample. The tooth count method ignores the possibility that particular pathologies may be concentrated in a few individuals but has the pragmatic advantage of providing data that are usually large enough to support statistical analysis.

CARIES

All teeth were examined macroscopically for caries, aided by microscopy where necessary. Postmortem calcareous deposits frequently obscured the interproximal faces of teeth so it is possible that the rates reported here are underestimated.

Results are summarized in table 17:14. In adults, 42.3 percent had at least one carious lesion and 4.8 percent of teeth were carious. Female teeth are slightly but not significantly more carious than male teeth, regardless of whether individuals or teeth are the unit of measurement. In both sexes, the proportion of individuals with at least one carious tooth reduces with age, but not significantly. This is not the pattern expected as caries is usually an age related phenomenon, although when using teeth as the unit of measurement, the proportion of carious teeth almost doubles with age. This increase is significant in the total sample (χ^2, p = 0.0376) but not in separate male and female samples, although in the females the increase is greater and close to significant (χ^2 p = 0.0876). The rates do not differ significantly when comparing young males with young females or older males with older females.

INFECTION

Infection of the teeth or supporting tissues was identified by the presence of lytic lesions in the bone adjacent to the alveolus. The majority of these were periapical and are therefore most likely indicative of infection of the tooth from caries or exposure of the pulp cavity through attrition/wear or traumatic damage to the tooth rather than infection of the periodontal tissues. The number of individuals where these lesions were observable is lower than for other dental pathologies because of the relatively poor preservation of the bone compared with the teeth. This prevented confident identification of the state of the alveolar bone in many cases.

The proportion of tooth positions with lytic lesions in the alveolar bone indicative of tooth infection was 6.0 percent (Table 17:14). Just over 40 percent of individuals had

TABLE 17:15 *Ban Lum Khao: summary of the proportion of teeth or tooth positions affected by dental conditions in adults (Domett 2004)*

	All adults	Females	Males
	a/n (%)	a/n (%)	a/n (%)
Caries	39/874	32/477	7/397
All adults	4.4	6.7	1.8
Young adults	29/499	26/339	3/160
	5.8	7.7	1.9
Older adults	10/377	6/138	4/237
	2.7	4.3	1.7
Alveolar lytic lesions	15/1138	6/607	9/531
All adults	1.3	1.0	1.7
Young adults	5/593	5/407	0/186
	0.8	1.2	0.0
Older adults	10/545	1/200	9/345
	1.8	0.5	2.6
Antemortem tooth loss	59/1138	31/607	28/531
All adults	5.2	5.1	5.3
Young adults	7/593	7/407	0/186
	1.2	1.7	0.0
Older adults	52/545	24/200	28/345
	9.5	12.0	8.1
Advanced wear	102/375	29/138	73/239
Older adults	27.1	21.0	30.5
Mean wear grades			
Young	2.84	2.84	2.84
Old	4.84	4.68	4.93

a= affected, n= total number of teeth observed

TABLE 17:16 *Comparison of dental conditions between Noen U-Loke and Ban Lum Khao by age and sex*

	Total	Females	Males
Caries			
All adults	=	=	NUL>BLK
Young adults	(BLK>NUL)	(BLK>NUL)	=
Older adults	NUL>BLK	=	NUL>BLK
Alveolar lytic lesions			
All adults	NUL>BLK	NUL>BLK	NUL>BLK
Young adults	=	=	=
Older adults	NUL>BLK	NUL>BLK	NUL>BLK
Antemortem tooth loss			
All adults	=	=	=
Young adults	=	=	=
Older adults	=	=	=
Advanced wear			
Older adults	NUL>BLK	NUL>BLK	NUL>BLK

( ) = close to significant difference

at least one lesion. A higher but non-significant proportion of females than males had evidence of infection but the males with infections had more lesions as evidenced by the similar proportions of teeth affected. Comparing the proportions by age groups shows a significant increase in lesions affecting teeth in older individuals in total and both sexes (all χ^2, $p<0.0001$, females χ^2, $p = 0.026$, males χ^2, $p<0.0001$). The proportions of individuals with lesions increases with age, although this is not statistically significant, probably as a result of the small sample sizes.

ANTEMORTEM TOOTH LOSS

Loss of a tooth during life as a consequence of pathology was identified where the tooth was missing and the alveolus had remodeled. A distinctive pattern of missing lateral incisors was found in multiple individuals. These teeth are excluded as it is unlikely they were lost through pathology. The possibilities that they were either deliberately removed (ablated) or failed to develop (agenesis) are discussed later in the chapter.

Just over 40 percent of individuals had lost at least one tooth antemortem and 5.2 percent of teeth were lost. More females than males had lost at least one tooth (not significant) and females had lost significantly more teeth than males (χ^2, $p <0.0001$). Antemortem tooth loss increased significantly with age in both sexes, regardless of whether it was measured per individual (all adults χ^2, $p=0.0002$, females χ^2, FET $p=0.0166$, males χ^2, FET $p = 0.0228$) or per tooth (all adults χ^2, $p<0.0001$, females χ^2, $p<0.0001$, males χ^2, $p<0.0001$). Sex differences are not significant in young adults. In older adults the proportion of individuals with at least one tooth lost is the same in both sexes but females have lost significantly more teeth than older males ($\chi^2 p=0.0029$).

PERIODONTAL DISEASE

The health of the tissues supporting the teeth is an important contributor to the picture of oral health. In addition to possible contributions to the lytic lesions from periodontal infection or inflammation, the alveolar crest can become porotic, flatten from its normally rounded contour, and resorb. Calculus (mineralized plaque) can form on the teeth, irritating and inflaming the periodontal tissues. Unfortunately we were unable to usefully define the condition of the alveolar crest as the bone was poorly preserved. There are difficulties with identifying resorption of the crest as the only measure is the relationship between the cemento-enamel junction (CEJ) of the tooth and the crest. As teeth can continue to erupt to maintain occlusion where there is significant attrition of the occlusal surface, the distance between the crest and the CEJ can reflect either this or resorption of the crest (or both). Without the indication of the condition of the crest it is not possible to differentiate the cause of a larger than normal distance between the crest and the CEJ and hence this is not presented here.

Calculus can form on the teeth, irritating and inflaming the periodontal tissues. Initially the intent was to record the presence of calculus but it was realized that although it was clearly present in some cases, in many others the postmortem deposition of the calcareous deposit that obscured the alveolar crest would also have obscured any calculus. It was therefore deemed inappropriate to attempt to quantify calculus deposits. It was clear, however, that there were no cases that would be graded as 'large' calculus deposits in the Brothwell (1981) scale. Calculus that was present was slight to moderate and the postmortem calcareous deposits were such that any calculus they were obscuring could only have been 'moderate' at most.

The pattern of dental health that appears here is one

of an age-related increase in pathologies and loss of teeth during life, which is the trend expected. Sex differences are non significant, apart from the higher proportion of teeth lost during life in older females than males.

ADVANCED WEAR

This is wear of the occlusal surfaces to the point where there is possible exposure of the pulp cavity and therefore access for infection to the tooth and periodontal tissues. Wear graded as 6-8 on the Molnar scale is judged as advanced wear.

All teeth with these grades of wear were in older individuals (given that dental wear was used as one of the bases for age estimation, this is to be expected) and affected very similar proportions of teeth in both sexes. This was recorded for comparison with Ban Lum Khao.

Regional comparison

The comparison of adult dental pathology with that at Ban Lum Khao is based on the data from Domett (2004) as summarized in table 17:15. The comparison is based on the tooth count method, rather than compounding the problems introduced to the individual count method by the incomplete dentitions.

Looking at overall data, rates of caries and antemortem tooth loss are strikingly similar at the two sites. In contrast, the rates of infection as indicated by alveolar lytic lesions are significantly higher at Noen U-Loke (χ^2 p=<0.01), as are rates of advanced wear (χ^2 p =0.0014). Mean wear grades are similar for both males and females to those at Noen U-Loke, although the differential between the sexes is greater in older individuals at Ban Lum Khao than at Noen U-Loke.

Comparing the evidence from the two sites by age and sex (Table 17:16) shows more detail of the differences. Caries rates are significantly higher in males at Noen U-Loke, because of higher caries in older males. Female caries rates do not differ significantly between the sites, although in reverse to the general trend of poorer dental health at Noen U-Loke, the young women at Ban Lum Khao have caries rates close to significantly higher than those in young women at Noen U-Loke (and actually higher rates than older females at Ban Lum Khao, although not significantly so). The significantly higher rates of alveolar lytic lesions and advanced wear at Noen U-Loke than at Ban Lum Khao are clearly a reflection of the frequencies in older adults. Antemortem tooth loss rates do not differ at all between the sites regardless of age and sex.

To summarise the comparison of dental conditions between the two sites, the rates of all conditions were similar at both sites in young people, with the exception of more caries in young males at Noen U-Loke. There were significant differences in older people with those at Noen U-Loke having more dental disease, although this did not appear to result in a greater loss of teeth during life. There is a possibility that the antemortem tooth loss at Noen U-Loke is underestimated, with a proportion of the missing anterior teeth, deemed to be either deliberately ablated or agenetic (see next section) being actually lost through disease.

There are several possible explanations for the differences between the sites. One is that the diet at Noen U-Loke was more abrasive and resulted in enough wear to allow tooth infection but not tooth loss. A second is that 'old' people at Noen U-Loke were actually older than those at Ban Lum Khao, allowing more opportunity for age-related dental disease to develop.

Sex differences, as detailed above, were not significant at Noen U-Loke, with the exception of higher rates of antemortem tooth loss in older females than in older males. At Ban Lum Khao, young women had significantly more caries than young men (χ^2 p=0.01) but rates had become similar in both sexes by old age. Older men had significantly more advanced wear than older women (χ^2, p=0.038). Otherwise there were no significant differences. The sex differences in dental health have been discussed in Domett (2004:145) as indicating possible differences in diet. In comparison the evidence from Noen U-Loke is more suggestive of a lack of sex differences in diet.

TOOTH ABLATION

Among the burials were numerous individuals with missing lateral incisors (e.g. Fig. 17:30 burial 4). This frequency and pattern of missing teeth raises the question of whether they were congenitally missing or lost during life, either through pathology or deliberate removal. Familial and twin studies suggest that there is a significant genetic component to hypodontia, the failure of a tooth to develop (Townsend *et al.* 1995). If the missing teeth are indeed a reflection of hypodontia, the high prevalence implies homogeneity in the population represented by the burial sample. This has significance for the interpretation of the site, as it would indicate endogamy and probably isolation of the community.

Details of the patterns and frequency are available in Nelsen *et al.* (2001) and are summarised here. Of the sample of 38 adults with preservation of the teeth and alveolar bone complete enough to allow assessment for missing lateral incisors in either maxilla or mandible, 79 percent (n=30) had at least one lateral incisor missing. Both maxillary and mandibular incisors were missing, bilaterally in both jaws in 30 percent of individuals (6/20). Overall, both jaws were almost equally affected, and almost half of the individuals have bilateral absence in one or both jaws. In the subadults, only two children of five with permanent teeth could be assessed and both had all incisors present.

The proportion of missing lateral incisors is unusually high compared with clinical reports of the preva-



FIG. 17:30 Upper: the anterior maxillary teeth of burial 4. The left lateral incisor is missing, with a space remaining between the central incisor and the canine. Lower: Anterior mandibular teeth, burial 4. The left lateral incisor is missing, with minimal space for it to have been present

lence of congenital absence of these teeth. In Asians, the prevalence is higher and the mandibular incisors more frequently affected than in the Europeans (all data are based on permanent dentition and exclude third molars). Nevertheless, the rates at Noen U-Loke are much higher than in any modern populations. In a small gene pool hypodontia could appear at a high level, although the prevalence is much higher at Noen U-Loke than even in samples of modern isolated populations (see Nelsen *et al.* 2001 for references).

An alternative explanation could be that the teeth were deliberately removed. Previous records of missing anterior teeth in prehistoric Thailand include a sample of skeletons excavated from the undisturbed prehistoric (4000-3500 BP) burial site of Khok Phanom Di in centralThailand. This sample included a high proportion of individuals with anterior teeth missing in distinctive, mostly symmetrical, patterns (Tayles 1996) although these were different from the patterns at Noen U-Loke.

Support for the ablation theory at Noen U-Loke is provided by a sex difference in the side involved and the presence of spaces for the missing teeth, which suggests an element of deliberate tooth removal, since there is no documentation in the literature of a correlation between sex and laterality of agenesis. The absence of all four lateral incisors in the older individuals implies a correlation with age, even though this is not supported by the complete data set, which again may reflect deliberate removal as a rite of passage with aging.



FIG. 17:31 The anterior maxillary teeth of burial 36

A third alternative is that there is a combination of agenesis and deliberate ablation involved. This could account for all the factors raised in the arguments for and against the two possibilities discussed above. No record of this has been found in the ethnographic literature but the indication of tribal or familial affinity is one of the reasons given for modification of appearance by various methods, including tooth ablation (Frazer 1910). If some members of a group have missing teeth, others may remove the same teeth in order to emulate their appearance. This is rather a complex explanation and is not favoured over the more likely explanation of a distinctive pattern of genetic agenesis or hypodontia, with the attendant implications for isolation and endogamy in the population and for the possibility of a high prevalence in such closed communities. The difference in side preference between the sexes suggests a link between the genes responsible for hypodontia and the sex genes.

A further feature noted on those individuals with missing lateral incisors was a depression of variable depth and extent on the anterior maxilla, between the roots of the central incisor and canine. Examples of this include B36, already described and illustrated in figure 17:11. There was

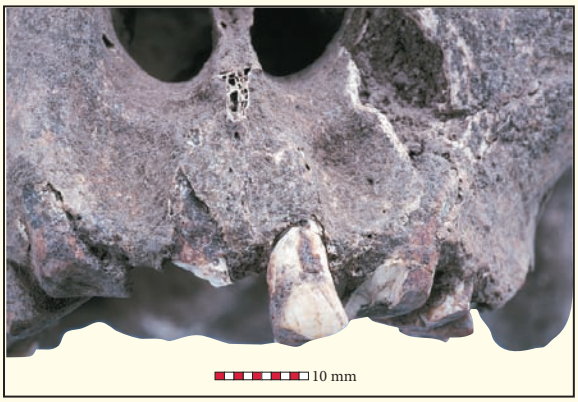


FIG. 17:32 The anterior maxilla of burial 42, with depressions at the location of the roots of the missing lateral incisors (the right central incisor and both canines were broken postmortem)



FIG. 17:33 The anterior maxilla of burial 33, with a missing right lateral incisor and a very narrow, deep cleft between the roots of the central incisor and canine. The right central incisor was broken postmortem

a small space where the incisor should have been. All other maxillary teeth were present. In the mandible all teeth were present except the left lateral incisor, with a space wide enough to have accommodated the missing tooth. B42, the older male 'leper' described above who was from the same area of the site, had very deep depressions above both missing lateral incisors. These were continuous with very rounded inferior nasal borders (Fig. 17:32).

B33, a probable male aged 25-30 years, had a deep, narrow depression running from the inferior right nasal border to the alveolar crest just superior to the site of the right lateral incisor (Fig. 17:33). All maxillary teeth were



FIG. 17:34 The anterior mandible of burial 5, with a depression below the site of the missing right lateral incisor

present except the right lateral maxillary incisor. There was a small space between the central incisor and canine where this tooth should have been. Both lateral incisors were missing in the mandible, with no space for the right side but adequate space for the left to have been present. All other mandibular teeth were present except for the right second molar which was lost antemortem through pathology. Only one individual, B5, an adult aged 20-25 years, probably a male, had a similar depression at the position of a missing mandibular incisor (Fig. 17:34).

Some individuals with all teeth present also had depressions between the roots of the maxillary teeth. An example is B107, the younger male 'leper' described above, with a deep depression extending from below the nasal margin to the alveolar crest on the left maxilla (Fig. 17:35) All anterior teeth were present and the depression is located in the area between the roots of the lateral incisor and the canine. A second example, a 20-25 year old male (B44) had deep indentations in the anterior maxilla between the roots of the incisors, associated with 'winging' of the central maxillary incisors, although post-mortem deformation of the skull may have contributed to this appearance (Fig. 17:36). The central incisors had marked shovelling, with a central pit, and the lateral incisors had '*dens invaginatus*' or '*dens in dente*'. The depressions are therefore not necessarily related to the missing teeth, despite co-existing in some individuals.

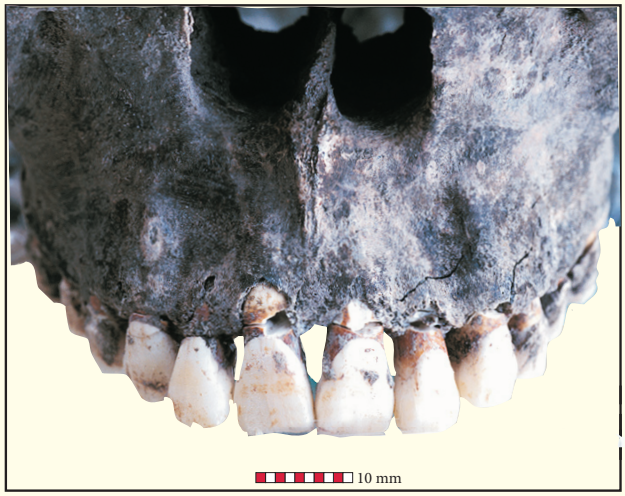


FIG. 17:35 The anterior maxilla of burial 107 with a deep depression on the left maxilla but no missing teeth

Industrial use of the anterior dentition is an unlikely

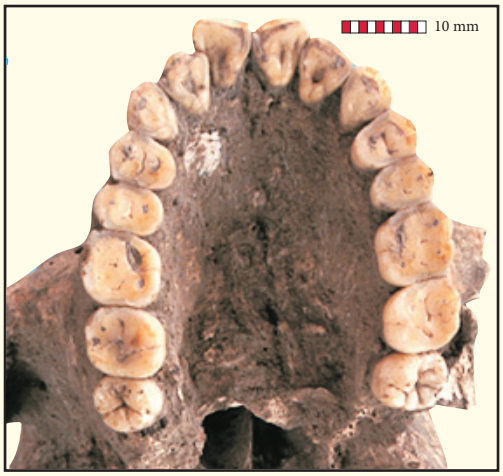


FIG. 17:36 Palatal view of maxillary dentition of burial 44, with winging of central incisors, marked shoveling and 'dens invaginatus' of lateral incisors. Fig. 17:4 shows an anterior view of the maxilla and teeth

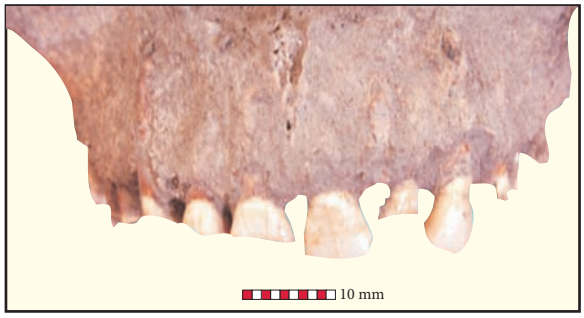


FIG. 17:37 Anterior view of maxillary dentition of burial 37, with very uneven tooth wear described in the text

contributor to the pattern of missing teeth. Only one individual, B37 (old female) has uneven tooth wear suggestive of industrial use (Fig. 17:37). In the maxilla, on the right side the wear has formed a concave pattern from the second premolar to the central incisor, with the apex at the canine; on the left side the wear is erratic, with the lateral incisor, the premolars and first molar severely worn but the central incisor and canine spared. In the mandible, the right side is well worn from the second molar to the canine and the incisors are very worn, with only a few remaining. The left incisors are missing, with space for two teeth, which may mean this was pathological loss. The left canine is heavily worn, similar to the right posterior teeth, the first premolar is missing, lost antemortem, and the remaining teeth are present and relatively less worn. The patterns of loss in the mandible may account for the irregularity of the wear on the right side of the maxilla, if there was some malocclusion. The wear pattern may have



FIG. 17:38 Anterior view of mandibular dentition of burial 27 with root abrasion discussed in the text

stimulated the degeneration of the temporo-mandibular joint on the right.

DENTAL ODDITIES

There are three individuals with unusual aspects to their dentitions. These are described and illustrated. None has particular significance for the community but they are nevertheless interesting as individual cases.

B27, one of the very well preserved skeletons from MP1,



FIG. 17:39 Maxillary dentition of burial 41. A: Palatal view with the labial aspect of the crown of the right central incisor visible, B: Anterior view with the root of the central incisor visible. The right lateral incisor is missing

a mid age male, has abrasion of the roots of his anterior mandibular teeth. This is in the form of a shallow horizontal groove, extending between 4-6mm from just above the CEJ down the labial surface of the roots (Fig. 17:38). It is present on the canines and incisors. There are substantial deposits of calculus on the lingual aspect of these teeth, slight deposits on the buccal aspects of adjacent teeth, and as can be seen in the figure, there is clearly significant periodontal disease around the teeth, with resorption and porosity of the crest, particularly on the labial aspect. The grooves were probably horizontally aligned during life. A couple of the incisors were loose and have been placed in the alveoli so the grooves do not align in the figure. The groove appears most likely to have been evidence of a habit this man developed, of vigorously scrubbing some abrasive material, possibly a stick, across his teeth. Whether this was an attempt to remove the calculus, in response to the irritation of the inflamed periodontal tissues, or simply a habit will not ever be known. Whatever his motivation, had he lived longer he would have no doubt have lost these teeth. Note that he was one of the ablation/agenesis cases, with a missing right lateral incisor.

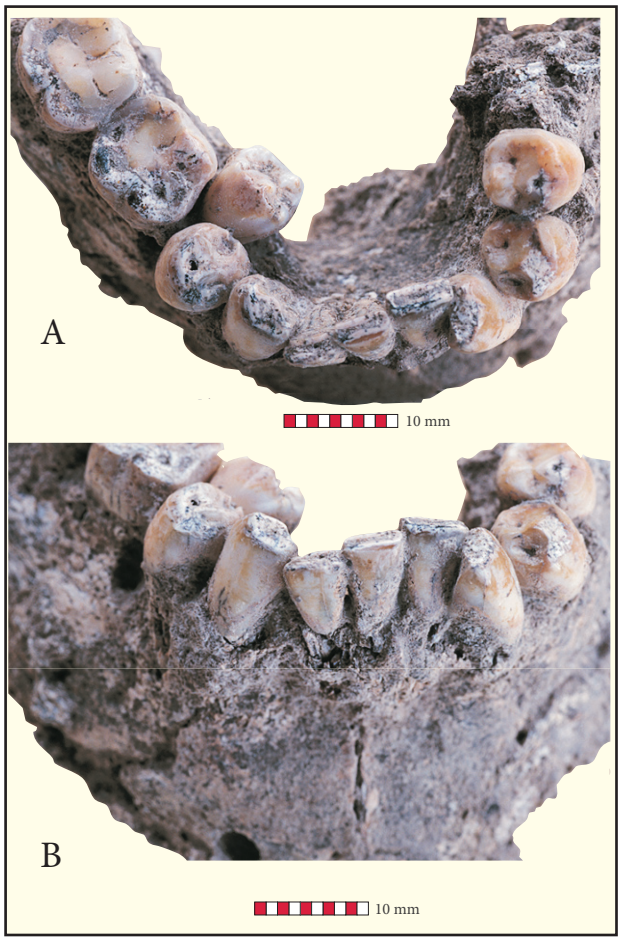


FIG. 17:40 Mandibular dentition of burial 74. A: Occlusal view showing the crowding and displacement described in the text, B: Anterior view

The second unusual case is B41, a child aged between 7 and 11 years. He appears to have suffered a blow to the maxillary right central incisor that occurred early in development, resulting in the crown being bent lingually more then 90 degrees, part way down the root. The root subsequently continued to grow upwards in the normal orientation. The lingual aspect of the tooth crown is lying adjacent to the palatal side of the alveolar process and the root remains in the alveolus, although this has relocated towards the anterior so there is no bone covering the root. The adjacent lateral incisor is missing (Fig. 17:39).

The third case is B74, a young adult male. He has significant crowding of the anterior teeth in his mandible. The left canine has rotated 90 degrees, the incisors overlap one another, despite the missing right lateral incisor, and most significantly the right second premolar has erupted lingually of the first premolar and first molar. The poor preservation of the bone might suggest these events had occurred or been exacerbated postmortem, except that the wear on the teeth is consistent with these relationships being antemortem (Fig. 17:40).

DISCUSSION AND CONCLUSIONS

As outlined in the introduction to this chapter, the overall aim of the research on the human skeletal remains from Noen U-Loke is to consider the evidence for the human biological responses to the development of the complex society would have had to exist in a community that was a precursor to the development of a highly organized state-level society. The hypothesis to be considered was that the population of Noen U-Loke would have been healthier than the preceding Bronze Age populations of the upper Mun River Valley, but paradoxically would have had more pathological lesions. The overall evidence for the status of the population is first summarized and discussed, before the hypothesis is considered in the light of the evidence.

The evidence for the demographic status of the Noen U-loke population is that it was growing. The ratios of juveniles to adults suggests that this growth may have been slower than that of the earlier Ban Lum Khao population, although the interpretation of the evidence is complicated by problems of confidence in the extent to which the samples may be representative of the populations.

There is no basis for identifying either of the two populations as being healthier overall. There are differences in the patterns of the individual indicators of health rather than in the overall population health status. In the subadults, the lower levels of growth disruption in the few children who died at Noen U-Loke suggests that they suffered fewer insults during their short lives and possibly died from acute illnesses. This compares with those at Ban Lum Khao who had multiple insults, perhaps reflecting chronic illnesses. This could conceivably even be interpreted as suggesting that the quality of life at Ban Lum Khao was poorer than at Noen U-Loke. The Ban Lum Khao population could have suffered with chronic illness, whereas the people at Noen U-Loke had a better quality of life, experiencing fewer episodes of illness, but with the introduction of novel infections proving acutely fatal in some instances. Given the evidence for the introduction of leprosy and possibly tuberculosis, it is not impossible that there were also introduced illnesses such as respiratory or gastrointestinal infections that leave no skeletal markers.

In those who survived to adulthood, growth disruption was experienced at a similar level in females at both sites, whereas Noen U-Loke males had significantly lower LEH levels than their Ban Lum Khao counterparts. Females at the two sites also had similar adult statures, whereas again the men differed. The men from Ban Lum Khao had a lower mean stature but a greater range, which suggests that poorer health during childhood had been experienced by a subgroup from this population. This is an enigma, as it suggests greater inequality during the bronze age than the later iron age. This is, of course, assuming that there was minimal interpopulation genetic diversity. Current research on stable isotopes in dental enamel by

Alex Bentley and Katharine Cox should begin to clarify this issue.

Both growth disruption and stature are non-specific indicators of health. The presence of evidence of periods of ill health and the extent to which genetic potential for stature might have been achieved cannot be attributed to any one cause. There may have been contributions from multiple causes such as nutritional deficiencies, either in quantity or quality; illnesses of many different types but especially gastro-intestinal and respiratory; and overlying these natural influences on growth may be cultural proscriptions on access to dietary resources or expectations of excessive physical contributions to community activities leading to exhaustion and lowered immunity.

Adult longevity shows only one significant difference between the two sites, a higher rate of mortality of young females at Ban Lum Khao than at Noen U-Loke. Otherwise there is no clear indication of differences in longevity of adults, although differences in dental health in older adults, discussed below, may be reflective of greater longevity at Noen U-Loke. The relative aging methods available do not allow a confident answer to this question.

Beyond the non-diagnostic evidence of health, skeletal pathology presents a very different picture at the two sites. At Noen U-Loke there is the evidence of the presence of infections not seen at Ban Lum Khao, in the form of leprosy and possibly tuberculosis. There are cases with lesions at Ban Lum Khao but these are non-diagnostic and may have been general, lowgrade infections. On the other hand, there is the evidence of skeletal fractures at Ban Lum Khao not matched at Noen U-Loke, although the chances that this is reflective of the poor preservation at Noen U-Loke, rather than an absence of traumatic injury, must not be discounted.

The evidence of dental wear and pathology presents an equally difficult picture to interpret. The similarity of dental conditions in young individuals is countered by an increase in attrition and dental infection over time, reflected in the poor dental health of older adults at Noen U-Loke than at Ban Lum Khao. This is possibly reflective of a dietary change, with increasing proportions of fibrous, non-cariogenic, foods in the Noen U-Loke diet. Alternatively, as these conditions are age-related, they may indicate that the 'old' age group of adults may have been chronologically older at Noen U-Loke, allowing more opportunity for these dental conditions to develop.

Of interest also is the relative health of the sexes at Noen U-Loke and in comparison to Ban Lum Khao. There are hints that there may have been less variation in health status between the sexes at Noen U-Loke, possibly reflecting equality of access to resources. There are more young adult males than females in the sample but the mortality rates by age do not differ significantly between the sexes. There is no clear evidence in dental conditions of sex-related differences in diet, despite some variation, particularly in older individuals.

The evidence from Noen U-Loke in comparison with Ban Lum Khao is that there is not a clear pattern of health change over time. A later publication will examine the detail of temporal change at Noen U-Loke but there is no evidence of a general decline as has been suggested for certain other parts of the world with intensification of agriculture. There may even conceivably have been an improvement in quality of life. As Pietrusewsky and Douglas (2002a) found with their comparison of late and early inhabitants of Ban Chiang, evidence of health changes with the increasing reliance on agriculture in the northeast of Thailand does not follow that seen elsewhere. This was probably influenced by an undoubtedly complex set of as yet undefined social and environmental factors. In particular, the nature of any genetic relationships between these two populations is a factor that may have significantly impacted on their relative health status.

We suggest that two features of the prehistoric Southeast Asian diet are important in the maintenance of health. The first is the higher nutritional value of rice than other carbohydrate staples (such as maize in particular), and the second is the adoption of this as a carbohydrate staple alongside the maintenance of a continuing contribution of foraged wild foods, permitting the maintenance of a balanced diet. The richness of the tropical environment allowed for the farming of domesticated rice, providing a reliable dietary base, without necessitating the loss of dietary diversity.

Acknowledgements

For contributions to the research on which this chapter is based, we wish to thank Dr Hallie Buckley, Nathamon Pureepatpong and Kirsten Nelsen.

TABLE A 1 *Noen U-Loke adults: measurements of postcranial joints*

	Femur head		Humerus head		Distal humerus width	
	Right	Left	Right	Left	Right	Left
Males						
1	-	-	-	-	65.5	-
5	-	-	-	-	61.6	64.4
26	47.1	47.4	-	-	62.6	63.7
27	45.8	45.7	43.1	44	63.2	63.3
61	-	-	-	-	63.7	63.2
42	46.4	46.8	-	-	65.3	66.4
69	48.0+	-	-	-	-	-
74	48.4	-	-	-	60.5	-
107	46.5	47	-	-	-	-
111	49	48	-	-	-	-
		45.7-48.4				60.5-66.4
Females						
36	-	37.7	-	-	-	-
37	38.5	-	-	-	52.2	51.2
62	-	41.3	-	-	-	-
108	44.7	45	-	-	58.5	58.5
		37.7-45.0				51.2-58.5

APPENDIX

TABLES AND BURIAL DESCRIPTIONS

Notes on dental data:
Dental data are summarised, and therefore not definitive.
Tooth wear used in age estimates is based on all teeth.
Dental completeness refers to teeth and tooth positions (i.e. where the supporting bone is present, allowing assessment of cause of missing teeth, which may be unerupted, lost during life, lost postmortem, ablated or agenetic).
Absence of third molars was recorded as agenesis where there are no interproximal wear facets on adjacent second molars.
'Missing' lateral incisors indicates possibly agenesis or ablation.
'Antemortem loss' refers to pathological loss.

Burial 1
Summary: Virtually complete, poorly preserved mid age adult male.
Location: Depth 1.45m. Adjacent to B3, has infant jar burial (B2) at head. Mortuary Phase 5.
Skeletal completeness and preservation: Skull complete but poorly preserved. Postcranial skeleton almost complete, except left clavicle, and distal legs and feet left in baulk. Bone poorly preserved with long bones represented by shafts only.
Age estimate: Mid age 35-40 based on tooth wear (grades 3-6).
Sex estimate: Male based on sciatic notch and skull.
Stature estimate: No estimate.
Skeletal pathology: Joints: none visible. Cribra orbitalia: not visible.
Dental completeness and pathology: All recorded. All third molars missing (agenesis) and right lateral incisors on both maxilla and mandible. Caries: none. Calculus present. No antemortem loss or infection.
Comments: Very robust skull, generally robust postcranial.
Burial 2
Summary: Very incomplete, poorly preserved full-term infant jar burial.
Location: Depth 1.31m. At head of B1. Mortuary Phase 5.
Skeletal completeness and preservation: Cranial fragments and tibial shaft only. Bone poorly preserved and very fragmented.
Age estimate: Full-term neonate based on dental formation.
Dental completeness: Crowns of eight unerupted teeth.
Comments: Iron rings (bracelets?) and bowls inside burial jar.
Burial 3

Summary: Very incomplete, poorly preserved infant.
Location: Depth 1.47m. Parallel to B1. Mortuary Phase 5.
Skeletal completeness and preservation: Fragments only, very poor condition, include part of a long bone shaft, either humerus or femur.
Age estimate: Infant based on size.
Comments: Identified on the basis of bracelets with bone fragments.

Burial 4
Summary: Virtually complete, poorly preserved adolescent.
Location: Depth 0.76m. Beyond feet of B12. Mortuary Phase 5.
Skeletal completeness and preservation: Skull complete but crushed. Most postcranial bones present but incomplete. No vertebrae. Bone poorly preserved with long bones represented by shafts only.
Age estimate: 15-18 years based on epiphyseal fusion (distal tibia and iliac crest unfused) and tooth wear (grades 1-2).
Skeletal pathology: Cribra orbitalia: none.
Dental completeness and pathology: All teeth recorded. Both left lateral incisors missing. No caries, calculus, infections, or antemortem tooth loss. Widespread LEH and opacity.

Burial 5
Summary: Virtually complete, poorly preserved young adult male.
Location: Depth 0.82m. Infant jar burial (B9) west of head. Mortuary Phase 5.
Skeletal completeness and preservation: Skull complete but partly damaged. Most of postcranial skeleton represented but bones incomplete. Bone fragmented and heavily concreted. Right tibia and fibula lost in posthole.
Age estimate: Young adult based on pubic symphysis and axial skeleton maturation. Tooth wear not used in estimate: grades 2-3.
Sex estimate: Male? based on pelvis and joint measurements. Skull feminine but this may reflect youthfulness
Stature estimate: 171cm based on humerus.
Skeletal pathology: Cribra orbitalia: not visible.
Dental completeness and pathology: All teeth recorded. Both right lateral incisors missing. No caries, infection, or antemortem loss. Slight calculus. LEH on three canines.
Comments: Tall young man.

Burial 6
Summary: Incomplete, poorly preserved full-term infant jar burial.
Location: Depth 1.02m. Between B7 and 8. Mortuary Phase 5.
Skeletal completeness and preservation: Poorly preserved fragments of skull vault, ribs, and unidentifiable long bones.
Age estimate: Full-term neonate based on rib size.

Burial 7
Summary: Very incomplete and poorly preserved infant age less than one year.
Location: Depth 1.03m. Infant jar burial (B6) adjacent. Mortuary Phase 5.
Skeletal completeness and preservation: Minimal fragments of unidentified long bones.
Age estimate: < 1 year, based on bone size.
Comments: Identified by bronze bangles containing bone fragments.

Burial 8
Summary: Incomplete and poorly preserved young adult of unknown sex.
Location: Depth 1.27m. Adjacent to two infants, B's 6 and 7, west of head. Mortuary Phase 5.
Skeletal completeness and preservation: Skull present but badly crushed and flattened. Post cranial skeleton represented by right upper limb and fragments of left.
Age estimate: Young adult based on tooth wear (grades 2-5)
Sex estimate: No estimate.
Stature estimate: No estimate.
Skeletal pathology: No evidence
Dental completeness and pathology: 27 teeth recorded. Not possible to assess whether incisors are missing; two third molars missing (agenesis). No caries, infections, or antemortem loss. Calculus slight-moderate. LEH on two teeth.

Burial 9
Summary: Very incomplete and poorly preserved ~ three-month-old infant, jar burial.
Location: Depth 0.69m. West of head of B5. Mortuary Phase 5.
Skeletal completeness and preservation: Skull frontal and mandible only, poorly preserved.
Age estimate: About 3 months based on dental formation.
Dental completeness: Crowns of seven unerupted deciduous teeth.
Comments: Infant jar burial with many artefacts.

Burial 10
Summary: Incomplete, poorly preserved old adult, possibly female.
Location: Depth 1.22m. Isolated burial. Mortuary Phase 5.
Skeletal completeness and preservation: Very fragmentary mandibular and postcranial remains, mainly from right upper limb.
Age estimate: Old adult based on tooth wear (grades 3-7).
Sex estimate: Female? based on mandible form and gracility.
Stature estimate: No estimate.
Skeletal pathology: Cribra orbitalia: not visible.
Dental completeness and pathology: Mandibular denti-

TABLE A2 *Noen U-Loke adults: shaft measurements*

	Minimum	Maximum	Antero-post.	Medio-lateral	Antero-post.	Medio-lateral
	Right/Left	Right/Left	Right/Left	Right/Left	Right/Left	Right/Left
Males						
26	17.8/-	24.5/-	31.4/32.6	28.3/29.1	38.4/38.7	21.7/22.2
27	16.6/17.1	22.6/22.6	28.4/-	29.4/-	36.4/35.4	19.8/20.7
44	-	-	-	-	32.1/34.2	20.9/21.0
Females						
108	15.6/14.9	22.8/22.7	-	-	33.1/33.5	22.2/22.3

tion complete, plus two loose maxillary teeth. Left lateral incisor missing. Both third molars missing (agenesis). No caries. One central incisor lost antemortem, moderate calculus, two infections. LEH on two teeth.

Burial 11

Summary: Very incomplete and poorly preserved full-term infant jar burial.

Location: Depth 0.76m. Isolated burial. Mortuary Phase 5.

Skeletal completeness and preservation: Few fragments only, including sphenoid base, ilium, and unidentified long bones.

Age estimate: Full-term neonate based on size.

Burial 12

Summary: Incomplete, poorly preserved old adult female.

Location: Depth 0.93m. At head of B4, parallel to B5. Mortuary Phase 5.

Skeletal completeness and preservation: Skull crushed and fragmented. Most of postcranial skeleton represented but bones fragmented. Bone heavily concreted. Left upper limb and proximal segment of right lower limb lost in postholes.

Age estimate: Old adult based on tooth wear (grades 2-7).

Sex estimate: Female based on cranium and gracility.

Stature estimate: No estimate.

Skeletal pathology: Cribra orbitalia: not visible. Joint degeneration in two foot phalanges.

Dental completeness and pathology: Almost all teeth present except right lateral incisors on both maxilla and mandible, two third molars (one agenesis) and one first molar (pathological loss). No caries. Moderate calculus. No LEH.

Burial 13

Summary: Very incomplete and poorly preserved infant approx. 3 months.

Location: Depth 1.99m. Adjacent to B15. Mortuary Phase 4D.

Skeletal completeness and preservation: No skull and very fragmentary postcranial skeleton, mainly right leg and foot.

Age estimate: Infant ~ 3 months, based on bone size.

Comments: Fragments preserved by bronze jewellery and accompanied by many beads.

Burial 14

Summary: Incomplete and poorly preserved mid age adult male.

Location: Depth 2.01. Over B21. Mortuary Phase 4D.

Skeletal completeness and preservation: Skull present but crushed and fragmented. Most of postcranial skeleton represented but bone very fragmented. Right tibia and fibula lost in posthole.

Age estimate: Mid adult based on tooth wear (grades 2-5).

Sex estimate: Male based on skull and sciatic notch.

Stature estimate: No estimate.

Skeletal pathology: Cribra orbitalia: not visible.

Dental completeness and pathology: All mandibular and some maxillary teeth present but most broken postmortem. No caries or calculus. One second molar lost antemortem. LEH on one canine.

Summary: Very wealthy man in his prime, with much jewellery including bronze belts and silver and gold earrings.

Burial 15

Summary: Very incomplete and poorly preserved mid age adult female.

Location: Depth 2.45m. Between B13 and B21. Mortuary Phase 4D. Field B20 amalgamated with this burial.
Skeletal completeness and preservation: Skull very fragmentary. Parts of postcranial skeleton represented but very fragmentary.
Age estimate: Mid adult based on tooth wear (grades 3-6).
Sex estimate: Female based on skull.
Stature estimate: No estimate.
Skeletal pathology: Cribra orbitalia: not visible.
Dental completeness and pathology: All teeth present except right lateral incisors on both maxilla and mandible. No caries, moderate calculus. Six teeth lost antemortem. LEH on two molars.

Burial 16

Summary: Very incomplete, poorly preserved and scattered young age adult female.
Location: Depth 2.08. Isolated burial. Mortuary Phase 4.
Skeletal completeness and preservation: Skull represented by occipital, parts of parietals and mandible. Right limbs and axial skeleton represented by fragments. Bone poorly preserved, chalky.
Age estimate: Young adult, based on tooth wear (grades 3-4).
Sex estimate: Female based on small mastoid and gracility.
Stature estimate: No estimate.
Skeletal pathology: Cribra orbitalia: not visible.
Dental completeness and pathology: Few teeth, mainly from right mandible. No caries, moderate calculus. LEH on three teeth.
Comments: Disarticulated scatter of bones.

Burial 17

Summary: Very incomplete and poorly preserved full-term infant jar burial.
Location: Depth 2.52m. Between two other jar burials, B18, 19 in isolated cluster. Mortuary Phase 4.
Skeletal completeness and preservation: Small fragments of postcranial skeleton, mainly lower limbs.
Age estimate: Full-term neonate, based on size.

Burial 18

Summary: Very incomplete and poorly preserved full-term infant jar burial
Location: Depth 2.62m. East of jar burials B17, 19. Mortuary Phase 4.
Skeletal completeness and preservation: Fragments include hand, pelvis.
Age estimate: Full-term neonate, based on size.

Burial 19

Summary: Complete, well preserved, full-term infant jar burial.
Location: Depth 2.36m. To west of jar burial B17. Mortuary Phase 4.
Skeletal completeness and preservation: virtually complete but broken skull. Most of postcranial bones present and virtually complete.
Age estimate: Full-term neonate, based on dental formation.
Dental completeness: Crowns of 7 unerupted deciduous teeth.

Burial 20

Remains amalgamated with Burial 15 after laboratory analysis and included above.

Burial 21

Summary: Very incomplete, poorly preserved adult of unknown age and sex.
Location: Depth 2.26m. Beneath B14, adjacent to B15. Mortuary Phase 4D.
Skeletal completeness and preservation: Lower limbs only recovered, without feet, which were removed in antiquity. Upper body in baulk. Bone in poor condition – rice burial.
Age estimate: Adult, based on size.
Sex estimate: No estimate.
Stature estimate: No estimate.
Comments: Partial 'rice' burial with upper body outside the square.

Burial 22

Summary: Incomplete poorly preserved infant 3-5 years.
Location: Depth 2.13m. Adjacent to, and above, B35. Mortuary Phase 3B.
Skeletal completeness and preservation: Fragments of maxilla and mandible, vertebrae, and limb bones in poor condition.
Age estimate: 3-5 years, based on dental formation.
Dental completeness: Seven unerupted deciduous teeth.
Comments: Possibly from a disturbed burial jar. Field B23 amalgamated with this burial.

Burial 23

Remains amalgamated with Burial 22 after laboratory analysis and included above.

Burial 24

Summary: Complete, well preserved but concreted, full-term infant jar burial.
Location: Depth 3.40m. Isolated in the NW corner of the square. Mortuary Phase 3.
Skeletal completeness and preservation: Virtually complete, including the skull, in good condition but cemented together.
Age estimate: Full-term neonate, based on dental formation.
Dental completeness: Crowns of two deciduous teeth present.

Burial 25

Summary: Very incomplete poorly preserved infant 2 years.
Location: Depth 2.38m. Beyond the head of B31. Mortuary Phase 4B.
Skeletal completeness and preservation: Crushed fragments of cranium, maxilla and mandible.

Age estimate: Two years, based on dental formation.
Dental completeness: Nine deciduous teeth present, some unerupted.
Comments: Fragments of an infant cranium, with glass-beads and bronze fragments where postcranial skeleton should have been.

Burial 26

Summary: Virtually complete well-preserved young adult male.
Location: Depth 3.65m. Adjacent and parallel to B27, grave cut into natural. Mortuary Phase 2.
Skeletal completeness and preservation: Virtually complete skeleton in very good condition. Skull disturbed in prehistory and represented by reconstructed vault, maxilla and partial mandible. Postcranial skeleton largely complete.
Age estimate: Young adult, based on skeletal maturation. Tooth wear grades 2-4.
Sex estimate: Male, based on pelvis and skull.
Stature estimate: 166.8, based on femur and tibia.
Pathology: Very minor joint degeneration in the form of marginal osteophytes on appendicular and spinal joints. Bilateral ossification of costal cartilages, aetiology unknown. This is variously reported as having a genetic basis, usually as one effect of a syndrome (Tuysuz B, Ungur S 2003), being reflective of metabolic or endocrine conditions, or as a consequence of aging (Rejtarova et al. 2004), although aging effects on calcification would rarely develop to the extent seen in this burial. The cause in this burial remains unknown.
Dental completeness and pathology: Many teeth present. No caries, moderate – severe calculus, one third molar lost recently antemortem, one first molar infected. Multiple enamel hypoplasia on four teeth.

Burial 27

Summary: Complete, very well preserved mid age adult male.
Location: Depth 4.12m. Adjacent and parallel to B26, grave cut into natural. Mortuary Phase 2.
Skeletal completeness and preservation: Complete skeleton in very good condition, including skull.
Age estimate: Mid adult, based on pubic symphysis and tooth wear (grades 3-5).
Sex estimate: Male, based on pelvis and skull.
Stature estimate: 164.6, based on femur and tibia.
Pathology: Minor joint degeneration in the form of marginal osteophytes on appendicular and spinal joints. Exception is the lumbar spine, (six vertebrae), with the first two fused together and the second severely affected, possibly by a vertebral disc prolapse.
Dental completeness and pathology: All teeth recorded. Right mandibular incisor missing. Both maxillary third molars agenesis. No caries, slight-moderate calculus, three teeth lost antemortem. Single enamel hypoplasia on one canine.
Comments: With very rich grave goods.

Burial 28

Summary: Unconfirmed fragments of an infant.
Location: Depth 2.42m. Above B49. Mortuary Phase 3B.
Skeletal completeness and preservation: Possible fragments of distal leg, in poor condition.
Age estimate: Infant, based on field estimate.
Comments: Rice chaff-filled pit over B49, with animal bones from several species and what was initially identified as a possible human infant distal tibia and fibula, cemented together. This could not be confirmed by comparison with other infants as the material has not been subsequently located.

Burial 29

Summary: Unconfirmed fragments of an infant.
Location: Depth 2.51. Above B30. Mortuary Phase 3B.
Skeletal completeness and preservation: Identified in the field as cranium and mandible.
Age estimate: Infant 2-4 years, based on dental eruption. Based on field estimate.
Comments: Also recovered with disarticulated adult bones, which were later combined with B30. Bones unable to be located during laboratory analysis.

Burial 30

Summary: Virtually complete, poorly preserved young adult female.
Location: Depth 2.70m. Parallel and to the east of B49. Mortuary Phase 3B.
Skeletal completeness and preservation: Virtually complete skeleton in poor condition, including adult bones recovered with B29. Skull present but crushed and degraded. Most bones of postcranial skeleton represented but either damaged or incomplete.
Age estimate: Young adult, based tooth wear (grades 2-4).
Sex estimate: Female, based on sciatic notch and size.
Stature estimate: 157.7, based on field measurement of femur.
Skeletal pathology: Not recordable.
Dental completeness and pathology: All but one tooth recorded. Left mandibular incisor missing. Caries on two molars, slight-moderate calculus, three mandibular molars lost antemortem. No LEH.
Comments: in poor condition, possibly a rice burial.

Burial 31

Summary: Virtually complete, variably preserved 12 year-old child.
Location: Depth 2.18m. Beyond feet of B25. Mortuary Phase 4B.
Skeletal completeness and preservation: virtually complete skeleton in variable condition. Skull fragmented. Most bones of postcranial skeleton represented but variably complete. Hands and fibulae missing.
Age estimate: ~ 12 years, based on dental formation (tooth wear not used in age estimate - grades 2-3).

Skeletal pathology: None visible.
Dental completeness and pathology: All permanent teeth present, including unerupted third molars. No caries, slight calculus. Single LEH on two teeth.
Comments: Recovered in three sections: skull and shoulders in first season, and feet in second season, with the mid section of the body removed from the baulk between the two squares at the end of the second season.

Burial 32

Summary: Incomplete, disarticulated but well preserved mid age male.
Location: Depth 2.52. Between B39 and B40. Mortuary Phase 3B.
Skeletal completeness and preservation: Incomplete skeleton, representing fragments of skull vault, left side, right upper limb and axial skeleton in good condition.
Age estimate: Mid adult, based on wear of two loose teeth (grades 5-6).
Sex estimate: Male, based on supraorbital morphology and robusticity.
Stature estimate: 166.3, based on ulna.
Pathology: Either no or very minor joint degeneration in the form of marginal osteophytes on few appendicular joints present.
Dental completeness and pathology: No observations possible.
Comment: Scatter of disarticulated bones and teeth.

Burial 33

Summary: Virtually complete, rice burial, variably preserved, young adult male.
Location: Depth 2.62m. Parallel and to the south of B48. Mortuary Phase 3B.
Skeletal completeness and preservation: Complete skeleton except for femora, skull including face in good condition but slightly distorted, postcranial skeleton in poor condition. Rice covering postcranial skeleton only.
Age estimate: Young adult, based on tooth wear (grades 1-3).
Sex estimate: Male?, based on cranium. Mandible 'feminine' but this possibly reflects youth.
Stature estimate: 167.0, based on radius.
Pathology: None observable.
Dental completeness and pathology: All teeth recorded. Three lateral incisors missing. Caries on two molars, slight calculus, one molar lost antemortem. No enamel hypoplasia.

Burial 34

Summary: Very incomplete poorly preserved infant or child.
Location: Depth 2.59. On the left humerus of B35. Mortuary Phase 3B.
Skeletal completeness and preservation: Cranial vault and base, very poor condition. Rice burial.
Age estimate: Infant or child, based on thickness of cranial vault fragments.
Comments: buried with adult B35.

Burial 35

Summary: Vitually complete very poorly preserved mid adult female.
Location: Depth 2.59m. Parallel to B39 and B30, beyond head of B40. With child cranium (B 34) over left humerus. Mortuary Phase 3B.
Skeletal completeness and preservation: Almost complete skeleton in very poor, fragmented, condition. Skull crushed flat with foramen magnum against palate. Most postcranial skeleton, except feet, represented but bones incomplete or fragmented.
Age estimate: Mid adult, based on tooth wear (grade 5-7) and significant loss of teeth during life.
Sex estimate: Female, based on pelvis and skull.
Stature estimate: No estimate.
Pathology: Not recordable.
Dental completeness and pathology: Most teeth recorded. No caries, seven teeth lost antemortem, moderate calculus. No agenesis, ablation or enamel hypoplasia.
Comments: with subadult B34 lying over left humerus.

Burial 36

Summary: Virtually complete, moderately well preserved young adult female.
Location: Depth 3.14m. Adjacent to B37, above B42. Mortuary Phase 3A.
Skeletal completeness and preservation: Almost complete skeleton in good condition. Skull complete but flattened side to side. Most of postcranial skeleton represented except legs and feet, although many bones damaged.
Age estimate: Young adult, based on tooth wear (grades 2-4).
Sex estimate: Female, based on skull and sciatic notch.
Stature estimate: 156.6, based on field measurement of humerus.
Pathology: No joint degeneration visible. Lytic lesions on bodies of lower thoracic spine diagnosed as possible tuberculosis (Tayles and Buckley 2004).
Dental completeness and pathology: All teeth recorded. Both left lateral incisors missing. No caries, calculus slight-moderate, no teeth lost antemortem. Multiple enamel hypoplasia on incisors, canines and premolars.
Comments: A young woman who possibly suffered (and died) from tuberculosis.

Burial 37

Comments: Virtually complete, moderately well preserved old adult female.
Location: Depth 3.14m. Between B36 and B44. Mortuary Phase 3A.
Skeletal completeness and preservation: Skull complete but frontal damaged. Most postcranial bones to mid tibia represented but incomplete. Bone moderately well preserved.
Age estimate: Old adult, based on pubic symphysis. Tooth wear not used in estimate: grade 3-8.

Sex estimate: Female, based on skull and sciatic notch.
Stature estimate: 153.2, based on humerus.
Pathology: Minor joint degeneration in the form of marginal osteophytes on appendicular and spinal joints.
Dental completeness and pathology: All maxillary and most mandibular teeth recorded. No caries, slight-moderate calculus, three teeth lost antemortem. Left lateral mandibular incisor missing. One maxillary M3 agenesis. No enamel hypoplasia.
Comments: Short elderly woman in the baby pig cluster

Burial 38

Summary: Virtually complete, very well preserved full-term infant jar burial
Location: Depth 2.95m. Beyond the heads of other burials in the cluster. Mortuary Phase 3A.
Skeletal completeness and preservation: Skull almost complete. Post cranial skeleton complete except right femur and pelvis.
Age estimate: Full-term neonate, based on dental formation.
Dental completeness: Seven unerupted deciduous teeth.
Comments: A newly born infant buried in a jar in the baby pig cluster.

Burial 39

Summary: Incomplete poorly preserved young adult male.
Location: Depth 2.65m. Most northerly burial in cluster. Mortuary Phase 3B.
Skeletal completeness and preservation: Skull vault almost complete but distorted; face missing. Most postcranial bones represented but fragmented and crushed.
Age estimate: Young adult, based on pubic symphysis. Tooth wear not used in estimate: grade 2-4.
Sex estimate: Male, based on pelvis and cranium. Mandible 'feminine' but this may reflect youth.
Stature estimate: 166.7, based on field measurement of humerus.
Pathology: None recordable.
Dental completeness and pathology: 12 teeth recorded. One molar with caries, calculus moderate. Two incisors with enamel hypoplasia.
Comments: Rice burial, with one large spiral bronze earring.

Burial 40

Summary: Virtually complete poorly preserved young adult female.
Location: Depth 2.71m. Beyond feet of B35, adjacent and parallel to B48. Mortuary Phase 3B.
Skeletal completeness and preservation: Skull represented by maxilla, mandible, and barely recognizable vault fragments. Most bones of post cranial skeleton represented except pelvis and most of femora, some complete, others fragmented. Condition variable from good to poor.
Age estimate: Young adult, based on epiphyseal fusion (distal femur, radius unfused). Tooth wear not used in estimate: grade 2-3.
Sex estimate: Female, based on mandible and gracility.
Stature estimate: 156.1 based on ulna.
Pathology: Not recordable.
Dental completeness and pathology: All teeth recorded. No caries, moderate calculus. All lateral incisors missing. Enamel hypoplasia on 11 teeth.

Burial 41

Summary: Virtually complete well preserved child aged 7-11 years.
Location: Depth 3.32m. Beneath B44. Mortuary Phase 3A.
Skeletal completeness and preservation: Skull almost complete but distorted. Most bones of postcranial skeleton represented, some complete but others fragmented. Preservation good.
Age estimate: 7-11 years, based on dental eruption and wear.
Pathology: Spondylolysis on L5. No cribra orbitalia (both orbits present and visible).
Dental completeness: Mixed dentition. 11 deciduous, seven permanent teeth present; one permanent tooth impacted.
Dental completeness and pathology: Caries on one deciduous canine, deciduous first molar and permanent first molar. wear 2-3; no calculus, enamel hypoplasia on two permanent incisors, opacities on six permanent teeth, localised enamel defects on two deciduous canines, single small pit in enamel on a deciduous first molar, impacted permanent central incisor.
Comments: Child in the baby pig cluster.

Burial 42

Summary: Virtually complete, fair-well preserved old adult male.
Location: Depth 3.32m. Beneath B36. Mortuary Phase 3A.
Skeletal completeness and preservation: Skull complete but slightly distorted. Postcranial skeleton complete except right forearm. Preservation variable from fair to good.
Age estimate: Old adult, based on tooth wear (grade 4-8), tooth loss during life, and pubic symphysis.
Sex estimate: Male, based on pelvis and cranium.
Stature estimate: 173.5, based on femur.
Pathology: Variable joint degeneration in the form of marginal osteophytes on appendicular and spinal joints.
Cranium - depression on R parietal (30x20mm), antemortem, no reactive bone, well healed. Mastoids asymmetrical, larger on R.
Lesions on distal tibiae/fibulae suggestive of infection; also lesions on feet consistent with leprosy infection (Tayles and Buckley 2004).
Dental completeness and pathology: All teeth recorded. Three caries, slight calculus, two molars lost antemortem. All lateral incisors missing. No enamel hypoplasia.
Comments: elderly man, suffering from leprosy, in the

baby pig cluster.

Burial 43

Summary: Virtually complete very well preserved full-term infant in a burial jar.

Location: Depth 2.68m. Isolated burial. Mortuary Phase 4.

Skeletal completeness and preservation: Skull largely complete but fragmented. Postcranial skeleton complete and in excellent condition.

Age estimate: Full-term neonate, based on dental formation.

Dental completeness: Crown of single deciduous first molar.

Burial 44

Summary: Virtually complete fair to well-preserved skeleton of a young adult male.

Location: Depth 3.21m. Above B44. Mortuary Phase 3A.

Skeletal completeness and preservation: Skull complete but slightly distorted. Most bones of postcranial skeleton represented but incomplete. Bone in condition variable from fair to good.

Age estimate: Young adult, based on epiphyseal fusion (incomplete fusion iliac crest). Tooth wear not used in estimate: grade 2-4.

Sex estimate: Male? based on mandible. Skull feminine but this may reflect youth. Sciatic notch equivocal.

Stature estimate: 167.5, based on femur.

Pathology: No joint degeneration. One metacarpal has a very narrow shaft but is otherwise normal in form and appearance. The cause of the shaft narrowing is unknown.

Dental completeness and pathology: All teeth present. One caries, slight-moderate calculus, no teeth missing or lost during life. Multiple enamel hypoplasia on five teeth.

Comments: Young man, buried prone, in the baby pig cluster.

Burial 45

Summary: Mostly disarticulated very incomplete fairly preserved young adult, probably a male.

Location: Depth 3.32m. Between B40 and B48. Mortuary Phase 3B.

Skeletal completeness and preservation: Articulated left lower limb from femur to foot, plus disarticulated bones in vicinity. Bone in fair condition.

Age estimate: Young adult, based on tooth wear (grade 2-4).

Sex estimate: Male?, based on long bone dimensions.

Stature estimate: no estimate.

Pathology: None observed.

Dental completeness and pathology: 16 teeth recorded. No caries, slight-moderate calculus. Linear enamel hypoplasia on one tooth.

Burial 46

Summary: Very incomplete and poorly preserved infant.

Location: Depth 2.58m. Burial of an infant, beneath and beyond head of Burial 31. Mortuary Phase 4B.

Skeletal completeness and preservation: Very fragile crushed fragments of the cranial vault, complete mandible, and unidentifiable fragments of the postcranial bones.

Age estimate: 1.5-4 years, based on dental formation and eruption.

Dental completeness: Nine deciduous teeth.

Comments: Very degraded fragments of the rice burial.

Burial 47

Summary: Rice filled grave cut with bronze ring and glass beads. No bones recovered.

Location: Depth 2.70m. Between B46 and 25. Mortuary Phase 4B.

Burial 48

Summary: Very incomplete, well preserved young adult female.

Location: Depth 3.32m. Commingled with the remains of another individual (B49) and in the vicinity of Burial 45. Mortuary Phase 3B.

Skeletal completeness and preservation: Complete, slightly distorted, cranium and part mandible.

Age estimate: Young adult, based on tooth wear (grade 2-4).

Sex estimate: Female, based on skull.

Dental completeness and pathology: All teeth recorded but half lost postmortem. No caries, slight to moderate calculus. All lateral incisors missing. Linear enamel hypoplasia on 5 teeth.

Summary: Skull of a young woman.

Burial 49

Summary: Complete poorly preserved mid age adult female.

Location: Depth 2.92m. Adjacent to B50, partly commingled with B48. Mortuary Phase 3B.

Skeletal completeness and preservation: Skull probably complete but fragmented. Most postcranial bones represented but fragmentary and poorly preserved.

Age estimate: Mid adult, based on tooth wear (grade 2-6).

Sex estimate: Female, based on skull.

Dental completeness and pathology: 18 teeth recorded, 4 lost postmortem. No caries, moderate calculus. Left max lateral incisors missing.

Burial 50

Summary: Incomplete and poorly preserved young adult male.

Location: Depth 2.91m. Adjacent to B49. Mortuary Phase 3B.

Skeletal completeness and preservation: Skull represented by vault, maxilla and mandibular fragments. Upper body poorly represented and poorly preserved; lower limbs virtually complete but poorly preserved.

Age estimate: Young adult, based on pubic symphysis. Tooth wear not used in estimate; grade 2-3.

Sex estimate: Male, based on pelvis. Skull feminine but may reflect youth.

Stature estimate: 171.2, based on humerus.
Pathology: There is a deep vertical groove above the right maxillary lateral incisor. The significance of this is discussed in relation to the missing lateral incisors in Nelsen *et al*. (2001) but no aetiology has been determined.
Dental completeness and pathology: All maxillary teeth and four mandibular recorded. No caries, slight-moderate calculus. Maxillary right lateral incisor missing. LEH on 5 teeth.
Burial 51
Summary: Loose teeth found in a pit.
Location: Square A2, Layer 4 Spit 7; Depth 4.20m. Mortuary Phase 2. In a pit.
Skeletal completeness and preservation: Teeth only, without bone. Mixed deciduous and partly formed permanent dentition, mainly maxillary.
Age estimate: 5-6 years based on formation and eruption.
Dental completeness and pathology: Two deciduous, ten permanent. Wear 1 on permanent first molars, 3 on deciduous second molar, linear enamel hypoplasia on two permanent canines.
Burial 52
Summary: Incomplete, poorly preserved old adult female.
Location: Depth 2.88m. Adjacent to B53. Mortuary Phase 3B.
Skeletal completeness and preservation: Skull complete but very distorted. Most postcranial bones represented except lower legs and feet. Bone poorly preserved.
Age estimate: Old adult, based on tooth wear (grade 4-8).
Sex estimate: Female, based on cranium and sciatic notch.
Dental completeness and pathology: 28 teeth recorded. No caries, moderate calculus, at least five molars lost antemortem. All lateral incisors missing. Multiple enamel hypoplasia on one canine.
Burial 53
Summary: Very incomplete poorly preserved adult of unknown age or sex.
Location: Depth 3.03m. Adjacent to the North of B52. Mortuary Phase 3B.
Skeletal completeness and preservation: Right limbs and left lower limb only, incomplete and poorly preserved.
Age estimate: Adult, based on bone size.
Sex estimate: No estimate.
Stature estimate: No estimate.
Burial 54
Summary: Very incomplete, poorly preserved old adult of unknown sex.
Location: Depth 2.72m. Between B53 and B55. Mortuary Phase 3B.
Skeletal completeness and preservation: Distal segments of lower limbs in anatomical position, with disarticulated partial mandible and radius. All in poor condition.
Age estimate: Old adult, based on antemortem tooth loss.
Sex estimate: No estimate.
Stature estimate: No estimate.
Dental completeness and pathology: Seven mandibular teeth recorded, six lost antemortem.
Comments: Elderly person, buried with bronze bells.
Burial 55
Summary: Very incomplete poorly preserved adult of unknown sex.
Location: Depth 3.03m. Between B50 and B54. Mortuary Phase 3B.
Skeletal completeness and preservation: Distal legs and feet, very poorly preserved.
Age estimate: Adult, based on bone size.
Sex estimate: No estimate.
Stature estimate: No estimate.
Burial 56
Summary: Very incomplete and poorly preserved 3 month infant.
Location: Depth 0.95m. Very fragmentary infant skeleton. North of two infants, B6 and 7. Mortuary Phase 5.
Skeletal completeness and preservation: Skull represented by much of the vault, very fragmented, and fragments of maxilla and mandible. Very fragile fragments of a few postcranial bones.
Age estimate: 3 months, based on dental formation.
Dental completeness and pathology: Two unerupted deciduous crowns.
Burial 57.1
Summary: Incomplete well preserved but fragmented and disarticulated child 12-15 years.
Location: Depth 0.55m. Scattered over 2m area. Mortuary Phase 5.
Skeletal completeness and preservation: Small fragments of skull, fragments of postcranial down to femora, well preserved bone. Including teeth.
Age estimate: 12-15 years, based on dental formation. Tooth wear not used in estimate: grade 2-3.
Dental completeness and pathology: 10 teeth recorded, no caries, slight calculus. LEH on two canines.
Burial 57.2
Summary: Very incomplete well preserved young adult of unknown sex.
Location: Depth 0.55m. Partial adult mandible with Burial 57.1. Mortuary Phase 5.
Skeletal completeness and preservation: Well preserved partial mandible and loose teeth.
Age estimate: Young adult, based on tooth wear (grade 3-4).
Sex estimate: No estimate.
Stature estimate: No estimate.
Dental completeness and pathology: 10 teeth recorded, no caries, moderate calculus, linear enamel hypoplasia

on one lateral incisor.

Burial 58

Summary: Very incomplete, poorly preserved full-term infant jar burial.

Location: Depth 0.58m. Isolated burial. Mortuary Phase 5.

Skeletal completeness and preservation: Fragments of skull and ribs, poorly preserved.

Dental completeness: Unerupted deciduous teeth.

Age estimate: Full-term neonate, based on dental formation.

Sex estimate: No estimate.

Stature estimate: No estimate.

Comments: Burial jar crushed.

Burial 59

Summary: Virtually complete but very poorly preserved young adult of unknown sex.

Location: Depth 0.94m. Adjacent to B72, with lower legs in south baulk. Mortuary Phase 5.

Skeletal completeness and preservation: Very small fragments of skull. Most postcranial bones represented but very poorly preserved and fragmented.

Age estimate: Young adult, based on tooth wear (grade 1-5).

Sex estimate: No estimate.

Stature estimate: No estimate.

Skeletal pathology: large foramina in one metatarsal and one hand phalanx.

Dental completeness and pathology Most teeth recorded. No caries, slight to moderate calculus, one molar lost antemortem. One third molar agenesis. LEH on one canine.

Burial 60

Summary: Virtually complete well preserved but fragmented young adult male.

Location: Depth 1.09m. Above B's 66, 70 and 73. Mortuary Phase 5.

Skeletal completeness and preservation: Very small fragments of skull and mandible. Most postcranial bones represented but incomplete or fragmented. Bone present is well preserved but coated with concretions.

Age estimate: Young adult, based on pubic symphysis and tooth wear (grade 2-3).

Sex estimate: Male, based on pelvis.

Stature estimate: 165.0 cm, based on field measurement of tibia.

Dental completeness and pathology: 11 teeth recorded. No caries, slight calculus.

Burial 61

Summary: Virtually complete variably preserved young adult male.

Location: Depth 1.27m. Above B67. Mortuary Phase 5.

Skeletal completeness and preservation: Most of skull present but degraded and distorted, with fragile bone. Most postcranial bones represented but incomplete with bone in good condition.

Age estimate: Young adult, based on tooth wear (grade 2-3).

Sex estimate: Male, based on cranium and sciatic notch fragment.

Stature estimate: No estimate.

Skeletal pathology: poor preservation of the spine so there is no bony evidence of damage from an iron projectile, which was lodged beside the bodies of T12/L1, medial to the transverse processes.

Dental completeness and pathology: 18 teeth recorded. No caries, moderate calculus. One third molar agenesis, one impacted.

Comments: buried prone with an iron projectile lodged in the thoraco-lumbar spine.

Burial 62

Summary: Virtually complete but poorly preserved skeleton of a mid adult female.

Location: Depth 1.54m. Adjacent to B69. Mortuary Phase 4C.

Skeletal completeness and preservation: Most of skull present but flattened antero-posteriorly. Most postcranial bones represented but incomplete, with bone poorly preserved and very fragile.

Age estimate: Mid adult, based on tooth wear (grade 3-6).

Sex estimate: Female, based on cranium and sciatic notch fragment.

Stature estimate: 151.4, based on field measurement of humerus.

Dental completeness and pathology: All teeth recorded. Four caries, slight calculus. No teeth lost or missing antemortem. No LEH.

Comments: Mid age woman of short stature.

Burial 63

Summary: Very incomplete, poorly preserved skeleton of an infant ~ 6months.

Location: Depth 1.62m. Beyond feet of B62. Mortuary Phase 4C.

Skeletal completeness and preservation: Skull unidentifiable fragments and teeth. Postcranial skeleton incomplete and fragmented. Bone fragile.

Age estimate: 3-9 months, based on dental formation.

Dental completeness: 10 unerupted deciduous teeth present.

Comment: Buried with many bronzes and pots.

Burial 64

Summary: Incomplete, poorly preserved, partially disarticulated, adult of unknown age. Possibly a female.

Location: Depth 1.57m. East of B67. Mortuary Phase 5.

Skeletal completeness and preservation: Lower limbs and hands in anatomical position, and disarticulated pelvic and forearm fragments. Not well preserved.

Age estimate: Adult, based on bone size.

Sex estimate: Female?, based on gracility.

Stature estimate: No estimate.

Burial 65
Summary: Disarticulated, very incomplete but well preserved, concreted adult of unknown age, possibly a male.
Location: Depth 1.02m. Scattered over Burial 68. Mortuary Phase 5.
Skeletal completeness and preservation: Disarticulated partial lower limb bones. Well preserved but coated with concretions.
Age estimate: Adult, based on size.
Sex estimate: Male?, based on robusticity.
Stature estimate: No estimate.
Burial 66
Summary: Incomplete in good condition mid age male.
Location: Depth 1.52m. Under B60, over B70. Mortuary Phase 5.
Skeletal completeness and preservation: Skull represented by lateral half of right side and mandible only. Postcranial skeleton represented by shoulders, spine and legs, in good condition.
Age estimate: Mid adult, based on tooth wear (grade 2-6).
Sex estimate: Male, based on long bone dimensions (tibia antero-posterior diameter 37.5mm) occipital and mandible.
Stature estimate: 167.0cm based on field measurement of tibia.
Dental completeness and pathology: 18 teeth recorded. No caries, slight to moderate calculus. Right maxillary incisor missing.
Burial 67
Summary: Virtually complete but poorly preserved young adult of unknown sex.
Location: Depth 1.57m. Beneath B61. Mortuary Phase 5.
Skeletal completeness and preservation: Most of skull, without face, represented but crushed. Most postcranial bones represented but incomplete. Bone fragmented in poor condition.
Age estimate: Young adult, based on tooth wear (grade 2-4).
Sex estimate: No estimate. Skull feminine but mandible depth masculine. Possibly young male?
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: 26 teeth recorded. Two caries, moderate calculus. Right mandibular incisor missing.
Comments: Loose bones, including a mandible, of another person over and around this skeleton.
Burial 68
Summary: Very incomplete, well preserved but concreted young adult male.
Location: Depth 1.25m. With B65 scattered over. Mortuary Phase 5.
Skeletal completeness and preservation: Skull represented by vault and mandible fragments. Postcranial represented by right leg and feet fragments. Bone in good condition but concreted.
Age estimate: Young adult, based on tooth wear (grade 2-5).
Sex estimate: Male?, based on mastoid process and robusticity.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: 25 teeth recorded. No caries, moderate calculus. No LEH.
Burial 69
Summary: Virtually complete, preservation variable fair to good, young adult male.
Location: Depth 1.82m. Above B85, 86. Mortuary Phase 4C.
Skeletal completeness and preservation: Skull complete but crushed and compressed. Most postcranial bones represented but incomplete. Bone in fair -good condition.
Age estimate: Young adult, based on maturation of axial skeleton and tooth wear (grade 2-4).
Sex estimate: Male, based on pelvis and cranium. Mandible feminine.
Stature estimate: 167.9, based on femur, lab measurement.
Skeletal pathology: None recorded.
Dental completeness and pathology: All teeth recorded. No caries, slight-moderate calculus. One third molar agenesis. Right maxillary lateral incisor missing. LEH on two canines.
Comments: buried with 4 bronze belts, bronze earrings, and an iron knife.
Burial 70
Summary: Secondary burial of an infant aged 3 years. Very incomplete and poorly preserved.
Location: Depth 1.77m. Secondary burial beyond the head of B66, over the feet of B73. Mortuary Phase 5.
Skeletal completeness and preservation: No skull. Postcranial skeleton very fragmented and fragile.
Age estimate: Child 3 years, based on dental formation.
Skeletal pathology: None recorded.
Dental completeness and pathology: Mixed dentition. Permanent dentition not erupted, no caries, LEH on all deciduous teeth.
Burial 71
Summary: Very incomplete fragments, fair preservation, of a full-term infant.
Location: Depth 1.77m. Adjacent to B70. Mortuary Phase 5.
Skeletal completeness and preservation: Fragments of skull vault, ribs and right scapula and femora.
Age estimate: Full-term neonate, based on dental formation
Dental completeness: Crowns of four deciduous teeth.
Comments: Identified by a bangle.
Burial 72

Summary: Very incomplete, well preserved adult of unknown age and sex.
Location: Depth 1.45m. To west of B59. Mortuary Phase 5.
Skeletal completeness and preservation: Part left upper chest and limb only, good preservation.
Age estimate: Adult, based on bone size.
Sex estimate: No estimate.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Burial 73
Summary: Incomplete poorly preserved adult of unknown age and sex.
Location: Depth 1.77m. B70 over the feet. Mortuary Phase 5.
Skeletal completeness and preservation: Most of skull present but crushed superior-inferiorly. Most postcranial bones represented but incomplete and fragmented. Bone fragile, although legs in fair condition.
Age estimate: Mid adult, based on tooth wear (grade 2-6).
Sex estimate: No estimate. Cranium equivocal.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: 19 teeth recorded. Two caries, slight-moderate calculus. LEH on two teeth.
Burial 74
Summary: Incomplete and poorly preserved young adult male.
Location: Depth 2.29m. Mortuary Phase 4C. Beneath and to west of B69.
Skeletal completeness and preservation: Most bones represented but very fragmented. Bone fragile. Rice burial
Age estimate: Young adult, based on tooth wear (grade 2-5).
Sex estimate: Male? Based on clavicle length (165mm). Skull equivocal.
Stature estimate: 171.6, based on femur and tibia.
Skeletal pathology: none recorded.
Dental completeness and pathology: All teeth recorded. One caries, slight-moderate calculus. Both right lateral incisors missing. No LEH.
Comments: Rice burial.
Burial 75
Summary: Incomplete poorly preserved adolescent 16-20 years of unknown sex.
Location: Depth 2.48m. Mortuary Phase 4C.
Skeletal completeness and preservation: Most bones represented but very fragmented. Bone fragile. Rice burial
Age estimate: 16-20 years, based on epiphyseal fusion (distal tibia, fibula unfused). Tooth wear not included in estimate: grade 2-4.
Sex estimate: No estimate.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: 13 teeth recorded. One caries, slight-moderate calculus. LEH on two teeth.
Comments: Rice burial. Bones blackened, in a very deep grave cut.
Burial 76
Summary: Incomplete poorly preserved mid adult of unknown sex.
Location: Depth 2.48m. Mortuary Phase 4B, south of the rest of the cluster.
Skeletal completeness and preservation: Most bones represented except cranium. but very fragmented. Bone very poor condition. Rice burial.
Age estimate: Mid adult, based on mandibular tooth wear (grade 3-6).
Sex estimate: No estimate.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: 13 teeth, all but two mandibular. No caries, no calculus recordable. One third molar agenesis. Left lateral mandibular incisor missing.
Comments: Rice burial with no cranium.
Burial 77
Summary: Incomplete but well preserved late-foetal or full-term infant.
Location: Depth 2.18m. Mortuary Phase 4B.
Skeletal completeness and preservation: Most bones represented, incomplete but in good condition. No teeth.
Age estimate: Late foetal or full-term neonate, based on diaphyseal lengths.
Skeletal pathology: None recorded.
Comments: Not a jar burial, with a bronze bangle.
Burial 78
Summary: Secondary burial, incomplete with variable preservation. Mid age adult of unknown sex.
Location: Depth 2.39m. Mortuary Phase 4A. Secondary burial.
Skeletal completeness and preservation: Most bones except the pelvis represented but with mixed preservation.
Age estimate: Mid adult, based on tooth wear (grade 4-6).
Sex estimate: No estimate. Skull and long bone dimensions equivocal.
Stature estimate: No estimate.
Skeletal pathology: One thoracic vertebral body has anterior collapse (wedge-shape). There is no clear aetiology for this, which may have been traumatic or possibly indicative of osteoporosis. Left tibia shaft has an area of periostitis on the anterior medial, extending ~ 30cm along the bone, centred on a slightly raised area of bone, which is coated and damaged so any surface/penetrating lesion would not be visible.
Dental completeness and pathology: 27 teeth recorded, many lost postmortem. Both mandibular lateral incisors missing. One third molar agenesis.
Comments: with glass beads. Bones filled with red sandy

soil but buried in dark matrix - indicates removal some distance from original burial site.

Burial 79

Summary: Incomplete poorly preserved infant 3-9 months.

Location: Depth 2.29m. Mortuary Phase 4B. one of group of infants, east of B31.

Skeletal completeness and preservation: Incomplete fragments including the skull and some long bones.

Age estimate: 3-9 months, based on dental formation.

Dental completeness: Crowns of five deciduous teeth.

Comments: bronze bangles and anklets, rice burial.

Burial 80

Summary: Grave cut with no bones recovered.

Location: Depth 2.71m. Mortuary Phase 4A. Grave cut filled with rice, no bone recovered.

Skeletal completeness and preservation: No bone recovered.

Comments: Bronze bangles, anklets, agate and glass beads, a spindle whorl and pots recovered.

Burial 81

Summary: Incomplete, well-preserved but cemented together. Full-term infant.

Location: Depth 2.33m. Mortuary Phase 4B. One of a group of infants.

Skeletal completeness and preservation: Bones present concreted together.

Age estimate: Full-term neonate, based on dental formation.

Dental completeness: Crown of one deciduous tooth.

Comments: Yellow-green glass beads; bronze bangles and anklets.

Burial 82

Summary: Incomplete very poorly preserved mid adult female.

Location: Depth 2.45m. Mortuary Phase 4C.

Skeletal completeness and preservation: Most bones represented but very fragile fragments.

Age estimate: Mid adult, based on tooth wear (grade 3-6).

Sex estimate: Female, based on skull.

Stature estimate: No estimate.

Skeletal pathology: No observations possible.

Dental completeness and pathology: 27 teeth recorded. One caries, slight-moderate calculus. Four teeth lost antemortem. Four teeth with LEH.

Comments: Heavily degraded rice burial.

Burial 83

Summary: Grave cut with no bones.

Location: Depth 2.31m. Mortuary Phase 4B.

Comments: Identified on the basis of a pot and glass beads.

Burial 84

Summary: incomplete well-preserved scatter of disarticulated adult bones of unknown age. Possibly male.

Location: Depth 2.43m. Mortuary Phase 4B.

Skeletal completeness and preservation: Humerus, hand and foot bones, in good condition.

Age estimate: Adult, based on size.

Sex estimate: Male?, based on robusticity and width of distal left humerus (63.5mm).

Stature estimate: No estimate.

Skeletal pathology: None observed.

Comments: These are too large to belong to the only adult burials in the vicinity (B98, B99).

Burial 85

Summary: Fragmentary infant.

Location: Depth 2.45m. Mortuary Phase 4C. Rice burial.

Skeletal completeness and preservation: Fragments of vertebrae, long bones.

Age estimate: Full-term neonate based on size.

Burial 86

Summary: Secondary burial, very incomplete and very poorly preserved, young adult possibly a male.

Location: Depth 2.30m. Mortuary Phase 4C.

Skeletal completeness and preservation: Secondary burial, minimal very poorly preserved, fragile fragments.

Age estimate: Young adult, based on tooth wear (grade 3-5).

Sex estimate: Male?, based on mandible.

Stature estimate: No estimate.

Skeletal pathology: No observations possible.

Dental completeness and pathology: 25 teeth recorded. No caries, slight-moderate calculus. One tooth with LEH. Agenesis all third molars.

Comments: Heavily degraded incomplete secondary rice burial.

Burial 87

Summary: Very incomplete, poorly preserved adult of unknown age and sex.

Location: Depth 2.55m. Mortuary Phase 4C.

Skeletal completeness and preservation: distal fibulae and feet only, very poorly preserved.

Age estimate: Adult, based on size.

Sex estimate: No estimate.

Stature estimate: No estimate.

Skeletal pathology: Proximal first phalanx of right foot has a lesion, possibly infectious, on dorsal surface.

Comments: Heavily degraded very incomplete rice burial.

Burial 88

Summary: Virtually complete, very well preserved full-term infant jar burial.

Location: Depth 2.46m. Mortuary Phase 4C. In cluster of jar burials with B89, B90 and B100.

Skeletal completeness and preservation: Complete except fragmented skull, very well preserved.

Age estimate: Full-term neonate, based on dental formation.

Comments: Jar filled with rice but nevertheless in excel-

lent condition.
Burial 89
Summary: Very incomplete, fragmented but well preserved late foetal infant jar burial.
Location: Depth 2.52m. Mortuary Phase 4C. In cluster of jar burials with B88, B90, B100.
Skeletal completeness and preservation: Fragments of axial and appendicular postcranial, but well preserved. Skull very fragmented and fragile. No teeth.
Age estimate: Late foetal, based on diaphyseal lengths.
Burial 90
Summary: Virtually complete, well preserved full-term infant jar burial.
Location: Depth 2.45m. Mortuary Phase 4C. In cluster of jar burials with B88, B89, B100.
Skeletal completeness and preservation: Most bones represented, well preserved.
Age estimate: Full-term infant, based on dental formation.
Burial 91
Summary: Very incomplete, fragmented poorly preserved 6 month old infant.
Location: Depth 2.51m. Mortuary Phase 4C. To east of B82.
Skeletal completeness and preservation: Skull and mandible fragments, with teeth.
Age estimate: Approx. 6 months, based on dental formation.
Comments: Not a jar burial; rice burial with bronze bangles and anklets.
Burial 92
Summary: Very incomplete, fragmented, variable preservation 2-4 year old infant.
Location: Depth 2.43m. Mortuary Phase 4B. Adjacent to B103.
Skeletal completeness and preservation: Very poorly represented skeleton, fragmented with highly variable preservation.
Age estimate: 2-4 years based on bone size.
Burial 93
Summary: Incomplete, fragmented but well preserved full-term infant jar burial.
Location: Depth 2.49m. Mortuary Phase 4B. Beyond feet of B98.
Skeletal completeness and preservation: very poorly represented skeleton, fragmented but good preservation.
Age estimate: Full-term infant, based on femur diaphyseal length.
Burial 94
Summary: Incomplete, good preservation, old age male.
Location: Depth 2.58m. Mortuary Phase 4A. Parallel to, and partly in, south baulk.
Skeletal completeness and preservation: Incomplete, left limbs remain in south baulk, good preservation. Skull distorted, face fragile.
Age estimate: Old adult, based on tooth wear (grade 3-8)
Sex estimate: Male, based on skull and clavicle length (155mm). Also radius maximum length (274mm).
Stature estimate: 172.7, based on the humerus.
Skeletal pathology: Both clavicles have an area of apparent remodelling/porosity near the lateral end, on the anterior/superior surface - possibly also an exostosis, similar to the evidence of leprosy on Burial 42. No observations were possible on hands or feet. On the base of the skull, the foramen magnum margin appears to have been possibly enlarged deliberately as there are no occipital condyles, but atlas superior articular facets are normal.
Dental completeness and pathology: Most teeth recorded. One caries, slight-moderate calculus. Six periapical cavities indicating infection resulting from extreme tooth wear. One tooth lost antemortem. All lateral incisors missing.
Comments: Elderly male, very tall and robust.
Burial 95
Summary: Disarticulated bones, some of which belong with B96. Others treated as loose bones.
Burial 96
Summary: Incomplete, poor preservation (rice burial), adult of unknown age or sex.
Location: Depth 2.61m. Mortuary Phase 4A. Partly disturbed. Some bones from this burial found with B95. Beneath B78.
Skeletal completeness and preservation: Most bones represented but very fragmented and poorly preserved. Cranium represented but incomplete. Loose teeth recovered with this burial do not clearly belong.
Age estimate: Adult, based on bone size.
Sex estimate: Equivocal. Sciatic notch fragment male, cranium female.
Stature estimate: No estimate.
Burial 97
Summary: virtually complete, poor preservation, infant.
Location: Depth 2.62m. Mortuary Phase 4, isolated burial.
Skeletal completeness and preservation: All bones represented except hands, poorly preserved. Skull largely complete but distorted and fragile.
Age estimate: 1.5-2.5 years, based on dental formation.
Skeletal pathology: Burial position unusual with both upper limbs fully flexed at elbow joints, left lower limb externally rotated, slightly flexed at the knee. Feet plantar flexed. Diagnosis of cerebral palsy (Tayles, 2001).
Dental completeness and pathology: No caries, wear 1-3, localised enamel hypoplasia on a single deciduous canine.
Comments: Infant with possible cerebral palsy.
Burial 98
Summary: Virtually complete, poorly preserved rice burial, old age male?
Location: Depth 2.52m. Mortuary Phase 4B. Adjacent to

B99.
Skeletal completeness and preservation: Most bones represented but fragmented and poorly preserved. Rice burial. Skull presented but very crushed and degraded.
Age estimate: old adult, based on tooth wear (grade 2-7).
Sex estimate: Male?, based on skull.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: 22 teeth recorded. No caries, no calculus recordable. One third molar lost antemortem, two periapical cavities suggesting tooth infection. Maxillary lateral incisors missing.

Burial 99

Summary: Virtually complete, poor preservation, old age female.
Location: Depth 2.43m. Mortuary Phase 4B. Adjacent to west of B98.
Skeletal completeness and preservation: Most bones represented but poorly preserved. Skull present but fragile, with cut.
Age estimate: old adult, based on tooth wear (grade 3-7)
Sex estimate: Female, based on skull and distal humerus width (52.1mm). Also radius length 222mm.
Stature estimate: No estimate.
Skeletal pathology: None recorded; skull cut through on coronal plane; detailed description in Tayles (2003).
Dental completeness and pathology: Most teeth recorded. No caries, slight calculus, five teeth lost antemortem. All lateral incisors missing. LEH on two teeth.
Comments: Elderly female, with head in a pot and extraordinary cranial cut.

Burial 100

Summary: Virtually complete, good preservation, full-term neonate jar burial.
Location: Depth 2.80m. Mortuary Phase 4C. Jar burial north of B88.
Skeletal completeness and preservation: Complete, excellent preservation. Skull crushed and partially damaged by collapse of burial jar.
Age estimate: Full-term neonate, based on dental formation.

Burial 101

Summary: Adult foot bones visible in section. No bone recovered.
Location: Depth 2.50m. Mortuary Phase 4, in eastern baulk.
Skeletal completeness and preservation: No bone recovered.
Age estimate: Adult, based on size of foot bones.

Burial 102

Summary: Very incomplete, poorly preserved, full-term neonate jar burial.
Location: Depth 1.40m. Mortuary Phase 5. Jar burial. Southwest extension of square, above Cluster 4A.
Skeletal completeness and preservation: Fragments of long bone shafts only, tibiae and possible femora.
Age estimate: Full-term neonate, based on bone dimensions.

Burial 103

Summary: Very incomplete, excellent preservation, full-term neonate.
Location: Depth 2.70m. Mortuary Phase 4B. Loose bones beneath Burial 98 jar.
Skeletal completeness and preservation: Very incomplete (right ulna and femur diaphyses, foot metatarsals and phalanx).
Age estimate: Full-term neonate, based on diaphyseal length.

Burial 104

Summary: Incomplete, good preservation, young female. Partly disarticulated.
Location: Depth 1.84m. Mortuary Phase 4A. Partly disturbed, mixed with B105,111. Lower body disturbed by B105.
Skeletal completeness and preservation: Incomplete, skull, cervical spine and upper ribs and humeri in situ, remainder of skeleton mostly represented but very fragmented. Bone generally in average condition. Skull compressed and poorly preserved.
Age estimate: Young adult, based on tooth wear (grade 2-5).
Sex estimate: Female, based on skull and greater sciatic notch.
Stature estimate: No estimate.
Skeletal pathology: None recorded.
Dental completeness and pathology: All teeth recorded except one third molar. No caries, slight-moderate calculus. Both left lateral incisors missing. No LEH.

Burial 105

Summary: Very incomplete, poor preservation, adult male secondary rice burial.
Location: Depth 2.57m. Mortuary Phase 4A. Mixed with B104, 111.
Skeletal completeness and preservation: Fragments ribs, vertebrae, other bones, disarticulated, coated and cemented. Feet and fibula in situ. No skull, mandibular fragments, no teeth.
Age estimate: Adult, based on bone size.
Sex estimate: Male, based on mandible.
Skeletal pathology: None recorded.
Comments: Secondary burial. Foot bones preserved by bronze toe rings.

Burial 106

Summary: Incomplete, excellent preservation, full-term neonate.
Location: Depth 3.88m. Mortuary Phase 2. Parallel and to south of B108.
Skeletal completeness and preservation: Incomplete, disturbed with lower limbs only preserved, in excellent condition.

Age estimate: Full-term neonate, based on diaphyseal lengths.
Comments: Disturbed extended full-term neonate.
Burial 107
Summary: Complete, excellent preservation, young male.
Location: Depth 3.99. Mortuary Phase 2. buried prone.
Skeletal completeness and preservation: Complete except distal half of right forearm. Skull complete.
Age estimate: Young adult, 16-20 years based on epiphyseal fusion (Proximal humerus, distal femur, distal fibula fusing. Sternal end of clavicle, distal radius and ulna, proximal fibula unfused). Tooth wear not used in estimate: grade 2-4.
Sex estimate: Male, based on pelvis. Skull has female characteristics but this may reflect the youth of this individual.
Stature estimate: 173.6, based on the femur and tibia.
Skeletal pathology: Hands have deformed interphalangeal joints, resorbed phalanges, areas of periostitis on phalanx shafts. Unusual remodeling of posterior of manubrium. Pathological lesions elsewhere, all suggestive of leprosy. Full description and differential diagnosis in Tayles and Buckley (2004).
Dental completeness and pathology: All teeth recorded. Third molars not yet erupted. No caries, moderate-severe calculus. All lateral incisors present. No LEH.
Comments: Tall young man buried prone with leprosy.
Burial 108
Summary: Complete, excellent preservation, old age female.
Location: Depth 3.70. Mortuary Phase 2.
Skeletal completeness and preservation: Complete, in excellent condition. Skull very slightly distorted
Age estimate: Old adult, based on pubic symphysis. Tooth wear not used in estimate: grade 2-8.
Sex estimate: Female, based on pelvis and skull.
Stature estimate: 159.3, based on the humerus.
Skeletal pathology: Diffuse joint degeneration, both appendicular and vertebral; collapsed body on vertebra T12.
Dental completeness and pathology: All teeth recorded. Eight caries, seven periapical cavities with infection from caries and extreme tooth wear. No calculus. No lateral incisors missing. LEH on one tooth.
Burial 109
Summary: Fragments, good preservation, identified as belonging to B113.
Burial 110
Summary: Incomplete, poor preservation, old age female.
Location: Depth 2.95. Mortuary Phase 4A. At right angle to B94.
Skeletal completeness and preservation: Most bones represented but fragmented and poorly preserved. Skull badly crushed and distorted
Age estimate: Old adult, based on tooth wear (grade 3-6).
Sex estimate: Female, based on sciatic notch fragment and frontal bone.
Stature estimate: No estimate.
Skeletal pathology: Multiple holes in skull (vault and facial bones), scapulae, vertebrae, pelvis, radius. Aetiology unclear but widespread distribution and specific locations suggest postmortem damage, probably by insect activity.
Dental completeness and pathology: All teeth recorded except one third molar. Two caries, two periapical cavities reflecting infection from extreme tooth wear or caries, slight-moderate calculus. Two teeth lost antemortem. Three lateral incisors missing. No LEH.
Burial 111
Summary: Incomplete, rice burial, poor preservation, young male?.
Location: Depth 2.57. Mortuary Phase 4A. Mixed with B105.
Skeletal completeness and preservation: Most bones except forearms represented, fragmented and in very poor condition. Skull very badly fragmented.
Age estimate: Young adult, based on axial skeleton maturation, tooth wear (grade 1-4).
Sex estimate: Male? Based on greater sciatic notch and cranium.
Stature estimate: No estimate.
Skeletal pathology: No joint degeneration, except right talus has a marked osteophyte on the anterior margin of the superior articular facet, which is inconsistent with the condition of other joints. There are two possible explanations; either the bone belongs to B104 or B105, or the osteophyte is evidence of trauma to the joint. There is also a possible lytic lesion in the area but poor preservation prevents definite identification. On the cranium both external auditory meati have tympanic dehiscence .
Dental completeness and pathology: 21 teeth recorded. No caries, slight-moderate calculus, LEH on one tooth.
Burial 112
Summary: Very incomplete, good preservation, infant.
Location: Depth 1.45m. Mortuary Phase 4A. Mixed with loose adult bone in a pit.
Skeletal completeness and preservation: Fragments skull vault, one tooth, ribs, vertebrae, right scapula. Good preservation.
Age estimate: 3.0 years based on size and dental formation.
Burial 113
Summary: Incomplete, poor preservation, young female.
Location: Depth 2.14. Mortuary Phase 4A. Below B109, adjacent to west baulk.
Skeletal completeness and preservation: Most bones represented, fragmented and in very poor condition. Skull very badly crushed.
Age estimate: Young adult, based on epiphyseal fusion

(bodies of sacral vertebrae 1-2 unfused, sternal end of clavicle, iliac crest recently fused). Tooth wear not included in estimate: grade 2-4.
Sex estimate: Female, based on cranium.
Stature estimate: No estimate.
Skeletal pathology: No joint degeneration, possible lytic lesion on one thoracic vertebra, although this may also be insect damage. There is also a possible lytic lesion on one hand phalanx.
Dental completeness and pathology: All teeth recorded except one third molar. No caries, slight-moderate calculus. Both maxillary left lateral incisors missing, with associated periapical cavities. LEH on four teeth.
Comment: Burial with gold beads.

Burial 114

Summary: Very incomplete, poor preservation, mid female.
Location: Depth 4.09. Mortuary Phase 2. South of B107.
Skeletal completeness and preservation: Most bones represented, very fragmented and in very poor condition. Skull mostly present but crushed laterally.
Age estimate: Mid adult, based on tooth wear (grade 3-5).
Sex estimate: Female, based on cranium.
Stature estimate: No estimate.
Skeletal pathology: None visible.
Dental completeness and pathology: All teeth recorded except one lateral incisor. No caries, slight calculus. Left lateral maxillary incisor missing. LEH on two teeth.

Burial 115

Summary: Incomplete, poor preservation, full-term neonate
Location: Depth 1.24. Mortuary Phase 5.
Skeletal completeness and preservation: Fragments of approximately half of the skeleton, fragmented and in poor condition. Skull fragmented and incomplete.
Age estimate: 4-6 months, based on dental formation
Comments: Buried with many grave offerings.

Burial 116

Summary: Very incomplete, poor preservation, full-term neonate.
Location: Depth 1.56. Mortuary Phase 5.
Skeletal completeness and preservation: Minimal fragments of cranium, mandible and two diaphyses.
Age estimate: Full-term neonate based on size.
Comments: Buried with beads.

Burial 117

Summary: Very incomplete, poor preservation, infant.
Location: Depth 2.43. Mortuary Phase 4B. Found within grave fill B99.
Skeletal completeness and preservation: Fragments of mandible and ribs, poorly preserved.
Age estimate: 2.5 years, based on dental formation.
Dental completeness and pathology: Four deciduous teeth present, wear 1-3l, enamel opacities.

Burial 118.1

Summary: Very incomplete, rice burial, poor preservation, adult.
Location: Depth 2.48. Mortuary Phase 4C. Beneath B74.
Skeletal completeness and preservation: Left forearm and tibiae, fragmented and in very poor condition.
Age estimate: Adult, based on bone size.
Sex estimate: No estimate.
Stature estimate: No estimate.
Comments: Forearm preserved by jewellery.

Burial 118.2

Summary: Very incomplete, poor preservation, adolescent.
Location: Depth 2.48. Mortuary Phase 4C. With B118.1.
Skeletal completeness and preservation: Two foot phalanges.
Age estimate: 14.5-16.0 years, based on epiphyseal fusion, (first proximal foot phalanx, proximal unfused, distal recently fused).
Summary: Very incomplete, poor preservation, full-term neonate.
Location: Depth 2.70. Mortuary Phase 4B. North of B120.
Skeletal completeness and preservation: Fragments cranium and femora and fibulae in very poor condition.
Age estimate: Full-term neonate, based on bone fragment size
Comments: Infant jar burial.

Burial 119

Summary: Very incomplete, poor preservation, full-term neonate.
Location: Depth 2.70. Mortuary Phase 4B. North of B120.
Skeletal completeness and preservation: Fragments cranium and femora and fibulae in very poor condition.
Age estimate: Full-term neonate, based on bone fragment size
Comments: Infant jar burial

Burial 120

Summary: Very incomplete, poor preservation, full-term neonate.
Location: Depth 2.70. Mortuary Phase 4B. Adjacent and to east of B31.
Skeletal completeness and preservation: Cranium, mandible and long bone fragments in poor condition.
Age estimate: Full-term neonate, based on dental formation.
Comments: Infant jar burial.

Burial 121

Summary: Very incomplete, poor preservation, infant.
Location: Depth 2.70. Mortuary Phase 4A. Beneath B104, mixed with B111.
Skeletal completeness and preservation: Fragments of cranial vault, ribs, vertebrae, appendicular skeleton, in poor condition.
Age estimate: 3 months, based on bone size.

Comments: One metatarsal or metacarpal preserved by bronze jewellery. Other fragments found with B111.

Burial 122

Summary: Very incomplete, rice burial, poor preservation, child.
Location: Depth 2.66. Mortuary Phase 4A. Beyond feet and below B94.
Skeletal completeness and preservation: Fragments of skull, ribs, forearms in very poor condition.
Age estimate: 5 years, based on dental formation.
Comments: Forearms preserved in bronze bangles

Burial 123

Summary: Very incomplete, poor preservation, full-term neonate.
Location: Depth 2.91. Mortuary Phase 4B. East of B120.
Skeletal completeness and preservation: Fragments skull, ribs, vertebrae, hands and feet in fair - poor condition.
Age estimate: Full-term neonate, based on dental formation.

Burial 124

Summary: Very incomplete, poor preservation, unknown age.
Location: Depth 2.61. Mortuary Phase 4A. Beneath B96.
Skeletal completeness and preservation: Fragments long bone shafts, probably radius and ulna, very poor condition.
Age estimate: No estimate: may be child or small adult.
Comments: Found with bronze bells.

Burial 125

Summary: Very incomplete, poor preservation, adult.
Location: Depth 4.40. Mortuary Phase 1. In north baulk.
Skeletal completeness and preservation: Fragment possible first metacarpal only.
Age estimate: Adult, based on size.
Sex estimate: No estimate.
Comments: Found with other unidentifiable bone fragments.

Burial 126

Summary: Very incomplete, poor preservation, infant.
Location: Depth 2.50. Mortuary Phase 4B. West of B99.
Skeletal completeness and preservation: Fragments of ribs and vertebrae only.
Age estimate: Infant – comparative size of vertebrae.
Comments: Infant jar burial.

Burial 127

Summary: Very incomplete, good preservation, old male.
Location: Depth 2.90m. Mortuary Phase 3B. location B2 feature 7.
Skeletal completeness and preservation: Cranium and possibly associated tibial shaft.
Age estimate: Old adult, based on tooth wear (grade 7-8)
Sex estimate: Male, based on cranium.
Stature estimate: No estimate.
Dental completeness and pathology: Complete maxillary dentition only recorded. No caries, four teeth lost antemortem, six periapical cavities. Left lateral incisors missing.

XVIII. THE ANALYSIS OF THE MORTUARY RECORD

S. TALBOT

AN IRON AGE CEMETERY

The extensive mortuary activity at Noen U-Loke is the subject of this chapter. Such activity was first revealed in excavations carried out by Wichakana in 1986 (1991; Higham 1996:221). The earliest graves found in these excavations were cut on a north-south orientation into the natural substrate and contained Bronze Age Prasat phase pots, shell disc beads and bronze and marine shell bracelets. In the next phase, burials were oriented east-west and interred with bronze bracelets, Iron Age Phimai Black vessels, agate ornaments and fragments of glass beads. In the third phase, burials were oriented north-south with Phimai tradition pots, iron tools, bronze bracelets and earrings, glass beads and an agate stud. One particularly rich grave contained an adult interred with a bronze headband, earrings and belt, iron rings, a tanged iron knife and a socketed iron tool.

The excavations of 1996-8 involved five mortuary phases (MP1-MP5), based on their relationships with stratigraphic features, and the sequence has been dated by seventeen radiocarbon determinations from the University of Waikato. The earliest phase of the burials recovered during these excavations, MP1, comprised a single, partially excavated Bronze Age grave on the northern edge of the excavation, burial 125, which contained Bronze Age Prasat phase pots. All other burials belonged to the Iron Age, spanning a period from 100-200 BC to not long after 400 AD.

Analysis of the Iron Age mortuary ritual at Noen U-Loke is not without difficulties. Some skeletons were badly disturbed and others poorly preserved. Burials were often interred in dense clusters, some extending beyond the bounds of the excavation. Nevertheless, the site possesses enormous advantages for any archaeologist attempting to understand late prehistoric Thailand. The first is the remedy it provides for the general lack of information about Iron Age society. Second is the excavation's unprecedented size, the cemetery being one of the largest yet excavated in Southeast Asia. The third is its diachronic range. The Noen U-Loke cemetery contained burials covering the course of the Iron Age (*c.* 500 BC-500 AD) to the eve of the Early Historic (*c.* 500-800 AD) period. Many mortuary analyses focus on the synchronic variation within a cemetery, but rather than attempting an archaeological ethnography of a specific point in time, in this case it is the site's diachronic range that shapes further analysis.

THEORIES OF MORTUARY ANALYSIS

The classic theories of Hertz and van Gennep
Archaeological mortuary analysis rests on the century-old foundation of the works of Hertz (1960, first published 1907) and van Gennep (1960, first published 1908). Both these students of Durkheim asserted that mortuary practices were idealised emulations of the existing social order, involving the creation of "a world analogous to ours, but more pleasant, and of a society organized in the same way as it is here" (van Gennep 1960:152).

For Hertz (1960), three entities were involved in mortuary ritual - the corpse, the soul and the living. With the death of an individual, a community lost more than just a unit, but was "stricken in the very principle of its life, in the faith it has in itself" (1960:78). Similarly, in a contemporary rural Thai context, death was a calamity to the family and to the community (de Young 1963:73-74). According to Hertz (1960), to sustain itself, a society could not admit that a once-integral individual could be lost to it forever, for to do so would be to disprove the immortality of the society itself, and the power of the relationships that held it together. The deceased instead entered a mythical ideal society of departed souls, which each society constructed in its own image, but free of external constraints and physical necessities.

For van Gennep (1960), death was the most important of all rites of passage. A three-stage ritual process allowed a society to deal with such events (see also Leach 1976). Firstly, rituals such as burning the deceased's possessions expressed their separation from the world. Next, their life-death transition was given shape through liminal rites such as cremation and burial. Finally, the deceased was incorporated back into society in a new form, through communal rites such as feasting in honour of ancestors.

The most important theoretical development since Hertz and van Gennep has been that mortuary practices are actively associated with economic behaviour and political roles (see for example Bartel 1982; Bloch 1971; Bloch and Parry 1982; Geertz 1980; Hodder 1982a; Metcalf and Huntington 1991; Strathern 1981; Weiner 1976). Mortuary practices *create* social order as much as reflect it. For example, in western Canada the ranked society of the Tlingit was largely constituted through the "mortuary/ancestral complex" of the potlatch (Kan 1989). Death allowed the living to renegotiate their own relationships and claims of social position in relation to the dead, the ancestors and the gods, and to an idealised version of society:

"In these rites, an attempt was made to reach agreement on the current distribution of power and prestige among the participating individuals and groups, by arranging all of them in a hierarchy . . . we see a contrast between everyday life where conflicts and disagreements between matrilineal relatives were common, and ritual in which they tried to achieve maximum cooperation and present a unified front to members of the opposite moiety. At the same time, the intermoeity relations themselves, which tended to be fragile and sensitive, were presented as harmonious" (Kan 1989:9-10).

The anthropological distinction between social structure and social system can be a useful one for archaeologists (Leach 1977; Pader 1982; Giddens 1979; Hodder 1980, 1982a; Morris 1987). A social system comprises a society's patterns of relationships, communication, power, dependence, authority, resources and trade. The framework is ecological, and archaeologists often talk about social systems in terms of degrees of complexity and relationships between subsystems such as trade and subsistence. Conversely, social structure is an ideal model or a mental template of the relative placings of individuals within the world that is created in practice largely through rituals such as the funeral (see Morris 1987:30-39). It comprises the rules and concepts that order and give meaning to the social system, including ideologies of domination, and symbolic principles such as purity and hygiene. It is continually renegotiated and manipulated, and part of the changing strategies and relations of power between different groups.

Social structure is clearly closely linked to the concept of an ideal society of the dead created by the living. For the Burmese Kachin, social structure comprised the approved "proper" relations between individuals and groups that were not always formally recognised. Nevertheless if anarchy was to be avoided, individuals had to be reminded occasionally of the underlying order that guided their activities. Ritual performances such as funerals momentarily made explicit what was otherwise "a fiction" (Leach 1977:15-16). The archaeological record captures something of this "fiction", that is elements of social structure rather than social system.

Hertz (1960) had in fact described similar links between ritual, societal ideals and political power in the case of the Huron "Feast of Souls". Recently buried bodies were exhumed by their families, decorated, and taken to distant central meeting places where feasting and distribution of goods took place. The bones of the individual were subsumed into the Huron nation, which could then claim the power of all the ancestors:

". . . by dealing with all their dead in common, the various domestic and local groups that form the higher unity become conscious of, and consequently maintain, the ties that bind them. In establishing a society of the dead, the society of the living regularly recreates itself (Hertz 1960:71-72).

Thus through mortuary ritual the society of the living can in fact recreate itself twice over: as an ideal society for the dead *and* as an ongoing political entity in the world of the living.

Theoretical approaches to archaeological mortuary analysis

The last thirty years have seen considerable theoretical debate concerning archaeological mortuary analysis. By the early 1970s many archaeologists had adopted the "New Archaeology", an explicitly scientific approach, which hypothesised that societies could be understood as social entities from their mortuary practices alone (Trigger 1989; Preucel 1991a, 1991b; Brown 1995; Preucel and Hodder 1996). Binford's important and complex (1971) study, in which he tested associations between mortuary variety and schemes of social complexity using enthographic data, remains an archaeological touchstone (Brown 1995; Carr 1995; O'Shea 1996). Around the same time, Saxe (1971; Brown 1995) used information and role theory to examine patterns in the physical remains of the dead. Both Binford and Saxe proposed similar "representative" relationships between societies and their mortuary rituals:

"Assuming an individual's treatment at death is a reflection of the position occupied in a status system in life, and that differences between individual treatments reflect the type of status system participated . . . the outlines of extinct social systems should be ascertainable" (Saxe 1971:39)

In this context, mortuary variability explicitly reflected the organization of society, and economic factors, rather than religion, philosophy or ideals, were the main cause of variation in burial behaviour (Parker Pearson 1995). The treatment of the corpse related to the marking of social identities that the individual had achieved in life (Barrett 1996:394-395). An explicit link between burial and society became central to much subsequent analysis. Many investigators concentrated on the identification of rank, matching patterns of burial to models of social complexity and a variety of different means for determining rank from the archaeological record were developed (Brown 1981; Wason 1994). For example, Shennan (1975) used an intuitive method based on types of grave goods, Tainter (1978) elaborated an effort-expenditure approach, Peebles and Kus (1977) included symbols of authority and Mainfort (1985) used historical trade records.

However, even at the time that the representationist position was forming, some suggested that the situation was more complex than might be convenient. Ucko's (1969) cautionary tales warned against common assumptions such as relationships between rich tombs and ruling classes. The complex natures of the archaeological record and of archaeological methodology were also considered and their limitations identified (Buikstra 1981; Brown 1995;

O'Shea 1984; Schiffer 1996). For example, human remains were subject, just like other archaeological artefacts, to a variety of reuse and depositional processes (Schiffer 1996:81) and sample sizes were often too small to enable meaningful statistical analysis (Jacobsen and Cullen 1991; Orton and Hodson 1981).

From the 1980s, the representationist model was challenged as part of a general "postprocessual" critique of archaeology (Hodder 1980, 1982a, 1982b, 1982c, 1991; Parker Pearson 1982a, 1982b, 1999; Shanks and Tilley 1987; Patterson 1989a, 1989b). One strand of such theory uses a textual metaphor, considering archaeology "not a matter of discovery, but rather one of interpretation" (Charles 1995:78; see also Hodder 1991; Preucel 1991b). A second, Marxist, strand deals with power, domination, and the production of knowledge (Tilley 1984; Shanks and Tilley 1982; Parker Pearson 1982a, 1982b, 1984). A third is concerned with ideology, communication and the historical specificity of knowledge (Leone 1984, 1991; Leone and Potter 1988). Another strand is the archaeology of gender (Conkey and Spector 1984, 1991; Dommasnes 1992; Hays-Gilpin and Whitley 1998).

The major contribution of these post-processual critiques was a realisation similar to that seen in anthropology, that mortuary ritual did not necessarily reflect actual social or political relations, but, as an idealised expression, could blur or even disguise them (Parker Pearson 1982a:112; cf. Hertz 1960).

Even lack of belief in an afterlife does not alter the nature of the ritual, in that the process in question is the reintegration of the deceased into the current society (in an ideal form) as a means to perpetuate the structure and worldview of the group. For example, in contemporary Western societies, the simplicity of high status burials hides status differentiation (Parker Pearson 1982a; McGuire 1988; see also Shanks and Tilley 1982; Pader 1982; Morris 1987). Mortuary practices were not a microcosm of social organization, but "the material expression and objectification of idealised relationships formulated about the dead by different individuals or groups within society" (Parker Pearson 1982a:110). In death people often become what they have not been in life (Hodder 1980:168).

The theoretical debate is still far from resolved although there have been recent attempts at détente (Brown 1995:21; Charles 1995; Chesson 1999; Renfrew and Bahn 1991; Thomas 1995; Preucel 1991a, 1991b; Preucel and Hodder 1996; Trigger 1989; Yoffee and Sherratt 1993; Ucko 1995). For example, "cognitive-processual archaeology" synthesises aspects of post-processualist thought, such as the role of ideology, into a processual tradition (Renfrew and Bahn 1991; Renfrew and Zubrow 1994; Renfrew and Scarre 1998). Similarly, Marxist "dialectical archaeology" has empirical concerns, such as how people made a living, but rejects the view that archaeologists can achieve objective understanding and stresses active participation (McGuire 1992:84-85).

Practical conclusions can be drawn from the debate. Firstly, the active roles of mortuary ritual and material culture in constructing society must be considered, in that the deceased are often manipulated for purposes of status aggrandisement between living groups (Parker Pearson 1982a:112, 1984, Kristiansen 1984). Mortuary analysis in archaeology is a consideration of the remains of the dynamic creation of social *structure*. Secondly, a contextual approach using long-term regional studies of mortuary remains in conjunction with other aspects of the archaeological record is desirable, if not always possible (Morris 1987, Beck 1995, O'Shea 1996). Thirdly, a useful model is that of the palimpsest, in which analysis must progressively peel back superimposed layers of processes, treatments and meanings (O'Shea 1996:11), including the formation of the archaeological record (Schiffer 1996) and the methodology applied. Another point is that diachronic control is essential, for, as a historical process, mortuary ritual changes over time (Cannon 1989; Little *et al.* 1992). Finally, specific historical information about individual societies should be the primary goal (McGuire 1992).

The cemetery is the most complex archaeological record, being the detailed material remains of representations of societal ideals, constructed by individuals actively pursuing their own goals. A funeral is one of the most dramatic occasions for such activity, bringing together as it does life and death, the future of society and the past of the ancestors. Naturally, such complexity, power and drama also appeal to archaeologists.

THE PEOPLE

Introduction

Before the analysis of mortuary ritual, it is important to determine if any demographic groups were excluded from burial in the cemetery (Buikstra 1981; O'Shea 1996). This section describes burials in the four Iron Age phases, before addressing general issues relating to age and sex composition and burial clusters. In total 118 individual Iron Age burials were found[1]. As a general principle, human bone in an undisturbed mortuary context defined a burial, although exceptions were made. For example, burials 80 and 28 were clearly indicated by a grave cut and positioning of jewellery, but soil conditions prevented bone preservation. Description of human remains was based on the preliminary results of morphological studies by the anatomists of the OAP - Dr Nancy Tayles (pers. comm.), Dr Hallie Buckley (pers. comm.), Dr Kate Domett and Kirsten Nelsen.

Many burials had been disturbed by the practice of inhumation of individuals in non-random mortuary clusters. While disturbed burials were often incomplete, they provided significant information, and patterns of disturbance were also informative. Note that disturbed is used as a preferred term to "secondary" due to the latter's association with mortuary rituals of deliberate second-

ary burial. It was also clear from the partially excavated burials along the walls of the excavation that the cemetery extended beyond the area excavated. Age categories were: neonate (foetal and newborns to 3 months); infant (between 3 months and 6 years); child (7-14 years); adult.j (juveniles of 15-19 years); adult.y (young adults of 20-29 years); adult.m (middle adults of 30-39 years); adult.s (senior adults of 40 years or more); and adult.u (adults of unknown age) (see also Domett 1999, 2001; Tayles 1999). Adult skeletons were also assigned a sex category based on anatomical determinations. While several of the sex assignments could not be conclusive, to exclude these burials from demographic analysis would have been potentially misleading. For example in MP3 Cluster B, all but one of the five definite adult identifications were female, although other burials were probable males.

The Burials

In the small sample of MP2, both sex and age were represented evenly across the demographic categories (Fig. 18:1 and Fig. 18:2). At this time, the burials were spatially dispersed across the site. According to radiocarbon dates, the MP2 burials belong to a period between 200-400 BC and 200-1 BC. As such, they can be considered as early Iron Age burials. Two males were buried adjacent to one another, one oriented to the north and the other to the south (burials 26 and 27). Their spatial arrangement, as the only such grouped burials in the phase, suggests that their deaths took place at the same time, and perhaps as part of the same event.

MP3 contained two burial clusters (Figs. 18:3 and 18:4) and an isolated neonate jar burial. Disturbed burials were associated with repeated inhumations at the same location. These burials sometimes consisted of the undisturbed lower extremities of adults, perhaps suggesting that graves were originally marked on the surface at the head end. Several of these isolated extremities were adorned with bronze bells and anklets, indicating that the individual had probably been interred with rich grave goods. For example, burial 54 comprised only the tibiae and fibulae of a senior adult, but was adorned with twenty-one bronze bells on the left foot and seven rings on the left toes. Some individuals were interred in a "bed" of rice, considered in this analysis as a special kind of grave good. The practice of burying very young infants in mortuary jars was also found during this phase. Radiocarbon dates suggest that the MP3 Cluster A graves to the north belong to the first two centuries AD, with the slightly higher MP3 Cluster B graves to the south being marginally later.

In MP4, four distinct burial clusters were represented, together with several isolated burials (Figs. 18:5 and 18:6). Radiocarbon dates suggest MP4 Cluster A, to the west, belongs to the second or third centuries AD, marginally later than the graves of MP3. MP4 Cluster A was situated at the edge of the excavation and not completely excavated. It contained nine adults, both male and female, and a single subadult. Many of the skeletons were poorly preserved and individuals were buried closely together, often disturbing other burials. Those burials disinterred by subsequent burials were sometimes reinterred in a bundled or crouching position (eg burial 78). One grave (burial 105) had a clay cap and another (burial 113) had a clay lining and cap.

The demographic composition of MP4 Cluster B was very different. It contained fourteen subadults (eight neonates), and only four adults, one of which (burial 76) was perhaps interred outside of the cluster. Two of the adults, a male and a female (burial 98 and 99), were over forty years of age. MP4 Cluster C contained four neonate jar burials (burials 89, 88, 90 and 100) in a cluster to the north of nine adult burials, and three other subadults. Two disturbed and incomplete burials at the base of the cluster could not be aged. MP 4 Cluster D contained three adult burials, including a mature adult male and a mature adult female, and an infant.

Unfortunately, there is no stratigraphic evidence to provide a relative chronology for MP4 Cluster A, MP4 Cluster B, and MP4 Cluster C, although the likelihood that the clusters are contemporary is a strong one (Higham pers. comm.). The radiocarbon dating of MP4 Cluster D burials to the north suggests that its perhaps slightly later graves lie within the period 200-400 AD.

All but two of the MP4 burials found outside clusters were infants or neonates. A single adult (burial 94) lay on the very edge of the excavation and may belong to another cluster with two subadults, burial 112 and burial 122. Another burial consisted of the disturbed remains of a young adult female (burial 16). In addition, three neonate jar burials (burials 17, 18 and 19) were found in a cluster in the northwest corner of the excavation, and another (burial 43) was found in isolation. Burial 97 was also found in isolation and contained a unique individual. Within the grave was found the skeleton of an infant of 1.5-2.5 years of age, apparently with a serious congenital condition, possibly cerebral palsy (Tayles pers. comm.).

Finally, MP5 burials may date to a considerable period (*c.*250 AD-400 AD). While a very few burials were superimposed, perhaps indicating some cultural remnants of earlier practices, burials did not form the large demographically mixed clusters of earlier phases, which were perhaps at least partly defined in relation to one another (Figs. 18:7 and 18:8). Consequently, MP5 burials were generally disturbed because of proximity to the surface (as little as half a metre below the current ground level), rather than the repeated inhumation of individuals at the same location.

Age and sex at Noen U-Loke

As mentioned, before the analysis of mortuary ritual, it is important to determine if any demographic groups were excluded from burial in the cemetery (Buikstra 1981; O'Shea 1996). In general, the age/sex profile of the entire

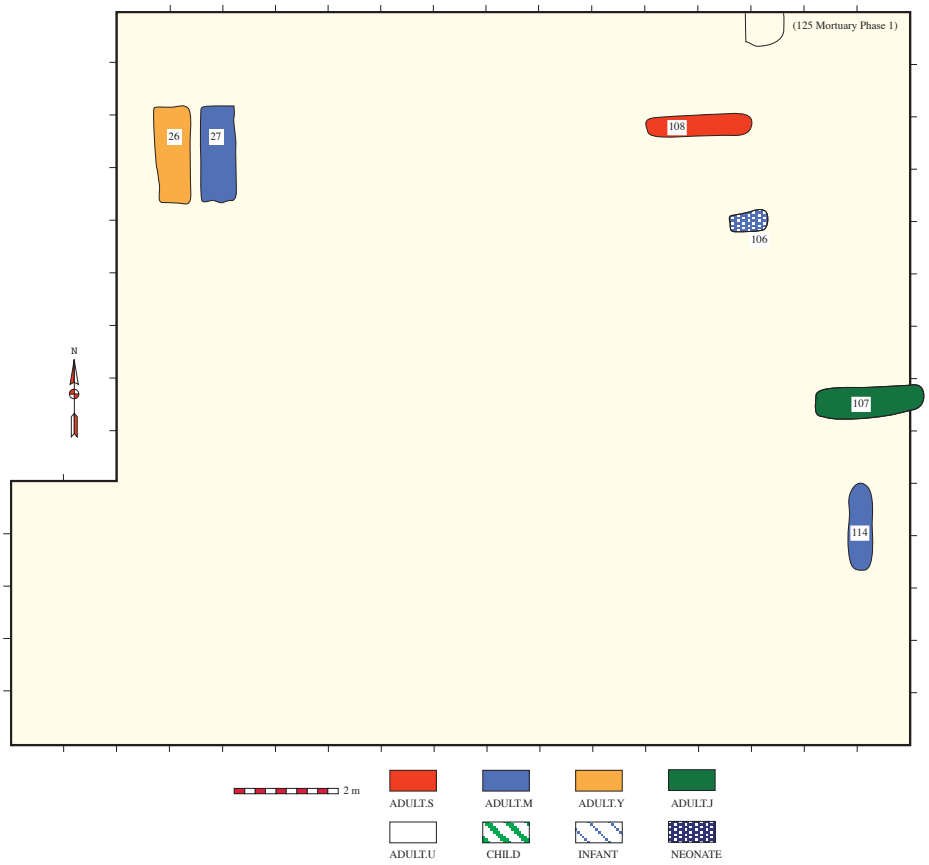


FIG. 18:1 Mortuary Phase 2 burials by age

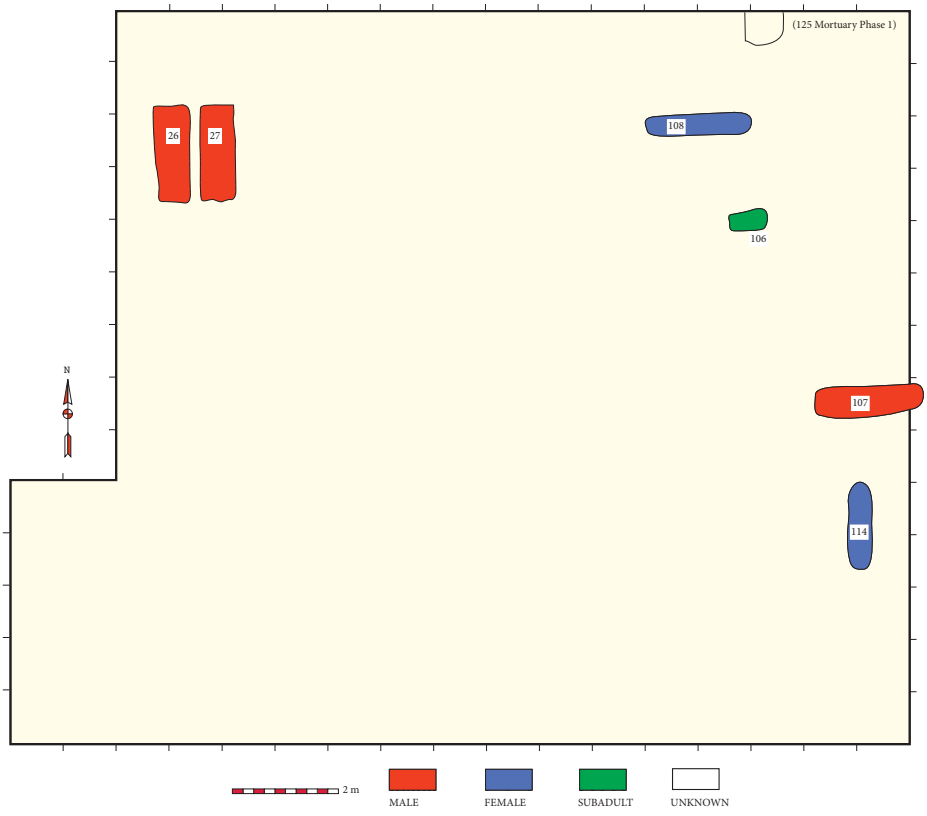


FIG. 18:2 Mortuary Phase 2 burials by sex

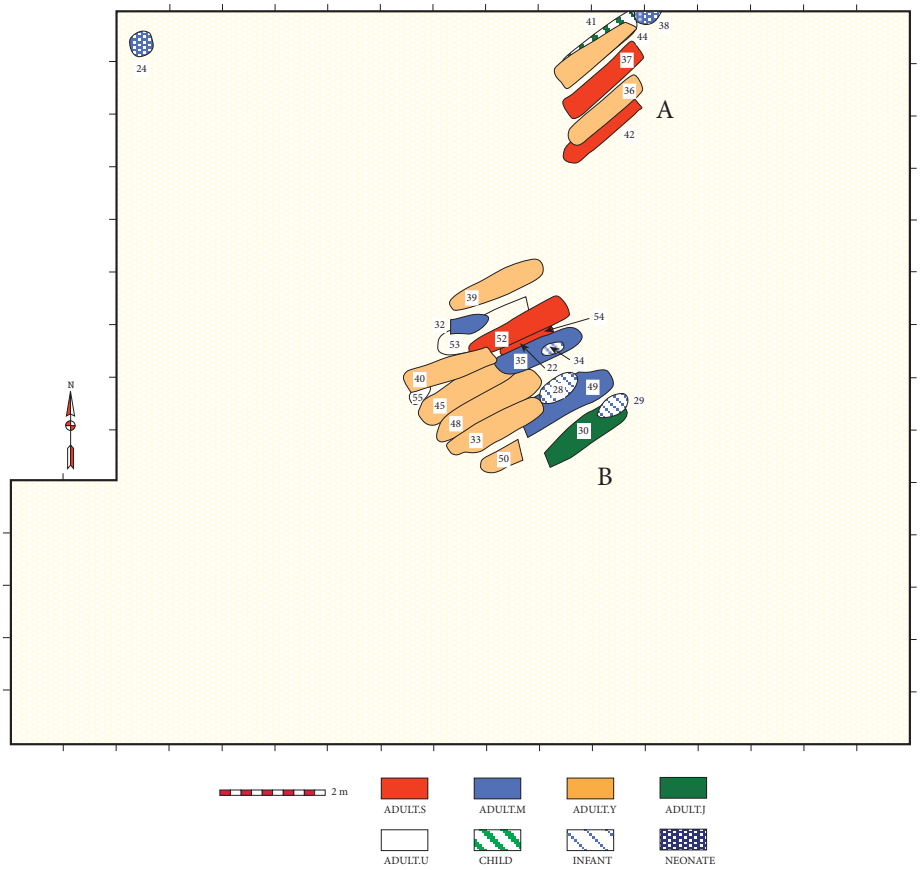


FIG. 18:3 Mortuary Phase 3 burials by age

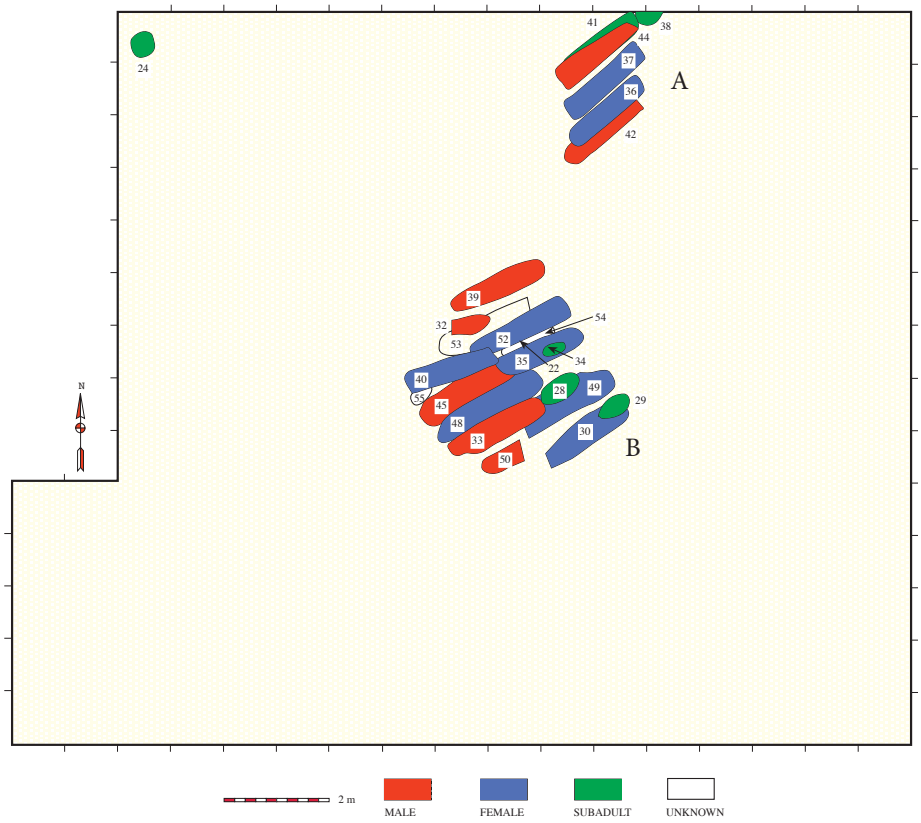


FIG. 18:4 Mortuary Phase 3 burials by sex

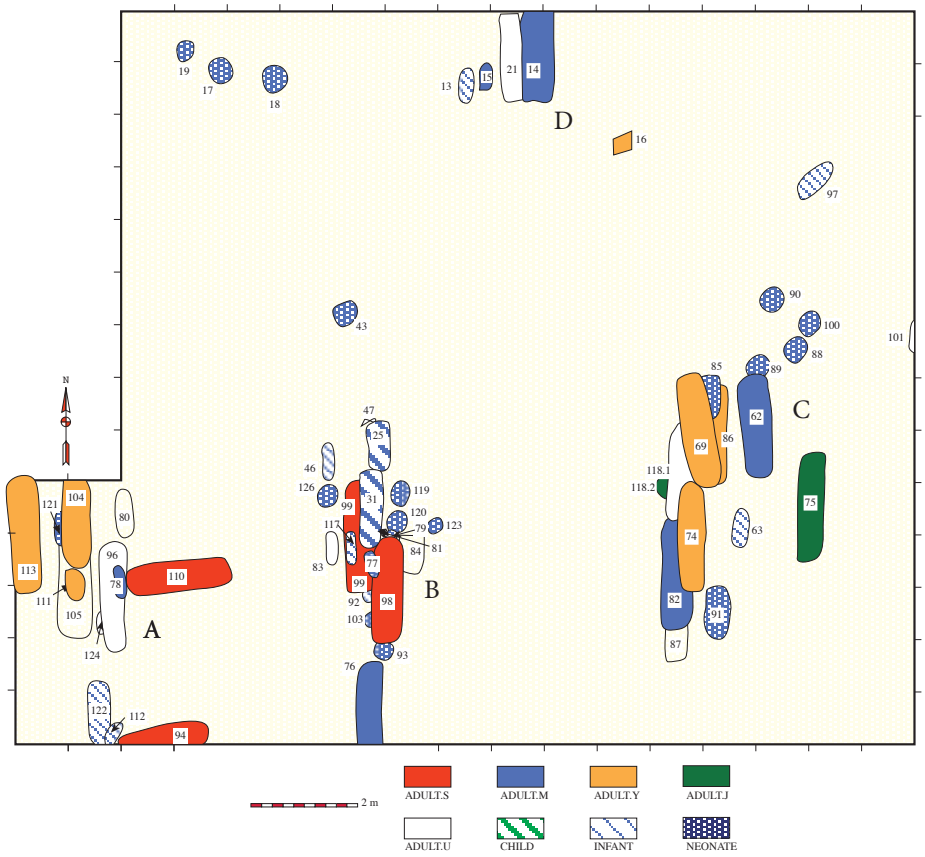


FIG. 18:5 Mortuary Phase 4 burials by age

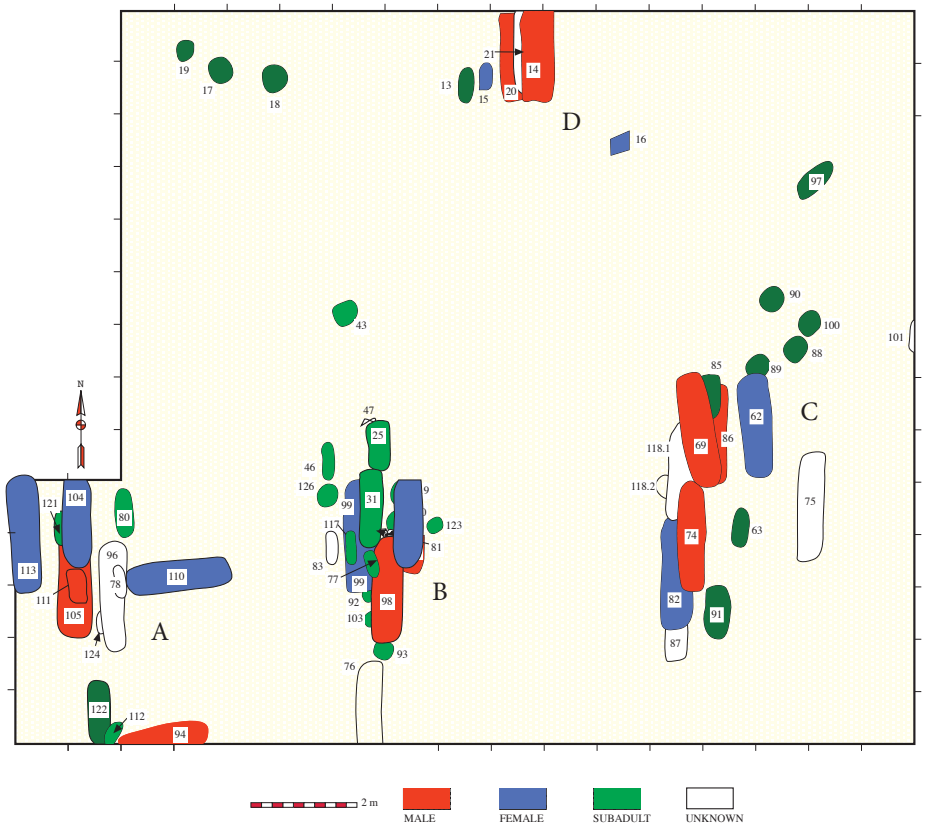


FIG. 18:6 Mortuary Phase 4 burials by sex

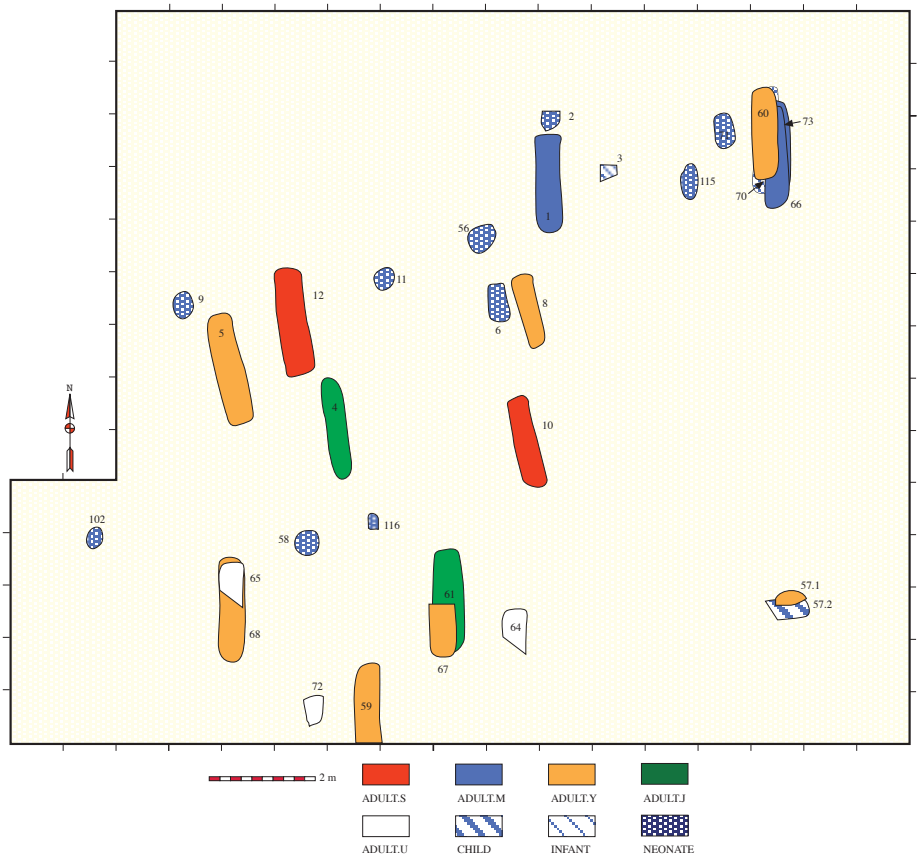


FIG. 18:7 Mortuary Phase 5 burials by age

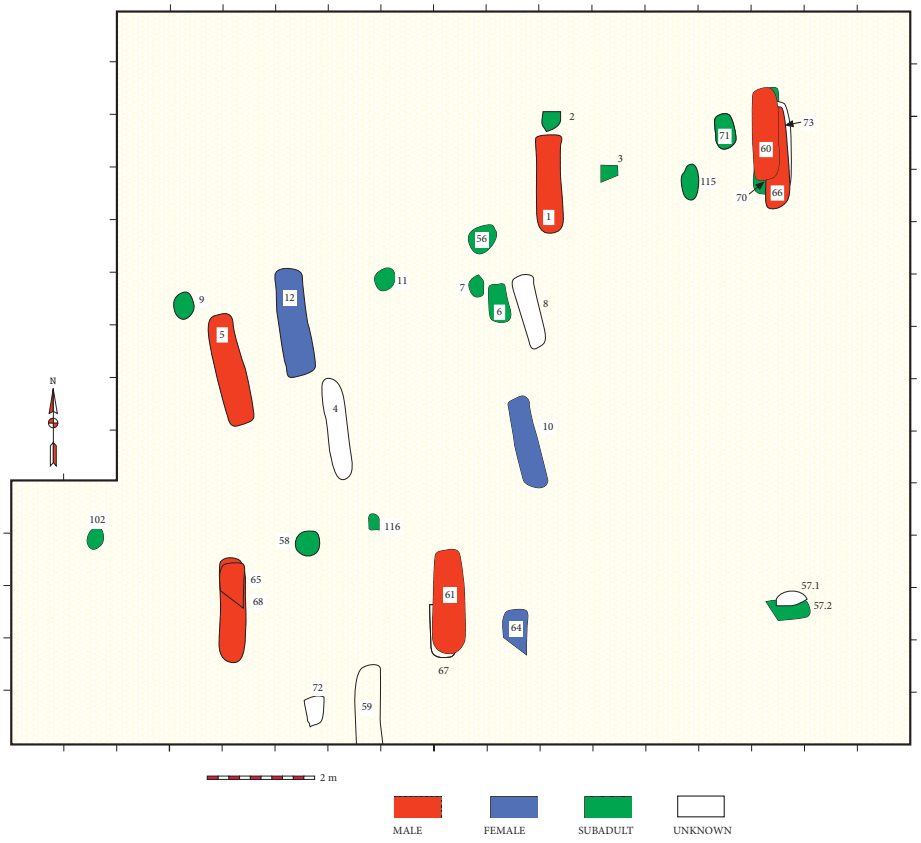


FIG. 18:8 Mortuary Phase 5 burials by sex

TABLE 18:1 *All Noen U-Loke burials*

	female	male	unsexable	Total
neonate	-	-	32	32
infant	-	-	15	15
child	-	-	5	5
adult.u	1	3	8	12
adult.j	1	2	3	6
adult.y	7	13	4	24
adult.m	6	5	3	14
adult.s	7	4	1	12
TOTAL	21	26	71	120

group of undisturbed Noen U-Loke burials is characteristic of that which might be expected from a prehistoric cemetery (Table 18:1). The high total number of neonates, infants and children found at the site – 44% of the total - suggests a high subadult mortality rate, a characteristic of many prehistoric populations. For example, at the Bronze Age site of Ban Lum Khao the subadult death rate was 46% (Domett 1999). All combinations of age and sex categories were represented in the cemetery.

Considering the mortuary phases separately, ratios of female to male deaths were approximately equal in each (Table 18:2). Some sex-differential mortuary treatment might be inferred in MP5, except that over 40% of the adult burials could not be sexed. Kolmogorov-Smirnov tests across phases showed no significant differences in terms of sex (with $p>0.05$) (Shennan 1988). Similar equal ratios of males to females were also apparent within the mortuary clusters (Figs. 18:4 and 18:6). In terms of age (Table 18:3), the MP2 sample though extremely small contained a variety of age categories. In the two subsequent phases, differences probably reflect burial clustering in relation to the area excavated, rather than rates of death or burial. For example, MP3 contained only two neonates, although clusters of jar burials analogous to those in MP4 might well exist beyond the excavation area. If adults are considered separately, age proportions follow similar trends. Kolmogorov-Smirnov tests showed no significant differences between phases in terms of age (with $p>0.05$) (Shennan 1988).

BURIAL PRACTICE

Grave treatment

The normative burial for all age groups except neonates was the inhumation of a single individual in an extended

TABLE 18:2 *Sex distribution*

	MP2		MP3		MP4		MP5		Total	
	no	%	no	%	no	%	no	%	no	%
female	2	33	8	32	8	14	3	10	21	18
male	3	50	7	28	9	16	7	23	26	22
unknown	0	0	3	12	9	16	7	23	19	16
subadult	1	17	7	28	31	54	13	43	52	44
TOTAL	6	100	25	100	57	100	30	100	118	100

TABLE 18:3 *Age distribution*

	MP2			MP3			MP4			MP5			Total		
	no	% total	% adult	no	% total	% adult	no	% total	% adult	no	% total	% adult	no	% total	% adult
neonate	1	17	-	2	8	-	19	33	-	10	33	-	32	27	-
infant	0	0	-	4	16	-	10	18	-	1	3	-	15	13	-
child	0	0	-	1	4	-	2	4	-	2	7	-	5	4	-
adult.u	0	0	0	2	8	11	7	12	27	3	10	18	12	10	18
adult.j	1	17	20	1	4	6	2	4	8	2	7	12	6	5	9
adult.y	1	17	20	8	32	44	7	12	27	7	23	41	23	19	35
adult.m	2	33	40	3	12	17	6	11	23	3	10	18	14	12	21
adult.s	1	17	20	4	16	22	4	7	15	2	7	12	11	9	17
TOTAL	6	100	100	25	100	100	57	100	100	30	100	100	118	100	100

supine position within a narrow semi-rectangular grave. In all phases, supine extended burials were by far the most numerous, followed by neonate jar burials in the phases in which they occurred (Table 18:4). Most neonates were buried inside large ceramic vessels, sometimes with a matching lid, or with another whole pot acting as a lid (eg burial 38). Some variations may have resulted from the seasonal production of pottery, in that specialised mortuary vessels may have been seasonally produced. In MP5, the presence of two burials (burial 9 and burial 58) inside pairs of jars with their rims together, suggests a change in practice perhaps associated with a decline in mortuary vessels in a possible context of the standardisation of ceramic production. In MP3 Cluster B, an infant (burial 34) was interred on the left forearm of a mature adult female (burial 35).

TABLE 18:4 *Grave treatment*

	supine extended burials	prone extended burials	neonate jar burials	disturbed burials	bundle burials
MP2 (n=6)	83%	17%	0%	0%	0%
MP3 (n=25)	76%	4%	8%	12%	0%
MP4 (n=57)	63%	0%	25%	9%	4%
MP5 (n=30)	50%	7%	23%	17%	3%

Four male burials were found in a prone position - MP2 burial 107, MP3 Cluster A burial 44, MP5 burial 1 and MP5 burial 61. Burial 61 was notable for the presence of a tanged iron projectile point lodged in the man's spine, which had entered his body from the front causing death. These prone burials may represent individuals with shared circumstances of death, perhaps related to an injury. Many burials were disturbed. Three burials (burial 70, a child, burial 78, a mature adult, and burial 111, a young adult male) were re-interred in a bundled position following the burial of subsequent individuals at the same location.

The arms of the individual were generally extended at their sides or lay over their pelvis, with the head facing forward or slightly to the left or right. Unfortunately, small samples, marked bone disturbance and poor bone preservation prevented detailed analysis of body position. The mortuary ritual may well have involved wrapping the body extensively in cloth. Interment in quantities of white cloth is a crucial part of the mortuary ritual in contemporary rural northern Thailand (Anusaranasasanakiarti and Keyes 1980) and Cambodia (Tholla n.d.) and impressions of various types of cloth have been found on corrosion products of metallic grave goods from Noen U-Loke. Consequently, the positioning of the body may have been uncertain at the time of interment.

Rice beds were found in many MP3-4 graves. Silicified rice formed striking white low-density ashy remains surrounding the body, which, although conspicuous during excavation, often compromised bone preservation, with teeth remaining better preserved (Nelsen 1999). Rice was clearly an important symbol for the Iron Age farmers of Noen U-Loke[2].

Burial clusters

Burial clusters varied in size but each was composed of a range of different age groups, in a manner generally consistent with the composition of the cemetery as a whole (Table 18:5). Burial clusters varied in their overall adult/subadult age composition, perhaps partly due to the practice of clustering subadult burials together. Note that some clusters in MP4 were not completely excavated.

TABLE 18:5 *Age group composition of mortuary clusters*

	adult.s	adult.m	adult.y	adult .j	adult.u	child	infant	neonate	total
MP3 Cluster A	2	-	2	-	-	-	1	1	6
MP3 Cluster B	2	3	6	1	2	-	4	-	18
MP4 Cluster A	1	1	3	-	3	-	1	1	10
MP4 Cluster B	2	1	1	-	1	2	4	8	19
MP4 Cluster C	-	2	3	2	2	-	1	6	16
MP4 Cluster D	-	2	-	-	1	-	1	-	4

There are demographic clues to the mechanism for cluster formation (Figs. 18:3-18:6). The different demographic compositions appear to relate to varying natural mortality within community subgroups. While there are some temporal differences between the clusters, perhaps the most probable hypothesis is that each cluster was composed of consanguinal individuals interred over a short period of time, perhaps two or three generations. Senior adults may have played a role in the formation of the clusters. In MP3 Cluster A, the southernmost burial was a senior adult male (burial 42) at the base of the cluster adjacent to a senior adult female (burial 37) (Figs. 18:3 and 18:4). At the base of MP3 Cluster B lay a senior adult female (burial 52) and a senior adult of unknown sex (burial 54). In MP4 Cluster B, perhaps slightly earlier than the others in the phase, a senior adult male (burial 98) and senior adult female (burial 99) were associated with two mature adults and sixteen subadults (Figs. 18:5 and 18:6). Unfortunately, the

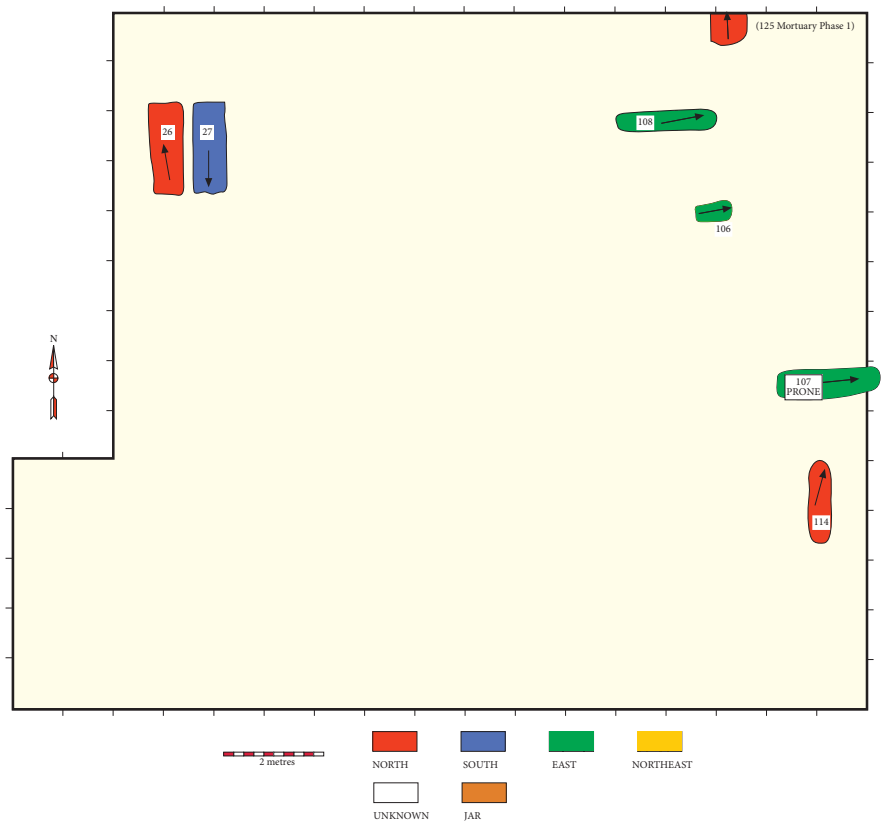


FIG. 18:9 Mortuary Phase 2 grave orientations

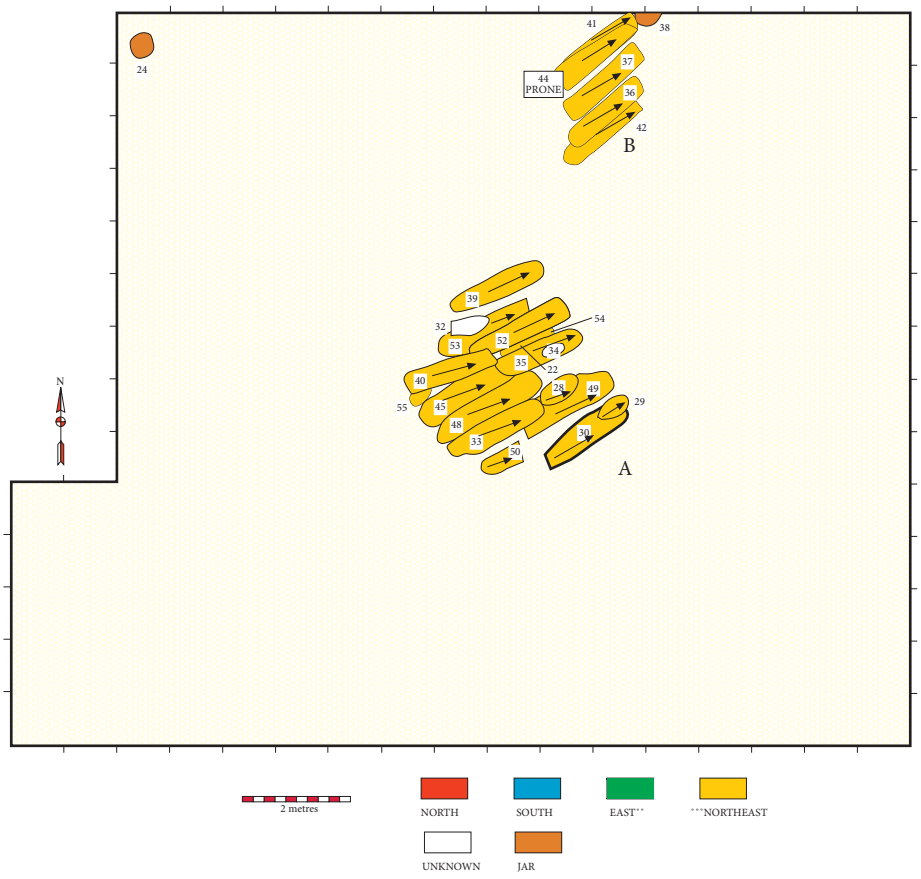


FIG. 18:10 Mortuary Phase 3 grave orientations

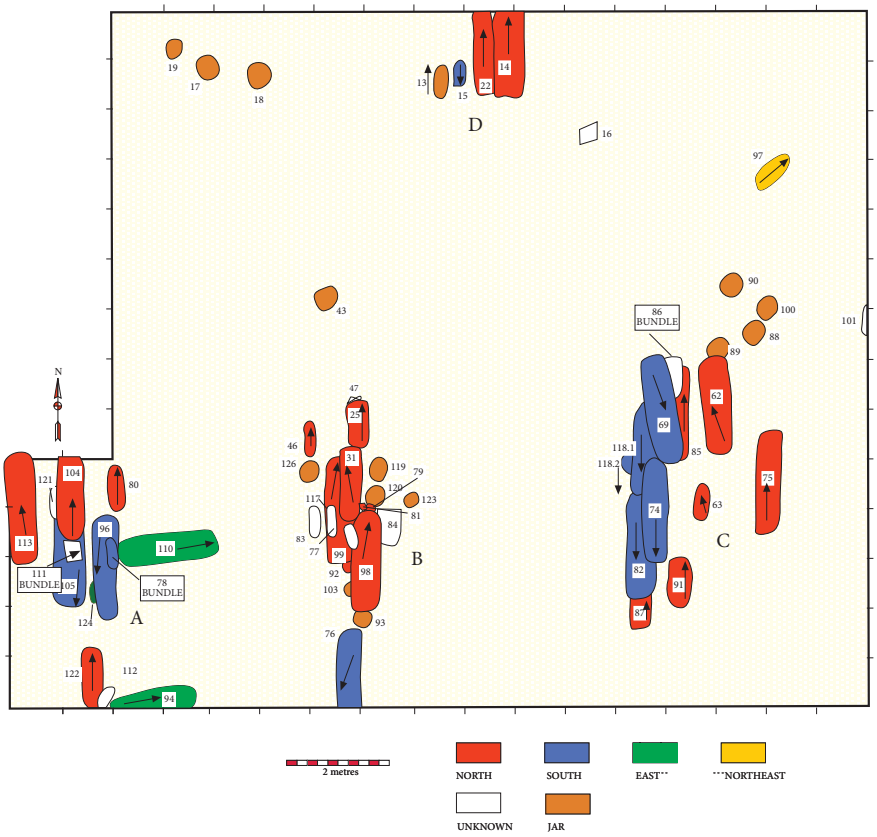


FIG. 18:11 Mortuary Phase 4 grave orientations

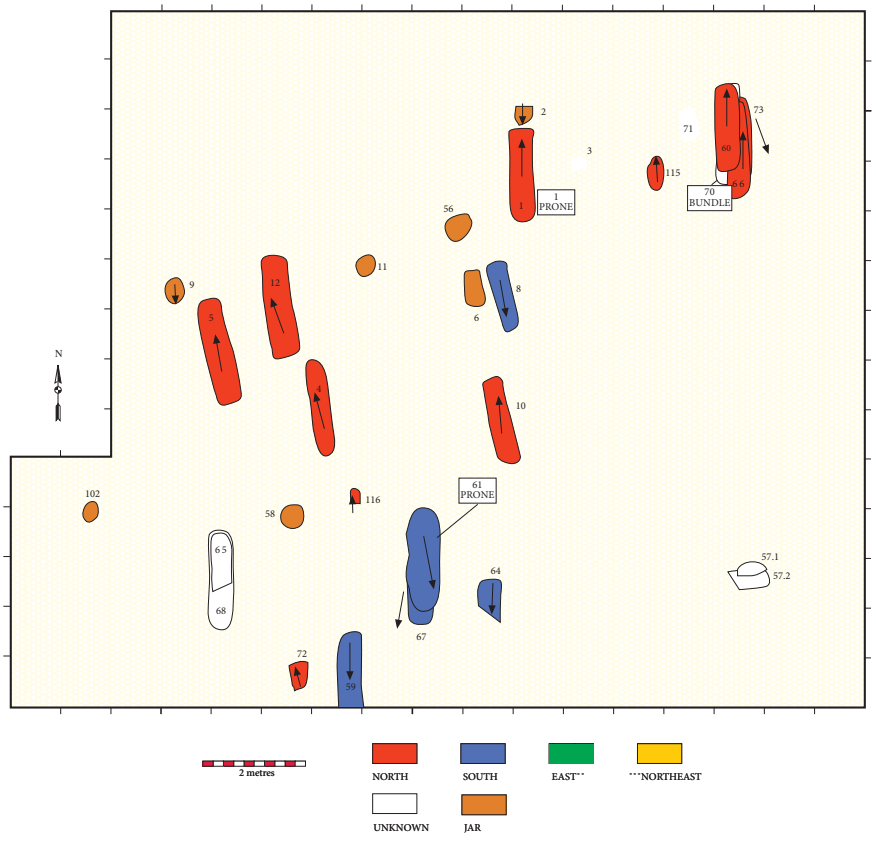


FIG. 18:12 Mortuary Phase 5 grave orientations

small sizes of the clusters mean chance cannot be ruled out as the cause of these female-male senior adult pairs. Yet, the clusters were otherwise varied in their size and demographic composition and these senior adults were found at the base of clusters. With an apparent focus on consanguinal identity apparent in the spatial distribution of burials, it would be fitting if the stimulus for the creation of new clusters was the death of a senior lineage member.

Grave orientation

Grave orientation is a common means of expressing social distinctions (O'Shea 1996:129), although these distinctions may not always be clear to the archaeologist. At Noen U-Loke, individuals were interred with their heads oriented to within twenty degrees of north, south, northeast or, very occasionally, east. The six graves in MP2 were oriented to the north, south and east (Fig. 18:9). No clear patterning relating to age or sex was apparent in this small sample. Two adjacent burials, (burials 26 and 27), both male, were interred in opposite directions. Two eastward oriented burials (burials 107 and 108) were a male and a female.

In MP3 (Fig. 18:10), graves were interred in two distinct and tightly packed clusters, both oriented at 60-70^{O} east of north. With the exception of two jar burials, no individuals or grave cuts were interred at any other angle. It seems likely that grave clusters were marked on the ground surface, or were perhaps buried beneath structures[3].

While most MP4 burials were oriented to the north, some were oriented to the south (Fig. 18:11), perhaps due to factors such as cause or time of death (Anusaranasasanakiarti and Keyes 1980). The south-oriented burials were all adults. Sex differences may have played a role in the north-south distribution of orientations of MP4 Cluster A, which was not completely excavated, but apparently did not elsewhere. In MP4 and MP5, with the exception of the two jar burials, southward facing burials were limited to adults. Such graves might perhaps represent those who had married into the community. Three MP4 burials were interred to the east. Two (burial 94 and burial 110) were senior adults, a male and a female, with younger individuals beyond their feet. Burial 124 was a disturbed adult grave. These three burials at the base of clusters may be slightly earlier date than others in MP4. Wichakana (1991; Higham 1996:221) recovered east-oriented graves during the middle phase of his excavations. A unique MP4 individual was oriented to the northeast. MP4 burial 97 was the infant with a serious congenital condition. The infant was not buried in a cluster, perhaps suggesting it was excluded from cluster membership, or perhaps was considered a member of the society as a whole.

A different set of social identities that cut across lineage appears to have been emphasised in MP5 (Fig. 18:12). In MP5, the tendency toward clustering dissipated, although some burials were superimposed (burials 60, 66, 73, and 70), usually in pairs (burials 57.1 and 57.2, burials 61 and 67, and burials 65 and 68). Unlike MP3 and MP4, most burials were not grouped in clusters and even neonate jar burials were no longer grouped. Without exception, MP5 graves lay along a north-south axis.

Summary: Burial at Noen U-Loke

There is no evidence that any particular age or sex groups were excluded from the Iron Age cemetery of Noen U-Loke. While age differences played a role in the clustering of adult and subadult burials, all mortuary phases had consistent age compositions. There was a high rate of infant, young adult and mature adult deaths, with few survivors over the age of forty. While most burials resembled others within their phase, certain individuals, such as a child with possible cerebral palsy and a young man possibly killed by an iron point, were perhaps accorded special treatment relating to their social identity or manner of death. Many characteristics were temporally consistent, with practices such as neonate jar burial perhaps retained from the Bronze Age. However, there were dramatic changes in the spatial distribution of burials that are particularly intriguing in the Iron Age context. While burial orientation was not regimented in MP2, by MP3, burial orientation and spatial distribution emphasised group – apparently lineage - identity. Most variation and elaboration in grave treatment, in terms of rice bed burials and clay-lined graves, occurred in MP3 and MP4. There is evidence that the graves were identifiable on the ground surface in some way, especially in the case of possible postholes for a mortuary structure surrounding burial 75 in MP4 Cluster C. By MP5, burials were ungrouped, but restricted to a north-south orientation pattern. This may indicate community-wide mortuary identities in which lineage group membership did not play as important a role in mortuary ritual.

GRAVE GOODS

"Only in the context of historical development is it possible to explain the variability and elaboration of a particular archaeological burial assemblage" (Cannon 1989:437).

Archaeologists analysing burial practice must do so with the awareness that they are studying the end result of several interrelated processes - demographic, social, symbolic, geological, excavatory, and statistical-analytical (Braun 1981:412). At Noen U-Loke, factors such as small samples, burial clustering, disturbed burials and incompletely excavated clusters provided "poor resolution" and precluded the use of complex statistical techniques for consideration of the distribution of grave goods (Brown 1987). However, as in many cases, relatively simple statistical approaches, often at the ordinal or nominal level, proved appropriate to address issues of interest (see Braun 1981; Read 1987; Whallon 1987; Madsen 1988; Baxter 1994; Brown 1995). The aim was to examine the changing mortuary repertoire

and distribution of grave goods at the site in order to cast light on the Iron Age community, using methods that allowed meaningful analysis of the data within the bounds set by the archaeological characteristics of the cemetery itself.

Excluding individual glass beads, approximately 2200 different grave goods were recovered from the site. Data were obtained primarily from preliminary excavation records but also from early versions of data set out in this volume. The goal here is not to reproduce detailed descriptive information about artefacts that is available elsewhere but to consider the changing mortuary assemblage as a whole. Burial analysis in the previous section provided a framework for a set of ten separate analyses of grave goods:

- The mortuary phases were represented by samples of different size.
- Burial clusters played a major role in the formation of the cemetery.
- Mortuary phases and clusters contained similar proportions of both sexes.
- Mortuary phases contained similar proportions of the various kinds of adult burials, but differing proportions of subadults and adults.

All grave goods were considered as symbolic ritual offerings that were actively included in graves. Many grave goods were ornamental, but other kinds of ornaments were not recovered in graves – for example shell (*Tridacna*), slate and perhaps clay bangles. Some artefacts, for example stone adzes, grinding stones and pottery anvils, were not found in graves and apparently did not have mortuary significance. This is in contrast to earlier Bronze Age sites in the region. While perhaps affected by sample size, such extra-mortuary finds support the contention that the inclusion of goods within a grave was an active process carried out by the living, and not simply the passive interment of all goods owned by the deceased. An ethnographic example of the complexity of the mortuary record comes from the animistic Naga tribes of northeastern India and Burma (Untracht 1997:53; von Furer-Haimendorf 1976). While Naga women are buried with just a few beads (Untracht 1997:56), they wear jewellery throughout their lives. Some ornaments such as bronze armlets are passed down as heirlooms "whose provenance is shrouded in mystery" (von Furer-Haimendorf 1976:199). The challenge for the archaeologist is to interpret mortuary evidence in such a context, where the material culture plays an active role in society, and where mortuary ritual need not be a direct reflection of every day life.

1. Did grave goods change over time?

One of the most striking characteristics of the grave good assemblage at Noen U-Loke was its diachronic variation. Differences in goods between the stratigraphically-derived mortuary phases were conspicuous and indicated the adoption of items into the mortuary ritual over the course of the Iron Age. While some differences may relate to sample size, general trends are apparent (Table 18:6; with goods found in more than one grave in the phase in bold). This first section describes grave goods in each phase in order to provide a diachronic overview of the entire mortuary assemblage. The often-disturbed nature of the burials prevented analysis of the placement of goods within graves, although common or striking cases are noted. Relationships between artefacts and individuals interred in the graves are considered elsewhere; here the focus is solely on the kinds of goods recovered. The number of artefacts in the phase (n), the number of graves in the phase containing the artefact (g), and the number of graves in the phase (t) are also provided.

Mortuary Phase 2 Grave Goods

Despite its small size (t=6), this mortuary phase is particularly significant as it demonstrates the mortuary ritual of the earliest Iron Age. The grave goods were characterised by faunal remains and some intriguing metal artefacts. Several were limited to the phase:

Tiger canine

Four tiger (*Panthera tigris*) canines, the only remains of this species found, lay at the neck of burial 27 (Cat. 483) (n=4, g=1)[4].

Pig tusk

Two matching pierced *Sus scrofa* tusks were worn at the neck of burial 26, in a similar fashion to the tiger teeth of burial 27 (Cat. 526) (n=2, g=1).

Bos ulna

The function of a shaped and pierced *Bos* ulna (Cat. 477) positioned at the left ankle of burial 27 is uncertain (n=1, g=1).

Turtle carapace

Trionychidae (turtle or tortoise) carapace fragments and vertebrae were recovered in burial 27 (Cat. 523 and Cat. 614), inside and adjacent to a pot that also contained pig forelimbs (n=1, g=1).

Deer ulna

An unworked *Cervus* sp. ulna (Cat. 1546) lay at the left upper arm of burial 107 (n=1, g=1).

Shell disc

Burial 27 wore two large shell discs as earrings, and another two were buried to the left of and beyond the feet (Cat. 479, 485 and 489). These marine (*Tridacna*) shell artefacts are among the earliest imported grave goods found at the site (n=4, g=1).

Bronze spear

Burial 27 contained two socketed bronze spears (Cat.

TABLE 18:6 *Grave goods from Noen U-Loke by mortuary phase*

MP2	MP3	MP4	MP5
tiger canine			
pig tusk			
Bos ulna			
turtle carapace			
deer ulna			
shell ear discs			
bronze spear			
iron bangle			
iron torc			
red ochre			
pig forelimb	**pig forelimb**		
fish offerings	fish offerings	fish offerings	
spindle whorl	**spindle whorl**	**spindle whorl**	
bronze torc		bronze torc	
iron tool		iron tool	
iron spear		iron spear	iron spear
bronze bangle	**bronze bangle**	**bronze bangle**	**bronze bangle**
bivalve shell	bivalve shell	**bivalve shell**	bivalve shell
ceramic vessel	**ceramic vessel**	**ceramic vessel**	**ceramic vessel**
	bone beads		
	Bos phalanges		
	pig skeleton		
	bronze spiral		
	rice bed	**rice bed**	
	bronze bell	**bronze bell**	
	carnelian bead	carnelian bead	
	shell bead		shell bead
	agate bead	**agate bead**	**agate bead**
	agate pendant	**agate pendant**	**agate pendant**
	glass bead	**glass bead**	**glass bead**
	bronze earring	**bronze earring**	**bronze earring**
	bronze finger ring	**bronze finger ring**	**bronze finger ring**
	bronze toe ring	**bronze toe ring**	**bronze toe ring**
	mortuary vessel	**mortuary vessel**	**mortuary vessel**
		egg	
		shell earring	
		ivory bangle	
		iron ?hairpin	
		iron winged object	
		clay coffin	
		bronze belt	
		bronze ring	
		silver/gold earcoil	
		iron blade	**iron blade**
		bronze anklet	bronze anklet
		bimetallic ring	bimetallic ring
		silver jewellery	silver jewellery
		gold bead	gold bead
			iron sickle
			deer antler

488), the only such bronze artefacts found at the site (*n*=2, *g*=1).

Iron bangle and torc

Two iron bangles (Cat. 1720) adorned the wrists of burial 108, who also wore an iron torc (Cat. 1718) around her neck. While bronze jewellery and iron tools were common, particularly in later phases, these five items were the only iron jewellery recovered at the site. The fact that all such jewellery was associated with a single burial suggests that it was a particularly rare, and perhaps even experimental, early use of iron (bangles: *n*=4, *g*=1, torc: *n*=1, *g*=1). Iron ore in the form of laterite is widespread in the region.

Red ochre

Two pieces of red ochre were recovered in burial 26 and 27 (*n*=2, *g*=2).

Other kinds of grave goods had a more lasting presence in the cemetery:

Pig forelimb

Sus scrofa forelimbs were found in three MP2 burials: one in burial 108, two in burial 26 (at the left arm and between the thighs), and ten in burial 27 (under the pelvis, in the grave fill and eight inside or near a pot). All came from young pigs, perhaps suggesting ritualised mortuary feasting activity. All but one were left forelimbs. Interestingly, burial 108, the only female burial in the phase with such offerings, contained a *right* forelimb (*n*=13, *g*=3).

Fish offering

Whole fish were included in three graves. The most common species by far was *Ophicephalus striatus* or "*pla chon*", still the most popular and widely consumed fish in Thailand today (Thosarat 2000:214). Burial 26 contained four skeletons of *O. striatus* (Cat. 538) inside a pot (Cat. 512). Burial 27 contained the bones of eleven fish (eight *O. striatus*) inside one pot (Cat. 476) and fifteen (ten *O. striatus*) in another (Cat. 487). Burial 107 contained a single *O. striatus* skeleton at the right femur (*n*=4, *g*=3).

Spindle whorl

Two ceramic spindle whorls were found in burial 26 and 27 (*n*=2, *g*=2).

Bronze torc

Burial 27 wore three bronze torcs (Cat. 482) at the neck (*n*=3, *g*=1).

Iron tool

A socketed iron tool (Cat. 478), perhaps a hoe, lay at the left ankle of burial 27 (*n*=1, *g*=1).

Iron spear

Beyond the head of burial 27 lay a socketed iron spear (Cat. 640) (*n*=1, *g*=1).

Bronze bangle

Burial 27 wore a bronze bangle on each wrist (Cat. 481, Cat. 520), and another was interred under the bronze spears (Cat. 561), (*n*=3, *g*=1).

Bivalve shell

Burials 106 and burial 108 contained bivalve shells (Cat. 1466 and Cat. 1721) (*n*=2, *g*=2).

Ceramic vessel

All six MP2 burials contained pots, with three burials (burials 26, 27 and 107) each containing four. Some held food offerings and they were generally positioned over the body or beyond the head or feet (*n*=18, *g*=6).

Mortuary Phase 3 Grave Goods

Several new grave goods were apparently introduced into the mortuary ritual during this phase, concurrent with the appearance of the first mortuary clusters (*t*=25). However, certain grave goods continued in use from before:

Pig forelimb

Burial 28 contained a *Sus* forelimb and burial 30 a *Sus* tibia (*n*=2, *g*=2).

Fish offering

An *Anabas testudineus* skeleton (Cat. 774) lay under a pot in burial 38 (*n*=1, *g*=1).

Spindle whorl

Several spindle whorls were recovered, with burial 32 containing four (*n*=16, *g*=9).

Bronze bangle

Many individuals wore bronze bangles, usually on both wrists, and up to six in total in the case of burial 35 and burial 40 (*n*=30, *g*=8).

Bivalve shell

A bivalve shell (*Hyriopsis* sp.) was recovered inside a pot in burial 24 (*n*=1, *g*=1).

Ceramic vessel

Four burials (burials 22, 24, 28 and 42) each contained a single pot (*n*=4, *g*=4).

Several kinds of mortuary grave goods were introduced, some limited to the phase:

Bone bead

A total of five bone beads were recovered in burials 42 and 33, in association with glass or shell beads, and categorised here as two bone bead artefacts (*n*=2, *g*=2).

Bos phalanges

A group of *Bos* phalanges was recovered with burial 28 (*n*=1, *g*=1).

Pig skeleton

Four burials each contained the skeleton of a very young pig (burials 28, 37, 40 and 41). Finds of the cranium (burial 30) and mandible (burial 49) of two young pigs were also included in this category to allow for the probable poor preservation of pig bone in the two rice bed burials (*n*=6, *g*=6).

Bronze spiral

Burial 39 wore a large (approximately 10cm across) head ornament (Cat. 626), the only such artefact recovered, although smaller flat or column spirals were regularly found at the ear or as a finger ring (*n*=1, *g*=1).

Other goods introduced during this phase were retained into later phases:

Rice bed

This phase was notable for the first rice bed burials (*n*=13, *t*=13).

Bronze bell

Burial 54 wore 22 bronze bells on its left ankle (*n*=22, *g*=1).

Carnelian bead

The carnelian beads recovered from this phase were long, narrow and beautifully faceted, similar to examples from many archaeological sites in Southeast Asia and India (Theunissen 2000; Untracht 1997). They were usually found at the neck. Burial 32 wore three such beads (*n*=10, *g*=7).

Shell bead

Fifteen shell disc beads were found at the head of burial 42 and four at the neck of burial 37, and are categorised here as two shell bead artefacts (*n*=2, *g*=2).

Agate bead

Hardstone banded agate beads came in two forms, in this case a barrel bead (Theunissen 2000). These were also usually found at the neck. Burial 30 wore thirteen

(*n*=20, *g*=5).

Agate pendant

Another form of agate was a semi-rectangular "pendant" (Theunissen 2000:229) usually worn singly at the neck (*n*=8, *g*=7).

Glass bead artefact

Over seven thousand small single colour glass trade beads were recovered in burials. In MP3, over 1200 glass beads were found in burials, comprising 17% of all such beads. While burial 37 contained 227 beads in the region of the neck, many burials contained less than 10 beads. For the purposes of this study, if glass beads were recovered in one area of the body, such as around the neck, the artefact quantity was considered as one, that is at least one multi-beaded artefact was found in the grave (*n*=15, *g*=15)[5].

Bronze earring

Burial 30 and burial 33 each wore a bronze earring (*n*=2, *g*=2).

Bronze finger ring

Up to sixteen bronze rings adorned the fingers of several individuals (*n*=53, *g*=7).

Bronze toe ring

Rings adorned the toes of two individuals whose remains were limited to the lower extremities. Burial 53 wore seven. Burial 54 wore nine on the remaining left foot alone, together with the bronze bells previously mentioned, emphasising the wealth of this burial (Cat. 702 and Cat. 717) (*n*=16, *g*=2).

Mortuary vessel

Two neonate jar burials were found in this phase (*n*=2, *g*=2).

Mortuary Phase 4 Grave Goods

MP4 contained 57 graves, the most of any mortuary phase at the site. The phase was notable for an efflorescence of metal artefacts. Other grave goods were more traditional:

Fish offering

Burial 100 contained an *O. striatus* and a *Clarias* sp. skeleton (*n*=1, *g*=1).

Spindle whorl

Spindle whorls were found in several burials. Burial 99 contained four at the left and right arm, and burial 98 two in the region of the head (*n*=12, *g*=7).

Bronze torc

Burial 96 wore a single bronze torc at the neck (Cat. 1518) (*n*=1, *g*=1).

Iron tool

A large socketed iron tool (Cat. 1244), possibly a hoe or agricultural implement, was recovered beside the skull of burial 96 (*n*=1, *g*=1).

Iron spear

An iron spear (Cat. 1674) lay beneath the femur of burial 69 (*n*=1, *g*=1).

Bronze bangle

Many individuals wore bronze bangles and some a great many - burial 14 wore 75 on *each* arm (*n*=384, *g*=21).

Bivalve shell

Burials 79, 90 and 91 were interred with bivalve shells (*n*=4, *g*=3).

Ceramic vessel

Most burials included at least one pot. Burials 96 and 14 contained eight, most positioned just beyond the head (*n*=101, *g*=33).

Rice bed

Eighteen individuals in this phase were interred in rice beds (*n*=18, *g*=18). (Some neonate jar burials also contained quantities of silicified rice.)

Bronze bell

Three individuals (burials 96, 120 and 124) wore small bronze bells. The disturbed lower legs of burial 124 were adorned with 21 such bells (*n*=24, *g*=3).

Carnelian bead

A carnelian bead was recovered with burial 118.1. This, the only carnelian artefact recovered outside of MP3, was globular, quite different to the long faceted beads of MP3 (*n*=1, *g*=1).

Agate bead

Eight individuals were buried with agate beads, usually worn at the neck (burials 14, 15, 46, 78, 80, 94, 97 and 113). One individual wore 22 – almost half of the agate beads in the phase (burial 113) (*n*=45, *g*=8).

Agate pendant

Several individuals wore (up to three) agate neck pendants (burials 13, 14, 15, 62, 86, 91, 99, 104, 113, 120 and 122) (*n*=16, *g*=11).

Glass bead

Over 5000 glass beads were recovered in burials in this phase, over 75% of all such beads at the site. Burial 13, the grave of an infant, contained 1719 glass beads, which were scattered throughout the grave. Twenty burials con-



FIG. 18:13 MP2 Burial 27 with bronze torc and tiger teeth

tained at least one glass-beaded artefact, with burial 14 having four, at the foot, head, and upper lower legs (*n*=24, *g*=20).

Bronze earring

Bronze earrings were common grave goods, with many individuals wearing a single earring at either ear. While most earrings were a plain split ring, some earrings had a spiral or plug form. Burial 62 wore eight earrings at each ear (*n*=44, *g*=20).

Bronze finger ring

Bronze finger rings were very common in this phase, usually in the form of a plain ring, but sometimes that of a spiral. Burial 69 wore several on each finger - to a total of 124 (*n*=387, *g*=16).

Bronze toe ring

Nine individuals wore bronze toe rings. Burial 105 wore 17 on the toes of the right foot, and 25 on the toes of the left (*n*=122, *g*=9).

Mortuary vessel

Fourteen neonate jar burials were recovered (*n*=14, *g*=14)

In contrast, some exceptional grave goods were limited to this phase, and often a single grave:

Egg

An intact bird's egg was recovered in the pelvic region of burial 31 (*n*=1, *g*=1).

Shell earring

A *Tridacna* shell earring was worn in the left ear of burial 110 (Cat. 1556) (*n*=1, *g*=1).



FIG. 18:14 MP3 Cluster A Burial 113 with gold beads, agate beads and bronze earrings

Ivory bangle

Two ivory bangles adorned the wrists of burial 97 (*n*=2, *g*=1).

Iron 'hairpin'

Two iron objects (Cat. 1684) were recovered on both sides of the skull of burial 118.1. They have been described as "bifurcated artefacts" (Connelly 2000:314) and were perhaps hairpins (*n*=2, *g*=1).

Iron spade

A large iron winged socketed object, possibly a spade (Cat. 1269), was recovered with burial 86 (*n*=1, *g*=1).

Clay 'coffin'

Two burials (burials 113 and 105) were lined, and in the case of burial 113, capped, with a thin layer of pale clay (*n*=2, *g*=2).

Bronze belt

The bronze belts recovered with burials 14, 69, 96, 105 and 111 were solid bronze bands with various, often spiraliform, clasps. Burial 69 wore four such belts (*n*=11, *g*=5).

Bronze ring

Bronze rings were occasionally interred underneath a ceramic vessel (Cat. 1012, Cat. 1291, Cat. 1559, Cat. 1904, Cat.

1949) (*n*=10, *g*=6).

Silver/gold earcoil

Burial 14 wore a silver and gold coil in each ear (*n*=2, *g*=1).

Some grave goods introduced into this phase also continued into the next:

Iron blade

Iron blades were found in twelve graves (*n*=15, *g*=12).

Bronze anklet

Twelve individuals wore anklets. Burial 80 wore eleven (*n*=69, *g*=12).

Bimetallic ring

Bimetallic (iron and bronze) rings were recovered in several burials of this phase. Usually the ring was worn at the neck or chest, perhaps as a clothing fastener, but on one occasion, a bimetallic ring was found on the largest toe on the left foot (burial 69). One neonate was interred with eight rings, some worn as bangles (burial 85) (*n*=29, *g*=10).

Silver jewellery

Burial 113 wore a silver finger ring on each hand (Cat. 1706 and Cat. 1550) and a silver toe ring (Cat. 1541). Burial 111 had a silver strip under the skull (Cat. 1579), and burial 105 wore a silver bangle on the left hand (Cat. 1534) (*n*=5, *g*=3).

Gold bead

Burial 113 wore a necklace of 64 small gold beads, here categorised as a gold beaded necklace (Cat. 1710) (*n*=1, *g*=1).

Mortuary Phase 5 Grave Goods

The final mortuary phase (*t*=30) was notable for its metallic, particularly iron, grave goods.

Iron spear

A tanged spear (Cat. 168) was found at the left forearm of burial 5 (*n*=1, *g*=1).

Bronze bangle

Several individuals wore bronze bangles. Burial 1 wore thirteen on the right arm and eight on the left (*n*=82, *g*=13).

Bivalve shell

Burial 67 contained a bivalve shell (Cat. 1912) bored with a hole (*n*=1, *g*=1).

Ceramic vessel

Pots were found in many graves, generally positioned on the abdomen or beyond the head (*n*=28, *g*=15).

Shell bead

Burial 116 wore 29 shell disc beads at the neck (cat. 1628) (n=1, g=1).

Agate bead

Three individuals were interred with agate beads. Burial 5 and burial 9 each wore four at the neck, and burial 10 wore one (*n*=9, *g*=3).

Agate pendant

Three individuals (burials 4, 5 and 73) wore a single agate pendant (*n*=3, *g*=3).

Glass beaded artefact

Four burials (burials 8, 73, 102 and 116) contained glass bead artefacts, usually worn at the neck (*n*=4, *g*=4). The total number of glass beads recovered was just over 500, far fewer than in previous phases even considering sample size.

Bronze earring

Nine individuals wore at least one bronze earring (*n*=13, *g*=9).

Bronze finger ring

While nine individuals wore finger rings, most were worn by burial 1 with 52 arranged on the fingers of both his hands (*n*=96, *g*=9).

Bronze toe ring

Burial 73 wore nine toe rings on the right foot, and burial 12 three on her left foot and five on her right (*n*=17, *g*=2).

Mortuary vessel

Seven neonate jar burials were recovered (*n*=7, *g*=7).

Iron blade

Thirteen burials were interred with a single iron blade (*n*=13, *g*=13).

Bronze anklet

Burial 10 wore an anklet on her right ankle, and burial 115 two on each side (*n*=5, *g*=2).

Bimetallic ring

Twelve burials wore bimetallic rings (*n*=21, *g*=12), often in the chest area, but also at the arm, pelvis and skull. Burial 1 contained four bimetallic rings, including two at the right shoulder. The neonate of burial 2 was also interred with four bimetallic rings, wearing one on the right arm and two on the left.

Silver earring

Burial 59 wore a single silver earring at the left ear (*n*=1, *g*=1).

Gold bead

A necklace of 39 gold beads was found at the neck of burial 68 (*n*=1, *g*=1).

Two new kinds of artefact appeared in this phase, one an iron tool:

Iron sickle

Eight burials contained iron sickles (*n*=8, *g*=8).

Antler

A worked antler (Cat. 1612) was found in burial 115 (*n*=1, *g*=1).

Discussion

There are two probable reasons for the major changes seen in the Noen U-Loke grave goods: firstly increased trade and changing access to exotic trade goods, and secondly culturally determined changes in mortuary ritual associated with social shifts during the Iron Age.

The grave goods of the first Iron Age mortuary phase at the site were characterised by faunal remains (Table 18:6). Some, including *Sus* forelimbs and fish bones, were contained in small pots, suggesting they were interred as food offerings. Others were apparently amuletic – in particular the *Sus* tusks of burial 26 (Cat. 526), and the tiger canines of burial 27 (Cat. 483). Again, an interesting ethnographic comparison of the complex symbolic role of such items comes from the Naga:

"[T]he teeth . . . of carnivorous, predator animals such as bears and tigers were highly valued because their possession indicated the wearer's bravery in the hunt. Pierced, they could be strung into a necklace or . . . used in a pendant. The wild boar . . . is ferocious when attacked and therefore a proper adversary to prove bravery. The large, lethal tusks . . . that curl along the head of a mature boar were used for ear ornaments, collars and necklaces, as well as to ornament cane hats or headdresses worn with ceremonial dress. The right to wear one pair was earned by taking the head of an enemy; "touching flesh", ie spearing a victim; or killing a tiger or leopard" (Untracht 1997:58).

In this early Iron Age phase, exotic shell objects provide some evidence of exchange, but most grave goods relate to the natural environment and could have been obtained locally. Metal objects were not widespread, and the iron jewellery indicates what may be experimental early Iron Age metal use. Iron was used to produce, not only tools and weapons, but also jewellery, with the senior adult female of burial 108 wearing a unique iron torc and two iron bracelets on each wrist. The only other iron objects, a socketed hoe and socketed spear, were associated with burial 27. All of the bronze artefacts in the phase, comprising three bangles, a socketed spear and a torc, were also found in burial 27 (Fig. 18:13).

A major change in ritual is apparent in MP3, with the appearance of clusters, rice bed burials, and a new set of grave goods. Imported beads and a diverse range of bronze ornaments were used to adorn almost every part of the body. There was a clear concern with the use of agricultural surplus in mortuary ritual – directly in the rice bed burials and perhaps indirectly through the interment of ornaments. No iron grave goods were found in this phase, perhaps indicative of the earlier experimental use of this metal. However, by MP4, iron took important new forms, such as blades and bimetallic rings. There were also ornaments of silver and gold. The resemblance of the gold beads recovered in graves such as burial 113 (Fig. 18:14) to those from Oc Eo is remarkable (Malleret 1959-1963: Plate XI) and indicates long-range trade activity along the Mekong and Mun Rivers. The people of Noen U-Loke also apparently had significantly greater access to bronze, and the inclination to include it in burials.

The distribution of bronze bangles provides an example of how ornaments may have actively been distributed throughout the community. Almost all individuals wore bangles, including young children who could not have obtained them independently. Some inkling of their social role might be found in nineteenth century records of contact between European visitors and the indigenous peoples of Indo-China:

"When he has recounted our individual virtues, another warrior imprisons our right wrists in a thick copper bracelet, an act which signifies the conclusion of a compact and an oath of blood-brotherhood" (Baudesson 1919:140).

In such a context, it is interesting to note that the very richest burials were heavily adorned with bronze bangles.

MP5 saw a continuation of the use of many of the grave goods found in earlier phases. The appearance of an iron "tool kit" comprising a blade and a sickle is perhaps indicated, with six burials containing both artefacts. Only two artefacts of animal origin were recovered in graves, in some contrast to MP2. Indeed, out of almost fifty kinds of grave good, only four were recovered in both MP2 and MP5, being iron spears, bronze bangles, bivalve shells and pots.

2. Did the use of grave goods change over time?

This analysis uses averages to compare the presence of specific grave goods in phases. Note that the distribution of artefacts within a phase is more complex than a simple average can express, and that averages are used here simply as a method of remedying the different sample sizes. Only undisturbed adult graves were used in this analysis, to reduce any disturbance or demographic effects (MP2

t=5, MP3 *t*=15, MP4 *t*=22, MP5 *t*=13). Some goods were more appropriate than others for temporal comparison. For example, silver-gold ear-coils were only found in a single grave. To make a meaningful comparison, only those goods found in more than one phase, in more than 20% of adult graves for at least one phase, were used. (The figure of 20% was selected in relation to MP2, where artefacts occurring in just a single undisturbed adult grave occurred in 20% of such graves.) It is likely that excavation of a larger area at the site would produce somewhat different figures, especially in MP2, and this analysis is designed to reveal general trends in the changing mortuary good repertoire.

Discussion

Fig. 18:15 shows the changing grave good repertoire at the site, with pig forelimbs declining and then disappearing, and rice beds and iron artefacts appearing as the mortuary phases progress. Ceramics appear in all phases, but in varying quantities. Agate and glass beads share similar distributions, which peak in MP3 and MP4 (Fig. 18:16). Except for one stylistically distinct bead, all carnelians were limited to MP3. Bronze grave goods, particularly finger rings and bangles, show a marked peak in MP4 (Fig. 18:17). The general trends seen in this quantitative analysis are also supported by the diachronic variation in less-common grave goods, indicated in the previous presence-absence analysis (Table 18:6).

In general, the pattern is one of an initial Iron Age phase, where metal use was somewhat experimental, and faunal remains provided the source of many grave goods. Some early artefacts, such as bivalve shells, spindle whorls, and ceramic vessels were found over a long time-span, albeit in varying quantities. In later phases, there was a general decline in faunal grave goods, in both the number of kinds of goods (eg tiger canines), and in quantities of goods (eg pig forelimbs). Very few faunal artefacts were found in the later graves at the site.

From the second Iron Age phase (MP3), new trade goods and methods of interring the dead, particularly burial clustering, became important. Traded agate and glass beads were most common at their introduction in MP3 and then declined into MP5. Carnelian beads were almost totally limited to MP3, which suggests a limited short-term availability of these goods within the trade network. Iron artefacts, after something of an experimental phase in MP2, were absent from MP3, and may perhaps have been passed on as heirlooms. The proliferation of bronze artefacts began in MP3, but reached a peak in MP4 with many variations (such as bronze bells, spirals, and belts), and higher numbers of common artefacts such as bangles and finger rings. This was concurrent with developments in grave treatment such as rice beds and clay linings, and the use of new metal ornaments such as bimetallic rings, and gold and silver jewellery. Iron became widespread only in MP4, when iron blades appeared, but there is no evidence of a quantitative intensification similar to that of the bronze ornaments. Bronze and iron were by this time used in quite different ways. Bronze was ornamental, whereas iron was used for tools. Although

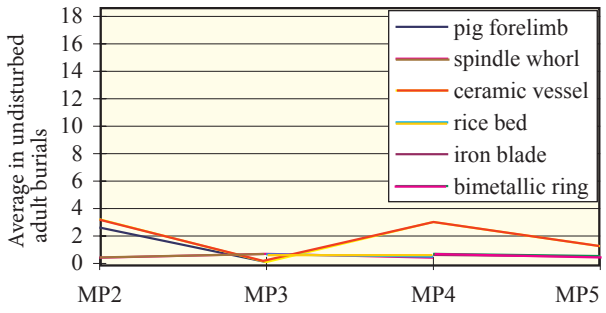


FIG. 18:15 Organic, ceramic, iron and bimetallic grave goods

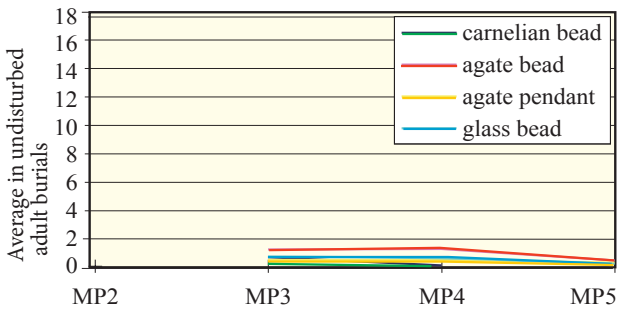


FIG. 18:16 Bead grave goods

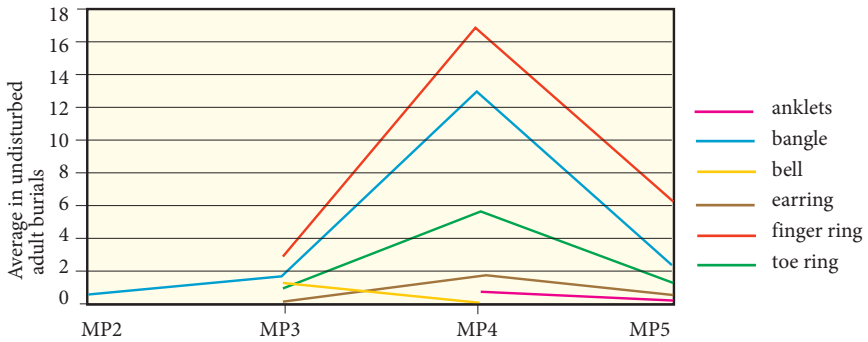


FIG. 18:17 Bronze grave goods

iron sickles were introduced in MP5, and while certain goods were retained, there was a general decline in average quantities from the previous phase, concurrent with the disappearance of burial clustering. By the final mortuary phase at Noen U-Loke, intensification in grave good quantity was over.

3. Did quantities of grave goods in graves change over time?

Wealth is a difficult concept to apply to prehistoric graves. In this study, wealth is defined simply in terms of quantities of grave goods relative to other graves within each phase. This approach avoids problems associated with ascribing value to "rare" or "symbolic" artefacts without contextual information, particularly when the excavation examined only part of the cemetery, sample sizes were small, and the grave good repertoire changed over several centuries. Consequently, more attention is paid to quantities of relatively common artefacts, rather than to the presence of "unique" artefacts. The assumption here is that richer means "more", not "different", although overall grave good diversity is considered in the next section. Within the same temporal context, 150 bronze bangles do indicate a "richer" grave than five bronze bangles. Perhaps the greatest difficulty with this conservative approach is a loss of information from ascribing the same numerical value of "one" to, for example, a pot, a bronze bangle, a bronze finger ring and a glass-beaded object. However, the advantage of being able to consider trends in grave wealth without imposing external ideas of value and symbolic importance far outweighs this loss. This analysis compares the mortuary phases in terms of the number of grave goods in undisturbed adult graves.

Discussion

As might be expected, the mean total quantity of grave goods in adult graves peaked in MP4, when the maximum number of grave goods per grave was extremely high (Fig. 18:18). However, minima remained at the same level – no goods or perhaps one artefact – in all phases. Thus, the increases in grave good quantity in MP4 did not apply to all graves in the phase.

Figure 18:19 compares graves of each mortuary phase in terms of their total number of goods (cf. Bayard 1984 Figure 6). Graves from each phase are ranked from the lowest to the highest quantity to allow comparison between the mortuary phases in spite of different sample sizes. Most graves in all phases contained less than 25 grave goods. Distributions in MP2 and MP3 were similar, increasing steadily to one or two rich graves. Maxima were also similar - the richest grave in MP2 contained 32 goods and the richest grave in MP3 contained 46 goods.

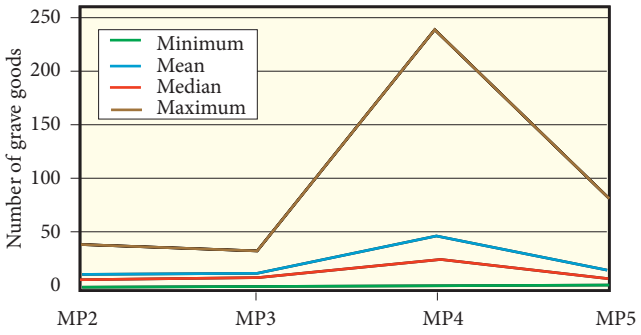


FIG. 18:18 Number of grave goods in undisturbed adult graves

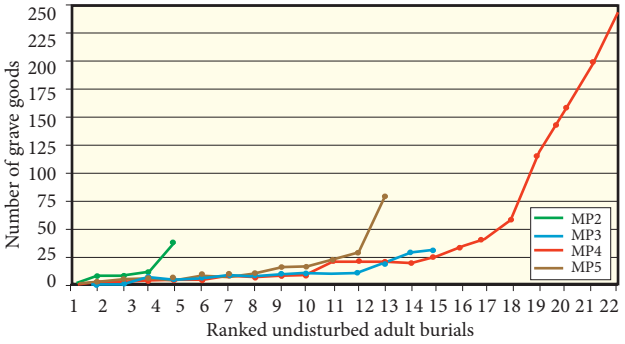


FIG. 18:19 Ranked total grave good quantities

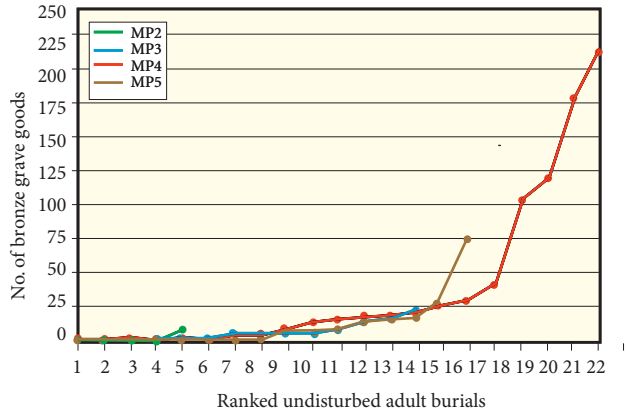


FIG. 18:20 Ranked bronze grave good quantities

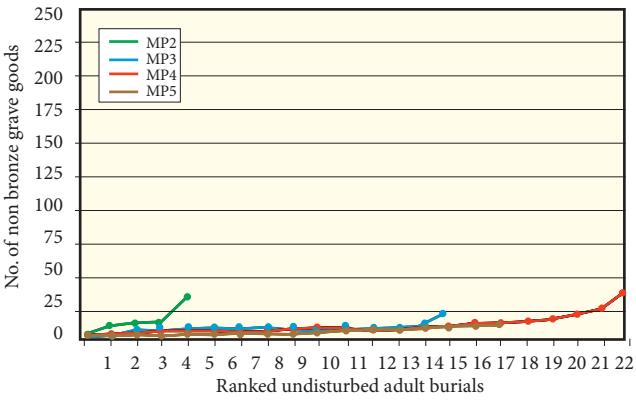


FIG. 18:21 Ranked non-bronze grave good quantities

MP4 had a more dramatic distribution, with an exponential rise in quantity. While the poor did not get poorer, the rich did indeed get richer. The richest grave in MP4 contained a remarkable 244 grave goods, over 10 times the phase median. Almost 50% of MP4 graves had less than 12 grave goods, yet the four richest graves in the phase (17% of graves) together contained more than 700. These four graves (burial 14, 69, 62 and 113) comprised 3% of the graves in the cemetery but contained almost a third of all grave goods. In MP5, there was a decline, and the richest grave contained 82 grave goods, over twice as many as the next richest, but considerably less than the richest graves of the previous phase. The previous intensification of grave wealth had waned.

Previous analysis suggested that the interment of bronze artefacts such as bangles and finger rings was a major characteristic of MP4. If graves are ranked in terms of bronze or non-bronze grave goods alone (Figs. 18:20 and 18:21), it is apparent that bronze artefacts were largely responsible for the peak in grave wealth seen in MP4.

4. Did the diversity of grave goods in graves change over time?

Identifying patterns of diversity allows another viewpoint of the grave good assemblage over time. Did the number of kinds of goods found in undisturbed adult graves change over time?

Discussion

Diversity of grave goods did not vary as dramatically as quantity (Fig. 18:22). Ranked diversities increased steadily in all phases (Fig. 18:23). All phases contained graves with no or only one kind of artefact, but also more diverse assemblages. Over half the graves in all phases contained less than seven kinds of goods. Means and medians were consistent. Maxima varied slightly with the most diverse assemblages found in MP2 (14 kinds) and MP4 (15 kinds). In contrast to the extraordinary peak in maximum quantity in MP4, the most diverse MP4 graves were not unprecedentedly so.

The implication, in conjunction with the changing grave good repertoire, is that there was ongoing substitution – rather than addition – of goods into the mortuary ritual. While the number of kinds of goods did not change markedly over time, the actual goods interred changed dramatically. In the context of Iron Age Northeast Thailand and the type of goods encountered, this would seem to relate to changing trade. For example, it is possible that with the introduction of traded beads, animal teeth were no longer worn and interred in burials.

5. Who were the rich individuals?

This analysis considers the richest undisturbed adult graves in the cemetery. (Disturbance made consideration of the poorest graves problematic. These graves did not form a notable subgroup, but seem to have been part of a steady continuum of wealth and tended to include one or two pots rather than other artefacts.) Do rich graves have anything in common? Who were the especially rich MP4 individuals?

Discussion

All phases contained relatively rich graves (Fig. 18:19). A more formal identification was made by calculating the greatest difference between burials ranked for grave good quantity in each phase (that is, the point of steepest slope in Fig. 18:19), which in each case occurred well towards the upper extreme. Table 18:7 identifies such graves in each mortuary phase, together with the upper decile point of grave good quantity. (Diversity did not show the same differentiation as wealth, with no similar notable subgroup. Not surprisingly, diverse graves were also rich. For comparison, graves in the top decile in terms of diversity are identified in table 18:8.) An ogive of grave good quantity indicates a distinct subgroup of very wealthy graves in MP4 (Fig. 18:24).

In MP2, the grave goods of burial 27 were by far the most numerous and diverse in the small sample (Fig. 18:25). This mature adult male wore three bronze torcs at his neck, and a broad bronze bangle on each wrist.

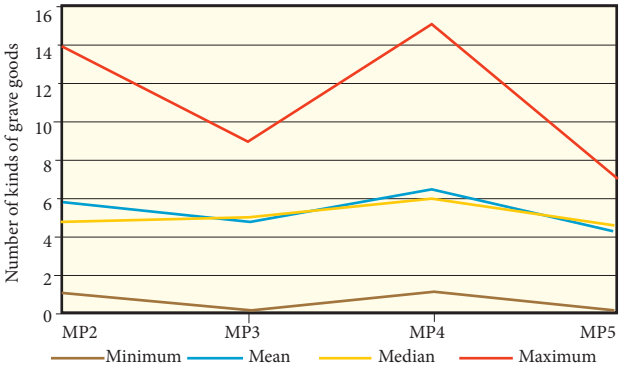


FIG. 18:22 Number of kinds of goods in undisturbed adult graves

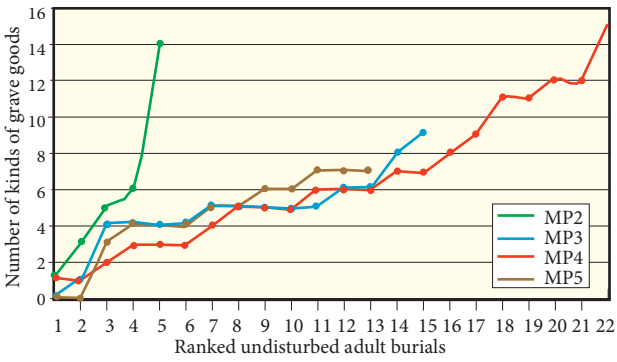


FIG. 18:23 Ranked grave good diversities

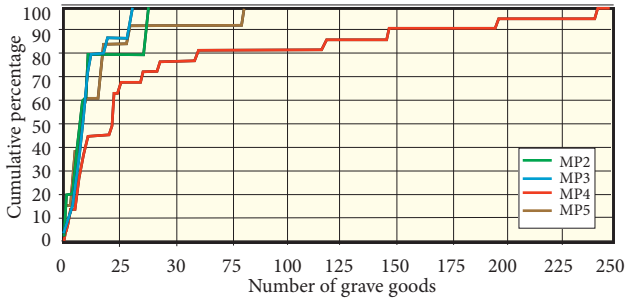


FIG. 18:24 Ogive of total adult grave good quantity

Another bangle lay beside two socketed bronze spearheads and two shell discs, all adjacent to a pot situated beyond the feet. Other pots lay beyond the feet, by the lower right arm, and beside the left knee. Fish and turtle bones were found inside one vessel. Many pig bones were recovered in this grave – in a pot beyond the feet, under the pelvis, beyond the feet and in the grave fill. A large socketed iron spearhead lay to the left of his cranium, and a socketed iron tool lay upright beside his left ankle. He wore shell ear discs and a tiger-canine necklace. Red ochre, a spindle whorl and a shaped *Bos* ulna comprised the remainder of grave goods. Whether this individual was placed at the top of a steady continuum of wealth – or was rather particularly wealthy – is unfortunately impossible to tell from the small existing sample of MP2. The latter is perhaps more likely in regard to the concentration of bronze within the grave.

In MP3, two burials ranked highly in quantity and diversity (Fig. 18:26). Both lay in MP3 Cluster B, which was marginally later than MP3 Cluster A. Burial 30 was a juvenile adult female, who lay in a rice bed and wore necklaces of thirteen agate beads, many glass beads and an agate pendant, three bronze bangles and ten bronze finger rings on her left arm, and a bronze earring. *Sus* foot bones lay at her left shoulder and a pig skull beside her head. Burial 35 contained a mature female in a rice bed burial. The cranium of burial 34, an infant or child, was found at her left forearm. This woman wore many ornaments - necklaces of two agate and many glass beads, an agate pendant, four bronze bangles and eleven finger rings on the left arm and two bangles and five finger rings on the right, and a bronze earring. Three spindle whorls were recovered from her grave. It is important to note that burial 54, the very disturbed remains of a senior adult in the form of the tibiae and fibulae alone at the base of the cluster, may have been especially rich, with twenty-one bells and seven rings on the left foot.

MP4, the largest phase, contained four extremely rich graves. These male and female individuals were found in all MP4 clusters except Cluster B (Fig. 18:27). (The richest in MP4 Cluster B – burial 98 - was ranked seventh overall.) All were interred in rice beds with many bronzes, especially bangles and finger rings, bimetallic rings, pots and iron blades. These graves comprised only 3% of those in the cemetery but contained almost a third of all grave goods. The largest assemblage belonged to MP4 Cluster D burial 14, a mature male interred with 244 grave goods, the second most diverse assemblage (Fig. 18:29). He lay in a rice bed, and wore an unprecedented number of bronzes, including three belts. Seventy-five bangles formed a heavy mass on each arm. He wore forty-six finger rings on his left hand, and twenty on his right, and two toe rings on each foot. He also wore two silver-gold ear coils, glass beads at his feet, legs and head, an agate bead and two agate pendants, and two bimetallic rings. Other artefacts in his grave included eight pots and an iron blade. Unfortunately, this burial could not be completely excavated.

Similarly, MP4 Cluster C burial 69 (Fig. 18:30) was a mature male interred in a rice bed burial. His 198 grave goods, fourth ranked for diversity, included four pots and many glass beads. Again, bronze was abundant, including

TABLE 18:7 *Graves in all phases identified as "rich"*

Phase	Burial	Age	Sex	Number	Upper Decile >
MP2	27	adult.m	M	38	27.2
MP3	30	adult.j	F	32	26.6
	35	adult.m	F	31	26.6
MP4	14	adult.m	M	244	155
	69	adult.y	M	198	155
	113	adult.y	F	159	155
	62	adult.m	F	119	155

TABLE 18:8 *Graves in the top decile of diversity*

Phase	Burial	Age	Sex	Diversity	Upper Decile>
MP2	27	adult.m	M	14	10.8
MP3	35	adult.m	F	8	7.2
	30	adult.j	F	9	7.2
MP4	96	adult.u	U	11	11
	69	adult.y	M	11	11
	14	adult.m	M	12	11
	105	adult.u	M	12	11
	113	adult.y	F	15	11
MP5	10	adult.s	F	7	7
	12	adult.s	F	7	7
	59	adult.y	M	7	7

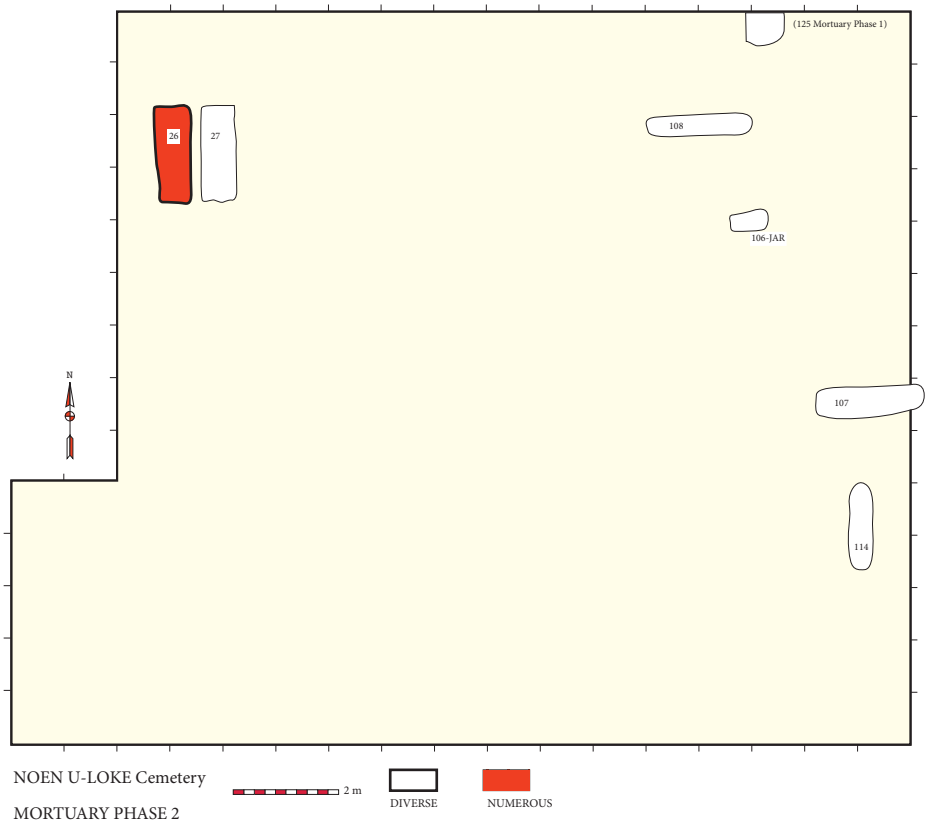


FIG. 18:25 Rich and diverse grave good assemblages in Mortuary Phase 2

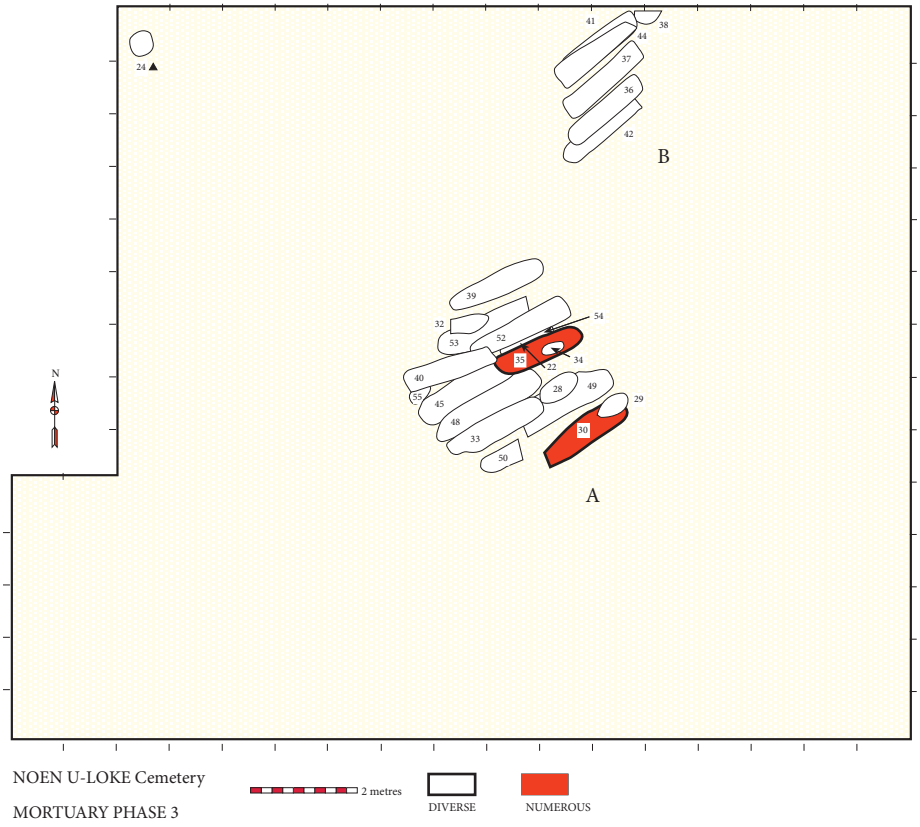


FIG. 18:26 Rich and diverse grave good assemblages in Mortuary Phase 3

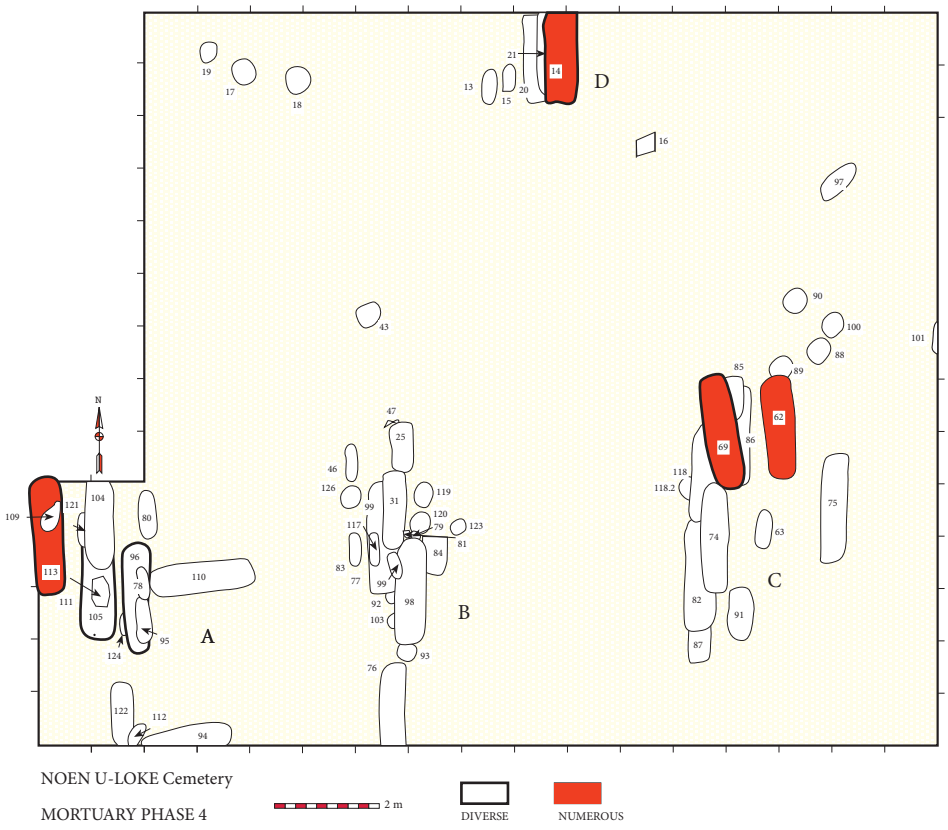


FIG. 18:27 Rich and diverse grave good assemblages in Mortuary Phase 4

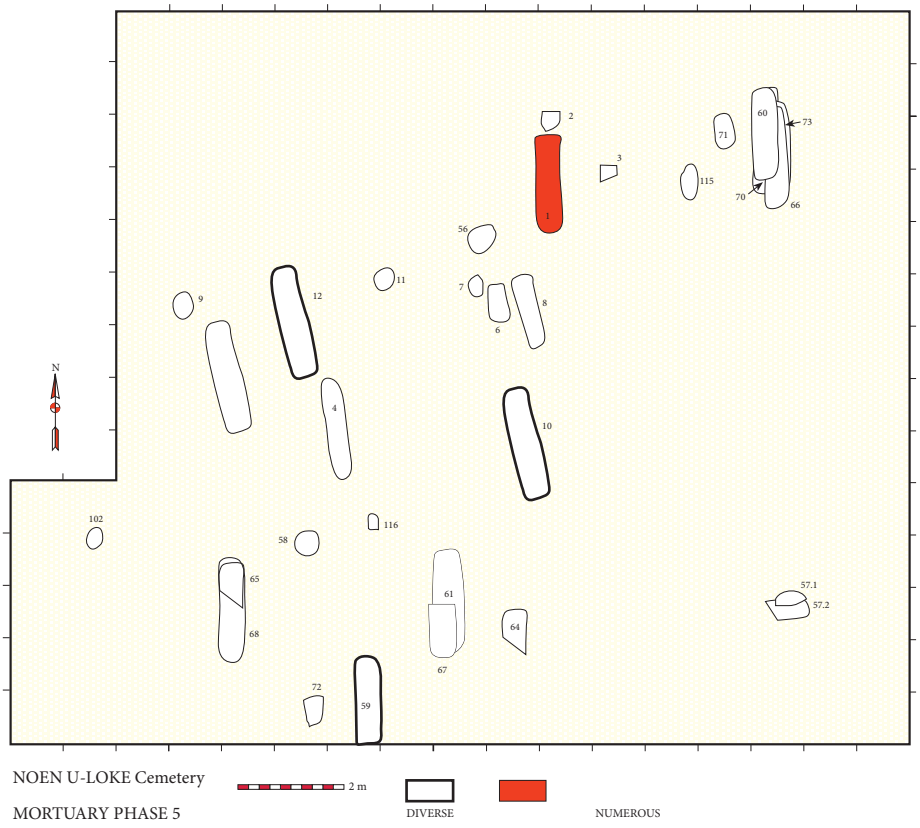


FIG. 18:28 Rich and diverse grave good assemblages in Mortuary Phase 5



FIG. 18:29 MP4 Cluster D Burial 14

two bronze earrings, four bronze belts and twenty-three bronze bangles. He also wore sixty bronze finger rings and thirty-three toe rings. Four bimetallic rings were recovered in this grave – two on the big toe of the left foot, another over the right femur and one under the chin. An iron blade lay to the right of his skull and an iron point rested below one femur.

The third richest grave in MP4 contained 159 artefacts, the most diverse range of grave goods in the phase. MP4 Cluster A burial 113 (Fig. 18:14) was a young adult female whose rice bed burial was lined and capped with clay. She was interred with necklaces of twenty-two agate and sixty-eight gold beads, two agate pendants, four pots, a bimetallic ring, an iron knife (with fabric remains visible in its corrosion), a silver finger ring on her left hand, and a silver toe ring on her left foot. She wore many bronze ornaments: two earrings, thirty-eight bangles, sixty-four finger rings and nine toe rings.

The fourth richest burial in the phase was also that of a woman. MP4 Cluster C burial 62 was a mature adult female. Again, the burial included silicified rice fill, and this time 119 grave goods. Three pottery vessels were present, and the woman wore an abundance of bronze jewellery – five anklets on each leg, sixty-five finger rings, twenty-five bangles, and eight earrings. An agate pendant, five bimetallic rings, an iron blade and four glass bead artefacts



FIG. 18:30 MP4 Cluster C Burial 69

comprised the remaining artefacts in her grave.

In terms of grave good diversity in MP4, certain MP4 Cluster A individuals may have had greater access to a wider range of goods than other burials in the phase (Fig. 18:27). This cluster contained the grave with the most diverse grave goods, burial 113 (Table 18:8), and other diverse assemblages in the phase belonged to two other burials from the cluster, MP4 Cluster A burial 105 and MP4 Cluster A burial 96[6].

The rich MP4 graves form a subgroup of burials, but one that was distributed across the apparently lineage-based clusters of the phase rather than grouped in a single cluster. Despite some differences, it seems that no one group could claim a considerably greater wealth than the others within the community and that much of the wealth of each of the lineage groups within the cemetery was concentrated in a single individual. (MP4 Cluster B is the obvious exception, but the following comparison of grave goods suggests this cluster may be slightly earlier than others within the phase.)

Burial 1 contained eighty-two artefacts, many more than other MP5 burials (Fig. 18:28). The grave contained a pot, many bronze ornaments – twenty-one bangles, two earcoils, and fifty-four finger rings – two bimetallic rings at the left upper leg and two by the right shoulder. This individual was a mature adult male buried, unusually, in a prone position. All graves in MP5 contained fewer than eight kinds of grave goods[7].

Summary

The Noen U-Loke cemetery contained rich adult graves in all mortuary phases. These individuals were not limited to any one sex or adult age range. In MP2, one of the five adult burials was particularly rich in comparison to other burials in the phase. In MP3, one cluster had two such graves, and was slightly later in date than the other cluster. In MP4, graves with extraordinarily large assemblages formed a distinct subgroup found in three of the four MP4 mortuary clusters, and one cluster may have had access to a more diverse range of artefacts. Finally, in MP5, one grave was notably richer than others in the phase, although on nothing like the scale of the burials of the previous phase.

6. What was the role of bronze?

Bronze artefacts were some of the most significant grave goods at the site. Quantities of bronze bangles and finger rings showed a marked peak in MP4, and bronze played a critical role in the intensification of mortuary ritual in this phase. This section considers the relationship between bronze and non-bronze artefacts in undisturbed adult graves. In particular, were the graves richest in bronze also richest in artefacts that were not made of bronze? How did the use of bronze in the cemetery change over time?

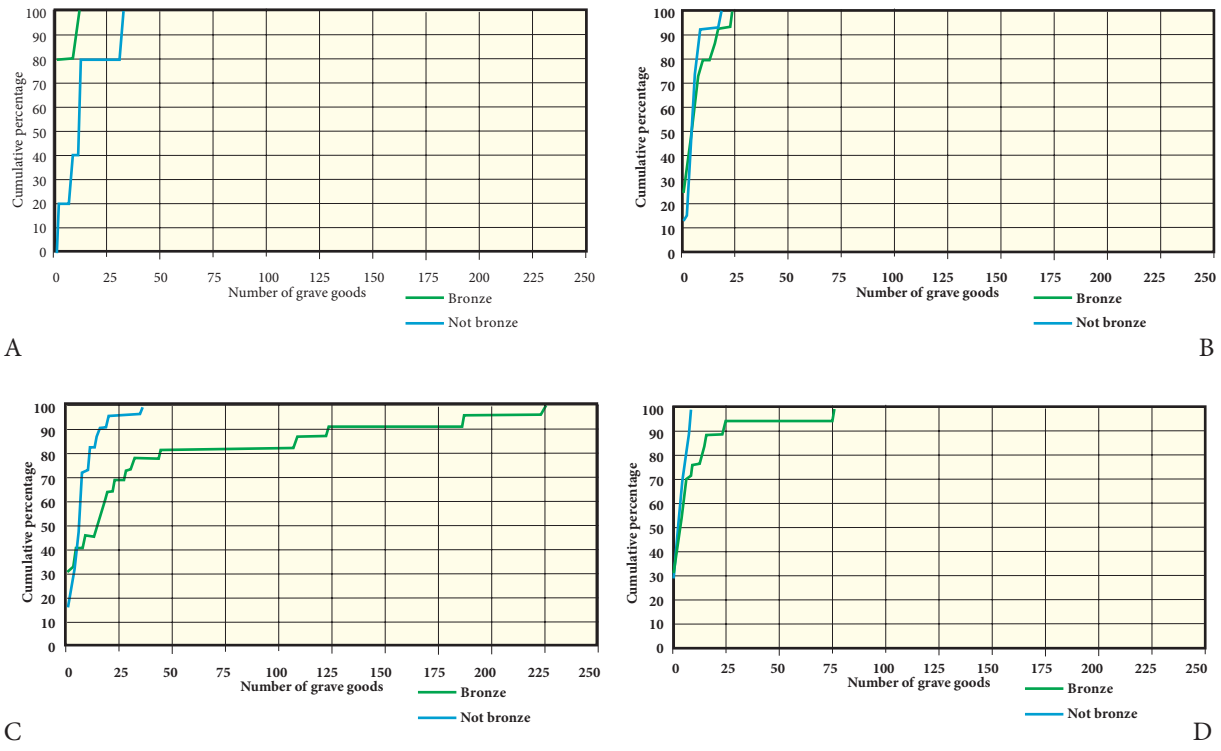
Discussion

Fig. 18:31 compares the relative cumulative frequencies of bronze and non-bronze artefacts in the first Iron Age mortuary phase at the site. In MP2, only one grave (20%) in the small sample contained bronze artefacts (burial 27), with 80% containing none. Burial 27 was a quite exceptional grave, containing by far the most numerous and diverse grave goods, and was also considerably richer than other burials in non-bronze artefacts. Bronze was not limited to jewellery in this phase, but was also cast into spearheads. In MP3, bronze was more common with only 13% of graves containing no bronze (Fig. 18:32). Of the two rich graves identified earlier, one (burial 35) was richest in bronze artefacts, and the other (burial 30) in non-bronze artefacts. By this period, bronze was more widespread and its distribution generally resembled that of other grave goods.

There was a dramatic shift in the relationship between bronze and non-bronze artefacts in MP4 (Fig. 18:33). Bronze was much more common. Only 9% of graves did not contain bronze. There was also very high degree of differentiation in the distribution of bronze, with the richest graves being very rich indeed (again burials 62, 113, 69, and 14). These four graves contained 49% of all bronze goods recovered in the cemetery. They were also rich in non-bronze artefacts, with the richest such grave being burial 113 followed by burial 14.

MP5 burial 1 was the richest in the phase in bronze and the third richest in non-bronze artefacts. However, in MP5, the concentration of bronzes seen in the richest graves was less intense (Fig. 18:34). While there was still a marked differentiation between the richest grave and other graves in terms of the number of bronzes, such differentiation was not seen non-bronze artefacts. MP5 burial 1 contained seventy-five bronze goods, almost three times as many than the next highest with twenty-four. Yet, all three of the graves richest in non-bronze artefacts (including MP5 burial 1) contained only seven or eight such artefacts. During this period, evidence suggests that "wealthy" graves were indicated by bronze ornaments and *not* by quantities of other goods.

In conclusion, the role of bronze changed over time. In MP2, bronze was introduced to the site. It was limited to the very richest grave, which also contained the richest and most diverse non-bronze grave goods. In this early Iron Age phase, bronze was used to make jewellery,



FIGS. 18:31-34 Ogives of bronze and non-bronze grave goods. A. MP2, B. MP3, C. MP4, D. MP5

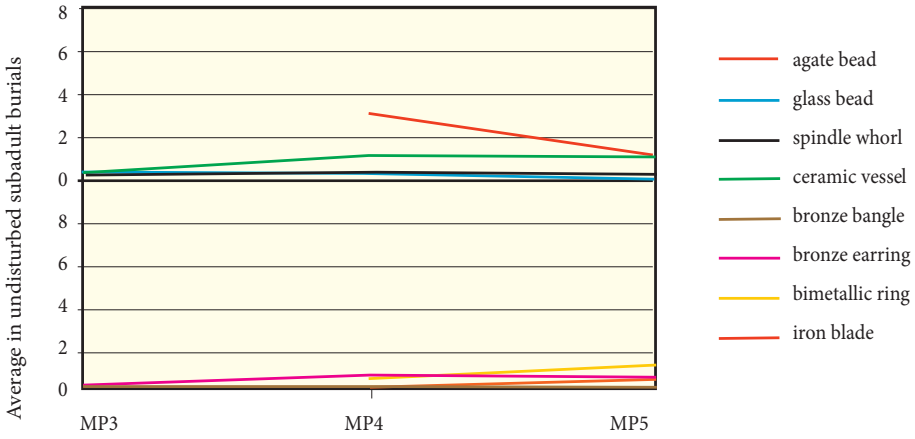


FIG. 18:35 Common goods in subadult graves

and spearheads that were perhaps more ornamental than functional. By MP3, bronze was more common, and it was distributed in a similar way to the non-bronze grave goods, with most graves containing similar amounts of artefacts. By MP4, bronze was widespread but it was also present in great quantities in the very richest graves. By this phase, bronze ornaments were apparently valued, not for their rarity as they were found in many graves, but as a currency of status. The value associated with bronze had shifted from one of quality to quantity. By MP5, bronze artefacts had become the main indicator of wealth, and in contrast to non-bronze artefacts, still showed at least some notable differentiation in grave wealth across the phase.

7. Were similar trends seen in subadult graves?

Previous analyses examined adult graves, yet much of the cemetery was composed of graves of individuals who had not reached adolescence. For brevity, this section contains a set of analyses of such burials as were not disturbed. Analysis of subadult graves is more problematic than that of adult graves. As only a single subadult was recovered in MP2, this phase was excluded and analysis was thus more limited temporally than that of the adults (MP3 t=7, MP4 t=30, MP5 t=10). Grave goods were also generally much less numerous, and the subadult category included a diverse range of individuals. However, despite these factors, similar patterns to those of the adult graves were seen, albeit with some interesting exceptions. A detailed age comparison is carried out in a later section.

Discussion

In terms of the mean numbers of goods, the same criteria were used as in the adult analysis (that is, those occurring in more than one phase and in more than 20% of burials for at least one phase) (Fig. 18:35). Subadult grave goods were generally less common, and only eight kinds of grave good fitted the criteria, most of which were found in small numbers. The changing mortuary repertoire was again apparent, with spindle whorls last present in MP4, ceramic vessels throughout, agate and glass beads introduced in MP3 and iron blades and bimetallic rings introduced in MP4. In contrast to adult graves, which fea-

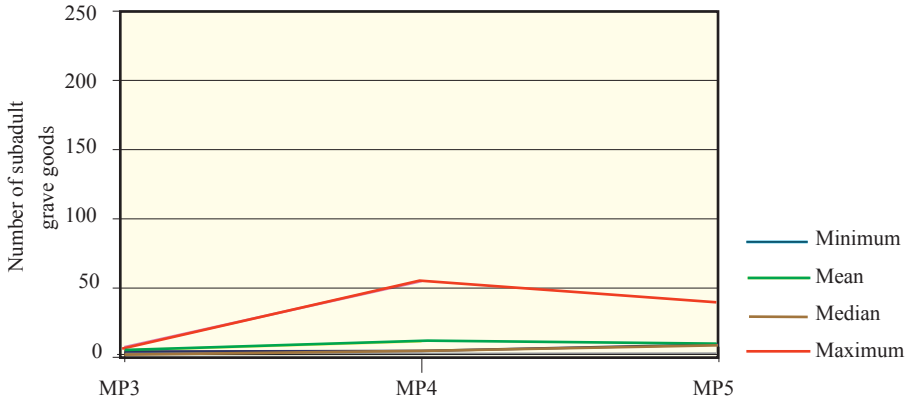


FIG. 18:36 Number of grave goods in undisturbed subadult graves

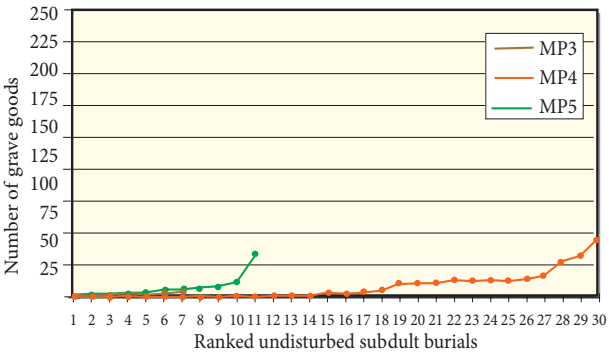


FIG. 18:37 Ranked total subadult grave good quanties

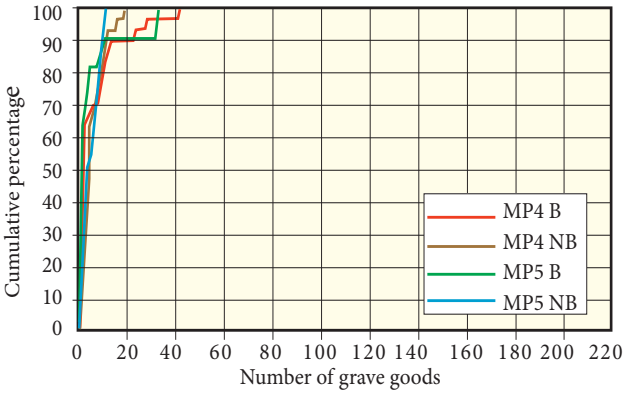


FIG. 18:38 Comparison of bronze and non-bronze grave goods

tured bronze from MP2, subadults were only interred with bronze bangles and earrings from MP4, when bronze was also much more commonly seen in the adult graves. In terms of quantities, subadults showed again similar trends to those of the adults, although figures were a great deal lower (Fig. 18:36). Again, maxima peaked in MP4 while means remained constant. Subadult grave wealth was generally very similar within each phase and over time (Fig. 18:37). The MP3 subadult graves contained similarly small numbers of goods.

In MP4, the three richest subadult graves were again distributed throughout the clusters. The richest was that of burial 122, associated with the possible cluster in the southwest of the unit. This infant was found in a rice bed surrounded by seven pots, wearing an agate pendant, glass beads, thirty-seven bronze bangles, a bronze toe spiral and two bronze earrings. MP4 Cluster C burial 63 was an infant buried with five pots, three bimetallic rings and many glass beads. Bronzes included fourteen bangles, seven anklets, a ring and an earring. MP4 Cluster A burial 80 comprised a rice bed burial filled with grave goods including a pot, spindle whorl and a necklace of glass and five agate beads. As mentioned, no human bone was recovered, and the rice filled grave is considered to be that of an infant based on the position of jewellery within the grave, particularly sixteen bangles and twelve anklets. These three graves contained the most bronze, and all three contained seven kinds of grave goods and were among the five most diverse subadult burials for the phase.

In MP5, the richest subadult burial by far, and one of the most diverse, was the grave of burial 115, containing a neonate who lay parallel with the complete shed antler of a deer. Other grave goods included thirty-one bronze bangles, four bronze anklets, a bronze earring and a bimetallic ring[8].

In terms of bronze grave goods, in MP3 no subadult graves contained bronze and in subsequent phases at least half of all subadult graves did not contain bronze (Fig. 18:38). Again, much of the wealth of the richest subadult burials in later phases was composed of bronze ornaments, although on nothing like the same scale as the richest adults.

8. Did grave goods differ according to age?

Earlier analysis suggested age was a cause of variation, with neonates often buried in separate clusters to adults. This analysis considers grave good quantity in ageable undisturbed graves and the distribution of specific goods in terms of age.

Discussion

The following graphs (Figs. 18:39-18:42) show all graves within a single phase ranked by quantity with the individual graves marked as either adult or subadult to allow for larger samples. In MP2 and MP3 almost all subadults were buried with fewer grave goods than adults (Figs. 18:39-18:40).

By MP4, certain rich adults were a great deal richer than others, and a very few subadults were richer than most of the adult burials (Fig. 18:41). The sixth richest burial was a subadult (MP4 burial 122, an infant). Similarly, MP5 contained an exceptionally rich subadult burial, the second richest in the phase (MP5 burial 115, a neonate) (Fig. 18:42)[9].

To summarise, in earlier Iron Age mortuary phases, subadults generally had fewer grave goods than adults. By MP4, rich subadult graves had appeared, concurrent with a group of very wealthy adult burials. The earlier subadult/adult age based division appears to have changed to a more complex one that at least in some cases would seem to relate to association with other members of the community.

As a preliminary step to identify grave goods that might be linked to particular age groups, analysis of specific goods was undertaken. In total fifty adults and forty-nine subadults were included, ignoring diachronic and demographic effects to allow for a better-sized sample (Table 18:9). Juvenile adults and children had very small samples, probably partly responsible for the absence of goods in these age categories. Table 18:9 compares the age distribu-

TABLE 18:9 *Comparison of goods by presence/absence*

	total t=99		adult.s t=10		adult.m t=14		adult.y t=20		adult.j t=6		child t=4		infant t=14		neonate t=31	
	no	%	no	%	no	%	no	%	no	%	no,	%	no	%	no	%
pottery vessel	49	50%	5	50%	9	64%	9	45%	3	50%	2	50%	9	64%	12	39%
bronze bangle	39	39%	5	50%	9	64%	8	40%	3	50%	2	50%	7	50%	5	16%
bronze earring	30	30%	4	40%	7	50%	6	30%	3	50%	2	50%	2	14%	6	19%
glass bead	32	30%	4	40%	6	43%	7	35%	1	17%	2	50%	6	43%	6	19%
bronze finger ring	28	28%	5	50%	7	50%	11	55%	3	50%	2	50%	-	-	-	-
rice bed	26	27%	2	20%	6	43%	8	40%	1	17%	1	25%	7	50%	1	3%
mortuary jar	22	22%	-	-	-	-	-	-	-	-	-	-	-	-	22	71%
agate pendant	20	20%	3	30%	5	36%	6	30%	2	33%	-	-	2	14%	2	7%
iron blade	20	20%	3	30%	4	29%	5	25%	2	33%	-	-	1	7%	5	16%
bimetallic ring	20	20%	-	-	3	21%	7	35%	-	-	1	25%	2	14%	7	23%
agate bead	16	16%	2	20%	5	36%	3	15%	1	17%	-	-	4	29%	1	3%
spindle whorl	15	15%	2	20%	5	36%	4	20%	-	-	1	25%	3	21%	-	-
bronze anklet	13	12%	1	10%	1	7%	1	5%	-	-	1	25%	4	29%	5	16%
bronze toe ring	9	9%	1	10%	3	21%	3	15%	1	17%	-	-	1	7%	-	-
iron sickle	8	8%	2	20%	-	-	3	15%	1	17%	-	-	-	-	2	7%
bivalve shell	7	7%	1	10%	-	-	1	5%	-	-	-	-	1	7%	4	13%
Sus skeleton	6	6%	2	20%	1	7%	1	5%	1	17%	1	25%	-	-	-	-
fish offering	5	6%	-	-	1	7%	1	5%	1	17%	-	-	-	-	2	7%
carnelian bead	5	5%	1	10%	2	14%	2	10%	-	-	-	-	-	-	-	-
Sus limb	5	5%	1	10%	1	7%	1	5%	1	17%	-	-	1	7%	-	-
shell bead	4	4%	2	20%	-	-	-	-	-	-	1	25%	-	-	1	3%
bronze belt	3	3%	-	-	1	7%	2	10%	-	-	-	-	-	-	-	-
iron point	3	3%	-	-	1	7%	2	10%	-	-	-	-	-	-	-	-
silver object	3	3%	-	-	-	-	3	15%	-	-	-	-	-	-	-	-

tion of grave goods, with "no." referring to the number of graves containing the artefact and "%" the overall percentage of such graves. Artefacts found in at least three ageable graves are ranked by the percentage of total graves containing the item.

There is little evidence of goods limited to age categories beyond that of adult and subadult. Clearly, mortuary jars were only found with neonates. While samples were very small, carnelian beads, iron points, silver jewellery and bronze belts were limited to adults. Agate pendants, iron sickles and especially iron blades were more common in the graves of adults. Bronze finger rings were worn by at least half of all children or older individuals, but not infants or neonates. Bronze bangles, toe rings and, to a lesser extent, earrings were more likely to be found with adults, while bronze anklets were more likely to be buried with subadults, perhaps partly the result of the size of artefacts.

With general trends identified suggesting some evidence for a division at a point between adult and subadult as the axis of age-based variation in the cemetery, both spatially and in terms of grave goods, goods were examined in a more specific temporal context. Were similar age-related patterns of distribution apparent in the individual phases? In this case, MP2 was omitted due to the small sample with a single subadult and age categories were consolidated into subadult and adults (including the unageable adults omitted from table 18:9) to allow for better-sized samples. A particularly cautious approach to any differences was necessary and all artefacts that occurred in fewer than three graves in the phase were excluded. The "A-S" column in tables 18:10-18:12 indicates the difference between the percentages of adult and subadult graves containing each kind of artefact, be it positive or negative, and the artefacts

TABLE 18:10 *Grave good distribution by age in MP3*

	Total		Adult			Subadult			A-S
	Count Graves	% Graves	Count	% A Graves (t=15)	Median	Count	% S Graves (t=7)	Median	% Graves
bronze bangle	8	36%	8	53%	4.0	-	-	-	53%
bronze finger ring	7	32%	7	47%	9.0	-	-	-	47%
agate pendant	6	27%	6	40%	1.5	-	-	-	40%
carnelian bead	6	27%	6	40%	2.0	-	-	-	40%
glass bead object	14	64%	11	73%	1.0	3	43%	1.0	30%
rice bed	13	59%	10	67%	1.0	3	43%	1.0	24%
Sus skeleton	6	27%	5	33%	1.0	1	14%	1.0	19%
agate bead	5	23%	4	27%	2.0	1	14%	1.0	12%
spindle whorl	7	32%	5	33%	2.0	2	29%	1.0	5%
shell bead	3	14%	2	13%	1.0	1	14%	1.0	-1%
pot	4	18%	1	7%	1.0	3	43%	1.0	-36%

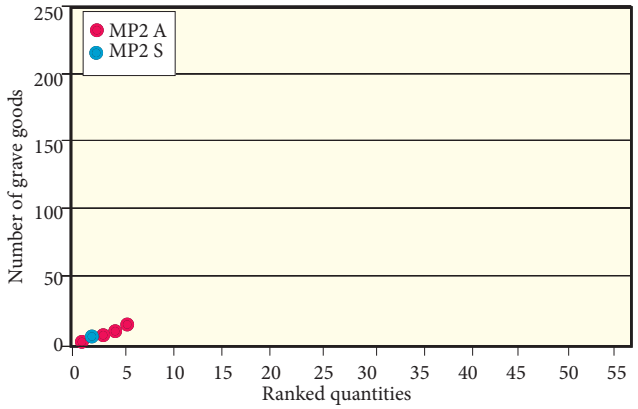


FIG. 18:39 Quantities of grave goods in MP2

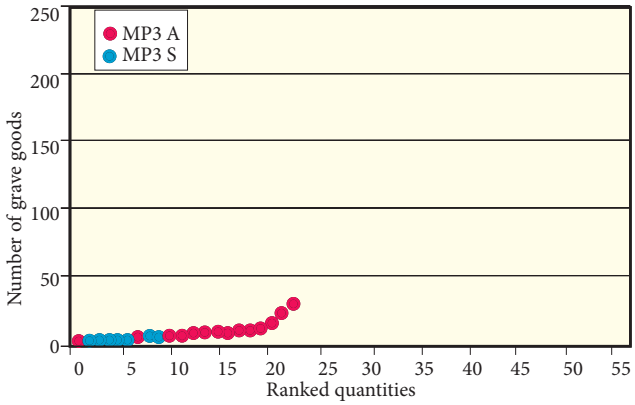


FIG. 18:40 Quantities of grave goods in MP3

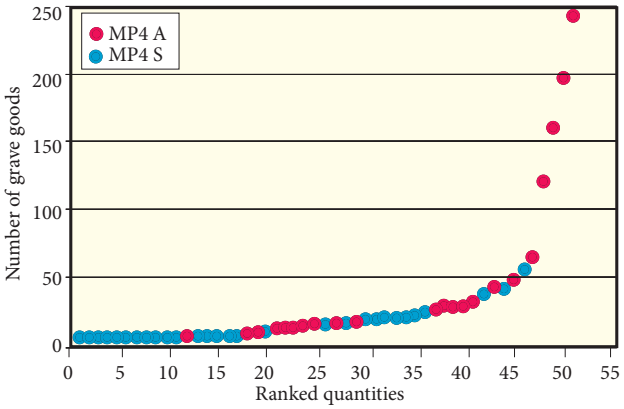


FIG. 18:41 Quantities of grave goods in MP4

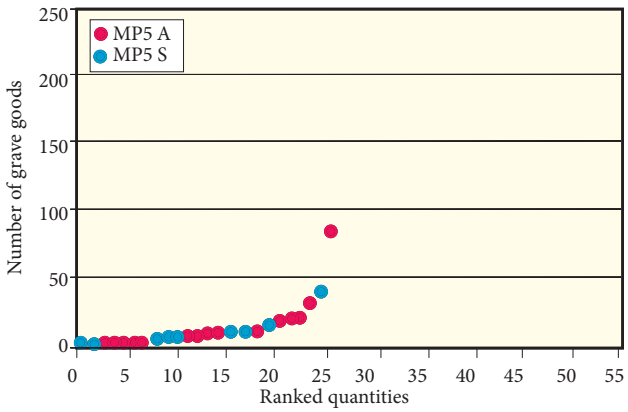


FIG. 18:42 Quantities of grave goods in MP5

TABLE 18:11 *Grave good distribution by age in MP4*

	Total		Adult			Subadult			A-S
	Count Graves	% Graves	Count	% A Graves (t=22)	Median	Count	% S Graves (t=29)	Median	% Graves
bronze finger ring	16	31%	14	64%	7.5	2	7%	5.0	57%
bronze earring	20	39%	14	64%	1.5	6	21%	1.0	43%
iron blade	12	24%	10	45%	1.0	2	7%	1.0	38%
pot	31	61%	18	82%	3.0	13	45%	2.0	37%
bronze toe ring	9	18%	8	36%	7.5	1	3%	1.0	33%
rice bed	17	33%	11	50%	1.0	6	21%	1.0	29%
bronze belt	5	10%	5	23%	2.0	-	-	-	23%
bimetallic ring	10	20%	7	32%	1.0	3	10%	3.0	22%
agate pendant	11	22%	7	32%	1.0	4	10%	1.0	22%
spindle whorl	7	14%	5	23%	1.0	2	7%	1.5	16%
agate bead	8	16%	5	23%	1.0	3	10%	5.0	13%
bronze bangle	19	37%	9	41%	13.0	10	34%	4.5	7%
glass bead object	18	35%	9	41%	1.0	9	31%	1.0	10%
bivalve shell	3	6%	-	-	-	3	10%	3.0	-10%
bronze anklets	11	22%	2	9%	10.0	9	31%	6.0	-22%
mortuary jar	14	27%	-	-	-	14	48%	1.0	-48%

TABLE 18:12 *Grave good distribution by age in MP5*

	Total		Adult			Subadult			A-S
	Count Graves	% Graves	Count	% A Graves (t=13)	Median	Count	% S Graves (t=12)	Median	% Graves
bronze finger ring	9	36%	9	69%	4.0	-	-	-	69%
iron sickle	8	32%	6	46%	1.0	2	17%	1.5	29%
bronze bangle	12	48%	8	62%	2.0	4	33%	6.5	29%
agate pendant	3	12%	3	23%	1.0	-	-	-	23%
iron blade	10	40%	6	46%	1.0	4	33%	1.0	13%
agate bead	3	12%	2	15%	2.5	1	8%	4.0	7%
bronze earring	9	36%	5	38%	1.0	4	33%	1.5	5%
glass bead object	4	16%	2	15%	1.0	2	17%	1.0	-2%
pot	12	48%	6	46%	2.5	6	50%	1.5	-4%
bimetallic ring	11	44%	4	31%	1.0	7	58%	1.0	-27%
mortuary jar	7	28%	-	-	-	7	58%	1.0	-58%

are ranked according to this figure. As all burials could be assigned either adult or subadult status, the median number of goods was also included.

In MP3 (Table 18:10), bronze was limited to adults and no subadults wore carnelian beads or agate pendants. (One subadult - burial 29, an infant - wore an agate bead.) Subadults were somewhat more likely to be buried with pots. Medians were similar, with the exception of bronze finger rings which had a median of nine in adult graves, but which were not found in the graves of subadults, perhaps partly related to the size of the objects[10].

In MP4 (Table 18:11), adults were more likely to be buried with small bronze objects such as earrings and finger rings, and with more bronze bangles (medians of 13.0 and 4.5), bronze toe rings (medians of 7.5 and 1.0) and perhaps bronze finger rings (medians of 7.5 and 5.0). The one exceptional artefact was the bronze anklet, which was more common in the graves of subadults. Iron blades were more common with adults. Glass beads were found in similar proportions in the adults and subadults of this phase, compared to a 30% difference in MP2.

In MP5 (Table 18:12), bronze finger rings were again more common and numerous with adults. Iron sickles, bronze bangles and perhaps agate pendants were more frequent in adult grave and mortuary jars were associated with subadults. The greatest single difference between adult and subadult proportions in any of the mortuary phases came in MP5, where 69% of adults - but not one subadult - wore bronze finger rings, although again this perhaps relate to the size of the rings themselves.

Such a diachronic approach provides a more detailed picture of the relationship between age and artefacts. In particular, introduced goods tended to appear in adult graves first. For example, in MP3, a striking characteristic was the absence of any bronze artefacts, agate pendants or carnelian beads in subadult graves. Thus at the time of the introduction of these goods into the cemetery, they were limited to adult graves. Glass beads also became more common in subadult graves over time. Over the course of the mortuary phases, bronze became interred with subadults, but it was generally found in more adult graves, in greater quantities, in all phases.

9. Did grave goods differ between women and men?

Previous analysis provided little evidence of differences between male and female burials in terms of inclusion in the cemetery or in burial treatment. Many of the skeletal remains were compromised by poor preservation and almost a quarter of adult burials could not be sexed. When disturbed burials were excluded, sexed sample sizes were especially small. Only twenty-three male and nineteen female burials were sexed and undisturbed and such burials were distributed across the mortuary phases. Based on this existing sample of graves, is there any evidence that grave goods differed between men and women?

Discussion

Distributions of grave good quantity and diversity by sex are compared in MP3 and MP4 (Figs. 18:43-18:46). (MP2 and MP5 each contained only two females and were excluded.) There is little evidence of variation in grave good quantity or diversity between the sexes. Note too that the group of very rich burials in MP4 included males and females.

All sexable graves in the four Iron Age phases were then considered as a group to determine any robust and long-term trends in the presence of particular goods in graves. Analysis focused on goods found in at least three sexed graves (Table 18:13). The "F-M" column in the following tables (Tables 18:13-18:15) indicates the difference between the percentages of female and male graves containing each kind of artefact, be it positive or negative, and the artefacts are ranked according to this figure[11].

Agate pendants were the only artefact differing by more than a third in at least three sexed graves (Table 18:13), although bronze bangles and earrings were also more common in female graves. Many artefacts, particularly bronze finger and toe rings, *Sus* forelimbs, spindle whorls and pots showed little difference (<5%), although some of these artefacts were found in very few graves (such as silver objects) or in many unsexable burials (such as iron blades). Only four artefacts found in more than two graves were sex-limited, and their samples were extremely small. Fish were found with three males in the tiny sample of MP2. Bronze anklets were found with three women found in MP4 and MP5. Similarly, iron points were recovered in the graves of three men in MP2, MP4 and MP5. The bronze belt has the strongest possibility of being a sex-limited grave good, found in the graves of four MP4 men and one unsexable MP4 adult.

Following this preliminary analysis, individual mortuary phases were considered separately. MP2 and MP5 were excluded because each contained only two sexable females, and because over a third of the MP5 adults were unsexable. In MP3, samples were small but most adults could be sexed (Table 18:14). Agate pendants and bronze bangles were more common in female graves. Common artefacts such as rice beds, glass beads and bronze finger rings showed little difference, if the small numbers of graves containing these artefacts were considered. Carnelian bead proportions were also very similar.

In MP4 (Table 18:15), again more women wore agate pendants, while men were now associated with bronze belts. Women were more likely to wear bronze earrings and bangles, and men bronze finger rings, iron blades and glass beads, although these goods were also found in high proportions of unsexable burials. For example, glass bead objects were found in five male graves (63%) and one female grave (14%), but another three adults - a third of all such burials - could not be sexed. In comparison, at least 80% of graves containing agate pendants, bronze bangles or bronze belts were sexable. The most common artefact

TABLE 18:13 *Grave goods found in at least three sexable adult graves*

	Total			Unsexable		Female		Male		F-M
	% adult graves with gg (t=55)	Count adult graves with gg	% sex-able / count adult graves	Count	% U graves (t=13)	Count	% F Graves (t=19)	Count	% M Graves (t=23)	Difference % Graves
agate pendant	29%	16	88%	2	15%	10	53%	4	17%	35%
bronze bangle	47%	26	85%	4	31%	13	68%	9	39%	29%
bronze earring	40%	22	73%	6	46%	10	53%	6	26%	27%
Sus skeleton	9%	5	100%	-	-	4	21%	1	4%	17%
bronze anklets	6%	3	100%	-	-	3	16%	-	-	16%
agate bead	20%	11	91%	1	8%	6	32%	4	17%	14%
rice bed	38%	21	81%	4	31%	9	47%	8	35%	13%
carnelian	13%	7	71%	2	15%	3	16%	2	9%	7%
iron sickle	11%	6	50%	3	23%	2	11%	1	4%	6%
bronze ring	7%	4	100%	-	-	2	11%	2	9%	2%
Sus forelimb	7%	4	100%	-	-	2	11%	2	9%	2%
bronze f ring	55%	30	73%	8	62%	10	53%	12	52%	1%
iron blade	29%	16	56%	7	54%	4	21%	5	22%	-1%
bronze t ring	20%	11	64%	4	31%	3	16%	4	17%	-2%
silver object	7%	4	75%	1	8%	1	5%	2	9%	-3%
spindle whorl	24%	13	92%	1	8%	5	26%	7	30%	-4%
pot	55%	30	70%	9	69%	9	47%	12	52%	-5%
glass bead	40%	22	73%	6	46%	6	32%	10	44%	-12%
iron point	6%	3	100%	-	-	-	-	3	13%	-13%
fish offering	6%	3	100%	-	-	-	-	3	13%	-13%
bimetallic ring	20%	11	91%	1	8%	3	16%	7	30%	-15%
bronze belt	9%	5	80%	1	8%	-	-	4	17%	-17%

TABLE 18:14 *Grave goods in at least three sexable adult MP3 graves*

	Total			Unsexable		Female		Male		F-M
	Count Graves with gg	% Graves with gg (t=15)	% graves sexed	Count	% U Graves (t=1)	Count	% F Graves (t=8)	Count	% M Graves (t=6)	% Graves
agate pendant	6	40%	100%	-	-	5	63%	1	17%	46%
Sus skeleton	5	33%	100%	-	-	4	50%	1	17%	33%
bronze bangle	7	47%	100%	-	-	5	63%	2	33%	29%
rice	10	67%	90%	1	100%	6	75%	3	50%	25%
agate bead	4	27%	100%	-		3	38%	1	17%	21%
bronze finger ring	7	47%	86%	1	100%	4	50%	2	33%	17%
carnelian bead	6	40%	83%	1	100%	3	38%	2	33%	4%
spindle whorl	5	33%	100%	-	-	3	38%	2	33%	4%
glass bead	11	73%	91%	1	100%	5	63%	5	83%	-21%

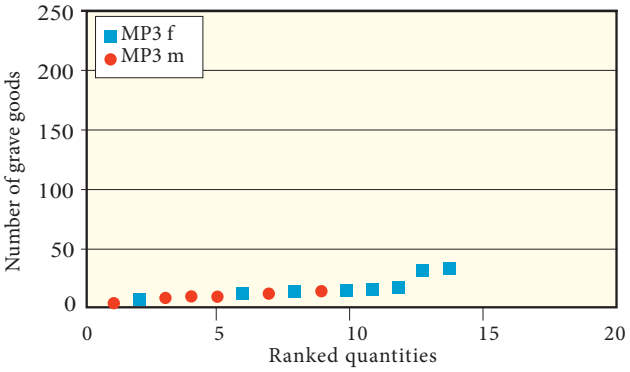


FIG. 18:43 Grave good quantity in MP3

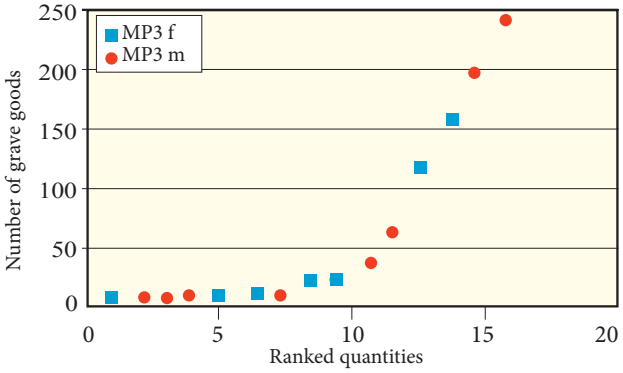


FIG. 18:44 Grave good quantity in MP4

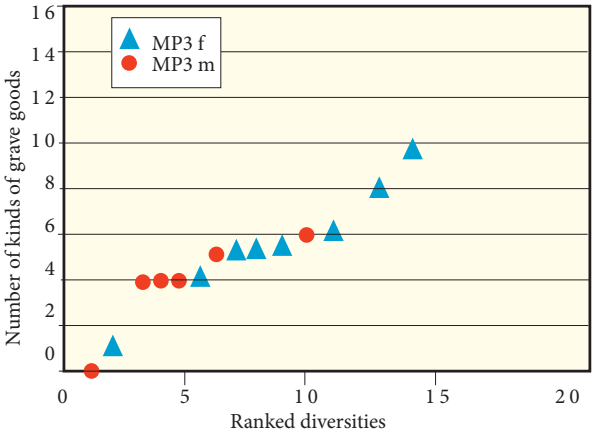


FIG. 18:45 Grave good diversity in MP3

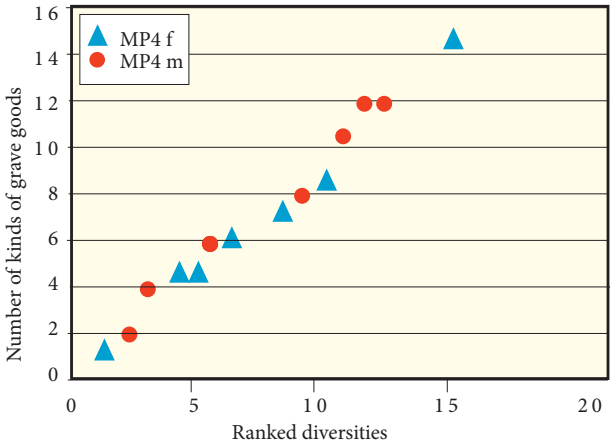


FIG. 18:46 Grave good diversity in MP4

was again a pot, found in 18 burials, and in very similar proportions of female (86%) and male (88%) graves.

In summary, while the existing sample is not well suited to comparing grave goods between the sexes, it provides little evidence of sex-related differences in terms of spatial distribution, inclusion in the cemetery, grave good quantity or grave good diversity. Only the bronze belt is a strong possibility of a sex-limited grave good, although women were perhaps more likely to be interred with agate pendants and bronze bangles. Burials cannot be sexed based on the basis of their grave goods, with the probable exception of bronze belts. Sex-related differences may occur in "rare" items such as tiger teeth that were associated only with certain individuals, but in the light of the small samples, this possibility cannot be confirmed. According to the existing sample, sex was not a major axis of mortuary variation in the cemetery of Noen U-Loke.

10. Did grave goods differ between the clusters?

Burial clusters were one of the most notable characteristics of the cemetery. Did the burial clusters found in the cemetery in MP3 and MP4 differ from one another in terms of grave goods from undisturbed burials?

Discussion - MP3

All MP3 adult burials were clustered. MP3 Cluster A contained four adults, and MP3 Cluster B eleven. Males and females were found in similar proportions in both. Considering the different sample sizes, there was little difference between the clusters in terms of grave good quantity or diversity, although MP3 Cluster B graves may have been slightly richer overall (Fig. 18:47 and Fig. 18:48). There were, however, marked differences between the MP3 clusters in terms of specific grave goods (Table 18:16). Rice beds, bronze bangles and carnelian beads were absent from MP3 Cluster A, but were found in over half of the graves of MP3 Cluster B.

Table 18:17 examines those grave goods found in at least three graves, in terms of numbers of goods, and, as all MP3 adult burials could be assigned a cluster, the maximum number of such goods found in an individual grave are also included (rice beds excepted). Differences were minimal between the clusters in terms of *Sus* skeleton and agate pendant maxima where the normative practice was that of a single artefact per grave. However, there were important differences, particularly in bronzes and agate beads. The maximum number of specific grave goods in a grave of MP3 Cluster A was never higher

TABLE 18:15 *Grave goods in at least three sexable adult MP4 burials*

	Total			Unsexable		Female		Male		F-M
	Count Graves with grave goods	% Graves with grave goods (t=22)	% graves sexed	Count	% U Graves (t=7)	Count	% F Graves (t=7)	Count	% M Graves (t=8)	% Graves
agate pendant	7	32%	100%	-	-	5	71%	2	25%	46%
bronze earring	14	64%	71%	4	57%	6	86%	4	50%	36%
bronze bangle	8	36%	100%	1	14%	5	71%	3	38%	34%
spindle whorl	5	23%	80%	1	14%	2	29%	2	25%	4%
agate bead	5	23%	80%	1	14%	2	29%	2	25%	4%
pot	18	82%	72%	5	71%	6	86%	7	88%	-2%
bimetallic ring	7	32%	100%	-	-	3	43%	4	50%	-7%
silver object	3	14%	100%	-	-	1	14%	2	25%	-11%
rice bed	9	41%	89%	1	14%	3	43%	5	63%	-20%
bronze toe ring	8	36%	75%	2	29%	2	29%	4	50%	-21%
bronze finger ring	14	64%	79%	3	43%	4	57%	7	88%	-30%
iron blade	10	45%	70%	3	43%	2	29%	5	63%	-34%
glass bead	9	41%	67%	3	43%	1	14%	5	63%	-48%
bronze belt	5	23%	80%	1	14%	-	-	4	50%	-50%

TABLE 18:16 *Grave goods in at least three MP3 graves (%)*

Grave Good	Cluster A		Cluster B		All	
	count graves	% graves	count graves	% graves	total % graves	range % graves
glass bead	2	50%	9	82%	73%	-32%
rice	-	-	10	91%	67%	-91%
bronze bangle	-	-	8	73%	53%	-73%
bronze finger ring	2	50%	5	45%	47%	5%
carnelian	-	-	6	55%	40%	-55%
agate pendant	1	25%	5	45%	40%	-20%
spindle whorl	-	-	5	45%	33%	-45%
Sus skeleton	2	50%	3	27%	33%	23%
agate bead	-	-	4	36%	27%	-36%

than in MP3 Cluster B. For example, the maximum for bronze finger rings in MP3 Cluster A was 9, while for MP3 Cluster B it was 16. (Note that in terms of individual glass beads – rather than glass-beaded objects - the maximum in a grave of MP3 Cluster A was 227, and in MP3 Cluster B it was much higher at 706.) Goods absent from MP3 Cluster A were found in high numbers in MP3 Cluster B. For example, bronze bangles were found in 73% of MP3 Cluster B adult graves, with a maximum of 6 in a single grave. Similar distributions were seen with other goods absent from MP3 Cluster A; agate beads (36% of MP3 Cluster B with a maximum of 13), spindle whorls (45% of MP3 Cluster B with a maximum of 4), and carnelian beads (55% of MP3 Cluster B burials with a maximum of 3).

The reason for these differences between the two clusters appears to be temporal. Stratigraphic evidence suggests that the two clusters differ marginally in age, with MP3 Cluster B being somewhat later, and this is apparent in the differences between the grave goods of the two clusters

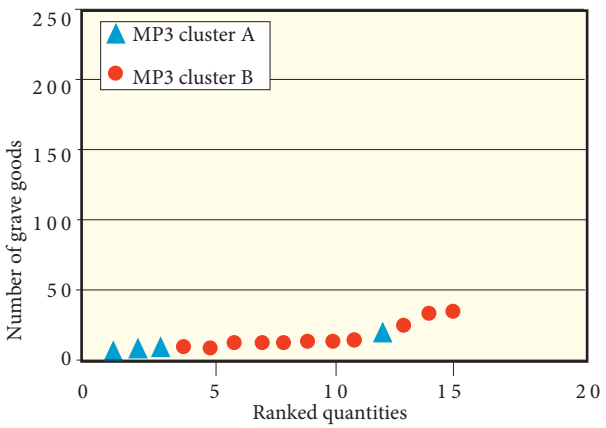


FIG. 18:47 Grave good quantities in MP3

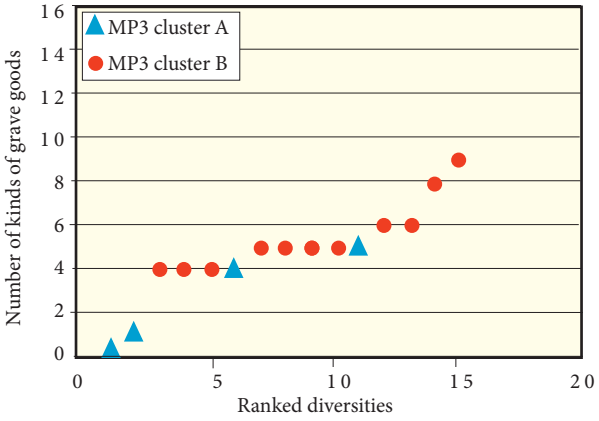


FIG. 18:48 Grave good diversities in MP3

(Table 18:18).

Of the MP3 grave goods, bronze finger rings, glass beads, agate pendants, agate beads, rice beds, carnelian beads, bronze earrings and bronze toe rings were first seen in MP3 and then continued into later phases. None of these artefacts was found in MP3 Cluster A and not MP3 Cluster B, and agate beads, rice beds, carnelian beads, bronze earrings and bronze toe rings were restricted to MP3 Cluster B. MP3 Cluster A contained a single agate pendant, while six were found in MP3 Cluster B. MP3 Cluster A is a smaller cluster, which may account for the absence of certain less common grave goods such as spindle whorls, but the overall pattern of difference is not easily explained by sample size.

MP2 bronzes were limited to the rich individual of burial 27, but were more common in MP3. Almost were recovered in MP3 Cluster B, including a large spiral head ornament. No bronze bangles were found in MP3 Cluster A, but MP3 Cluster B contained thirty in its eleven adult burials, with a maximum of six in a single grave. In fact, only two burials in MP3 Cluster A contained any bronze whatsoever - burial 37, a senior woman, wore nine finger rings and burial 36, a young woman, wore three of these small ornaments.

Carnelian beads have a particularly interesting distribution, with all but one such bead at the site found in MP3 Cluster B. The other bead occurred in a grave in MP4, and was of a globular shape quite different to the long faceted beads of the graves of the previous phase. Ten long faceted beads were recovered in the MP3 Cluster B, all associated with six adults, who were male and female, young, mature and senior. Why were carnelian beads limited to MP3 Cluster B? In the light of the diachronic difference between the clusters, the most likely explanation is that such beads were perhaps only of limited availability in the exchange network. The beads show limited diversity, despite the wide range found elsewhere in Southeast Asia, and are of a relatively rare type (Theunissen 2000:240-241).

Turning to subadult graves, all but one of the MP3 subadults were found in clusters (the exception a jar burial, burial 24). The distribution of subadult artefacts was sympathetic to that of the adults. Graves of a child (burial

TABLE 18:17 *Grave goods in at least three adult MP3 graves (maxima)*

Grave Good	Cluster A		Cluster B		All	
	number objects	max.	number objects	max.	total number	max. A-B
Sus skeleton	2	1	3	1	5	0
glass bead	2	1	9	1	11	0
agate pendant	1	1	6	2	7	-1
carnelian	-	-	10	3	10	-3
spindle	-	-	11	4	11	-4
bronze bangle	-	-	30	6	30	-6
bronze finger ring	12	9	41	16	53	-7
agate bead	-	-	19	13	19	-13

TABLE 18:18 *Grave goods in MP2, MP3 and MP4*

MP2	MP3 Cluster A	MP3 Cluster B	MP4
pig forelimb		pig forelimb	
ceramic vessel	ceramic vessel		ceramic vessel
spindle whorl		spindle whorl	spindle whorl
bronze bangle		bronze bangle	bronze bangle
	shell bead		
	pig skeleton	pig skeleton	
	bone beads	bone beads	
	bronze finger ring	bronze finger ring	bronze finger ring
	glass bead	glass bead	glass bead
	agate pendant	agate pendant	agate pendant
		agate bead	agate bead
		rice bed	rice bed
		carnelian bead	carnelian bead
		bronze earring	bronze earring
		bronze toe ring	bronze toe ring
		bronze spiral	

41) and neonate (burial 38) in MP3 Cluster A contained a *Sus* skeleton, fish offering, mortuary jar, and glass and shell beads. Agate and glass beads, pots, rice beds, *Bos* phalanges, a *Sus* forelimb and spindle whorls were found with four MP3 Cluster B infants (burials 29, 34, 2, 28). Again, agate beads, rice beds and spindles were limited to MP3 Cluster B.

Discussion – MP4

All but one of the twenty-two MP4 adults were clustered. If MP3 was an important juncture in terms of burial clustering, rice beds, beads and bronze, the subsequent phase was notable for intensification of mortuary effort, especially in the very rich graves found in three of the four clusters (Fig. 18:49). Most grave good diversities were similar, although the most diverse graves of MP4 Cluster A were perhaps particularly so (Fig. 18:50).

Most artefacts were present in all clusters (Table 18:19). The most notable exception was silver. MP4 Cluster A, which contained a particularly diverse range of goods also contained all the silver artefacts in the phase, except the silver-gold earcoils in MP4 Cluster D burial 14, suggesting that MP4 Cluster A individuals may have had greater access to this metal. Spindle whorls showed the greatest range, found in 100% of the (three) adult graves of MP4 Cluster B, but just a single grave in both MP4 Cluster A and MP4 Cluster C, and no graves in MP4 Cluster D and MP5. This distribution highlights perhaps the most notable characteristic of the artefact distribution, the slightly different assemblage found in MP4 Cluster B. In addition to the greater frequency of spindle whorls, MP4 Cluster B contained no bronze toe rings, belts, bimetallic rings, agate beads or silver objects. It was however limited to only three adults, and based on overall proportions all of these goods might have been expected to be found in only one or even none of the adult graves of the cluster. Yet, the fact that five such artefacts were absent from the cluster is more suggestive.

Maxima of specific goods were distributed throughout the clusters (Table 18:20; rice beds excluded). In only six cases was the range of the maxima divided by the total number of goods more than a third: agate beads (22/25=88%), bangles (137/293=47%), spindle whorls (4/9=44%), belts (4/11=36%), toe rings (42/118=36%) and silver artefacts (2/5=40%). MP4 Cluster B contained the lowest maxima for all of these goods except for spindle whorls, of which it had the highest.

One explanation for the differing grave good distribution in regard to MP4 Cluster B would again be temporal difference (Table. 18:21). This cluster was limited to just three adult burials, but none contained gold or silver jewellery or bronze belts, which appeared for the first time in this phase, and none was especially rich or diverse. Another important characteristic of MP4 was the introduction of iron goods such as blades and bimetallic rings. MP4 Cluster B contained only two iron objects, both blades, in its three adult burials. In contrast, MP4 Cluster A contained ten iron objects in its seven adult burials, MP4 Cluster C contained nineteen in its eight, and MP4 Cluster D contained three in its three. Perhaps more tellingly, fifteen bimetallic rings were found in seven of the MP4 adult graves, none of which were located in MP4 Cluster B. Rather than being "less wealthy" than others this cluster may well simply have been slightly earlier.

Again, most subadult burials were clustered, and subadult grave good distributions were sympathetic to those of the adults. The richest subadult burial in the phase was in fact that of the infant of burial 122 which contained 52 grave goods in total but which was not located in one of the definite burial clusters. The richest subadult graves in MP4 Cluster A (burial 80) and MP4 Cluster C (burial 63) each contained over thirty grave goods, and MP4 Cluster D (burial 13) contained an extraordinary number of glass beads. Again, rich graves were distributed across the clusters, except perhaps for MP4 Cluster B. The goods

TABLE 18:19 *Grave goods in at least three MP4 adult graves*

	Cluster A		Cluster B		Cluster C		Cluster D		All	
Grave Good	no. graves	% graves (n=7)	no. graves	% graves (n=3)	no. graves	% graves (n=8)	no. graves	% graves (n=3)	total % graves	range % graves
pottery vessel	5	71%	3	100%	7	88%	3	100%	86%	29%
bronze earring	5	71%	3	100%	5	63%	1	33%	67%	67%
bronze finger ring	5	71%	2	67%	4	50%	2	67%	62%	21%
rice	3	43%	2	67%	3	38%	3	100%	52%	63%
bronze bangle	2	29%	2	67%	4	50%	2	67%	48%	38%
iron blade	3	43%	2	67%	4	50%	1	33%	48%	33%
glass bead	4	57%	1	33%	2	25%	2	67%	43%	42%
bronze toe ring	2	29%	-	-	4	50%	1	33%	33%	50%
bimetallic	3	43%	-	-	3	38%	1	33%	33%	43%
agate pend	2	29%	1	33%	2	25%	2	67%	33%	42%
spindle	1	14%	3	100%	1	13%	-	-	24%	100%
bronze belt	3	43%	-	-	1	13%	1	33%	24%	43%
agate bead	22	29%	-	-	-	-	2	67%	19%	67%
silver jewellery	3	43%	-	-	-	-	-	-	14%	43%

TABLE 18:20 *Grave goods in at least three MP4 adult graves*

	Cluster A		Cluster B		Cluster C		Cluster D		All	
Grave Good	no. (n=7)	max.	no. (n=3)	max.	no. (n=8)	max.	no. (n=3)	max.	total no.	range max. /total
bronze finger ring	85	64	26	16	195	125	68	66	374	29%
bronze bangle	46	38	21	13	74	25	152	150	293	47%
bronze toe ring	51	42	-	-	63	33	4	4	118	36%
pottery vessel	24	8	8	3	24	5	10	8	66	8%
bronze earring	8	2	12	9	13	8	1	1	34	24%
agate bead	23	22	-	-	-	-	2	1	25	88%
bimetallic ring	3	1	-	-	10	5	2	2	15	33%
iron blade	5	2	2	1	5	2	1	1	13	8%
bronze belt	4	2	-	-	4	4	3	3	11	36%
glass bead	4	1	1	1	1	1	5	4	11	27%
agate pendant	4	2	1	1	2	1	3	1	10	10%
spindle whorl	1	1	7	4	1	1	-	-	9	44%
silver jewellery	5	2	-	-	-	-	-	-	5	40%

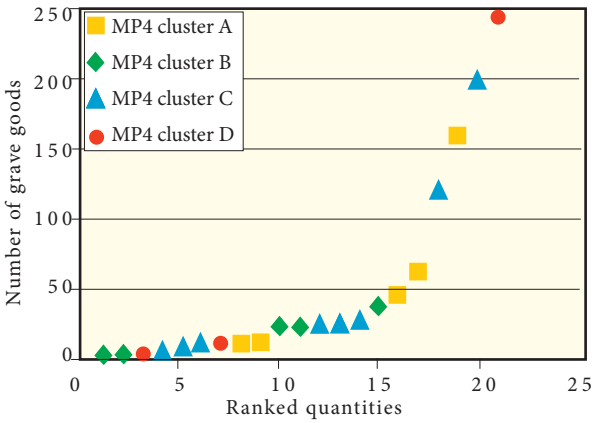


FIG. 18:49 Ranked MP4 grave good quantities by cluster

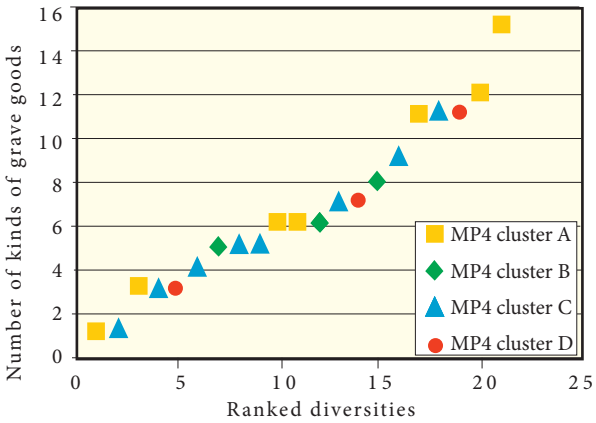


FIG. 18:50 Ranked MP4 grave good diversities by cluster

identified in the adult analysis as showing the most difference between clusters were silver objects, bronze belts and toe rings, spindle whorls, bimetallic and other iron objects, and agate beads. No subadult wore silver or a bronze belt, and just a single (unclustered) subadult in the entire cemetery, MP4 burial 122, wore a bronze toe ring. However, bimetallic rings were again absent from MP4 Cluster B and this time also from MP4 Cluster A. Spindle whorls were again absent from MP4 Cluster D, and this time also from MP4 Cluster C. MP4 Cluster B burial 46 did however contain an iron blade and several agate beads, the latter the only such artefacts in the cluster. This anomaly could be explained if this grave was somewhat later than others in the cluster. Again, while sample size effects should not be forgotten, some temporal difference between the MP4 clusters is suggested, particularly in the distribution of bimetallic rings (absent from MP4 Cluster B and previous phases) and spindle whorls (absent from MP4 Cluster C, MP4 Cluster D and from the subsequent phase).

Summary - MP3 and MP4

The differences in grave goods between the two clusters of MP3 would seem to result from the gradual introduction of new kinds of grave goods into the mortuary ritual. The earlier cluster of MP3 (MP3 Cluster A) indicates the introduction of new practices such as burial clustering, and contained new grave goods such as a single agate pendant, glass beads and bronze finger rings that were small and particularly portable. MP3 Cluster B represents an increased concern with the use of agricultural surplus in mortuary ritual – both directly in the form of the rice bed burials and indirectly in the greater numbers of exotic beads and bronze status symbols. MP3 Cluster B marks the beginning of the period of intensified use of bronze in graves, a practice that reached its peak in the subsequent phase. In MP4 there were relatively few differences in most grave goods between all four clusters, especially when the small sample sizes are considered. MP4 Cluster A may have had access to a wider range of grave goods, including silver. This cluster was not completely excavated but also saw graves capped with clay and the only gold beads in the phase. All clusters except MP4 Cluster B contained an exceptionally rich adult. All goods that were found in more than seven adult graves in total in the phase (the equivalent of 33% of such graves) were recovered in all four clusters. The distribution of artefacts such as bimetallic rings and spindle whorls suggest that MP4 Cluster B may be slightly earlier than others in the phase, which share a more similar grave good repertoire.

MORTUARY RITUAL AT NOEN U-LOKE

Heterarchy and hierarchy in Iron Age mortuary ritual

According to White (1995), the mortuary tradition of prehistoric Thailand had four important heterarchical characteristics. Firstly, there was a continuum rather than step progression of grave wealth, with "rich" graves being rich simply because they were at one end of a continuum. Criteria denoting social differentiation differed from cemetery to cemetery, with differences in the prominence of exotic artefacts perhaps relating to cultural differences. Graves of children were often as well or better endowed than adults. Finally, distinctive graves were so not so much because of great wealth or "obvious political power", but in a more individualised or "ego-focused" sense, such as the female potter's burial of burial 15 at Khok Phanom Di (White 1995:110). White (1995:102) was unable to consider comparable Iron Age data, as there was "a paucity of archaeological data for the immediate pre-state period (c. 200 BC – AD 800)".

Noen U-Loke clearly provides remedy to this situation. With the exception of the rich infant burials, quite different trends appear in this late prehistoric site. White (1995:112) suggested that more hierarchical elements might well have been introduced into local communities during the Iron Age, although heterarchical elements did not fade away altogether, and the mortuary data from Noen U-Loke supports this understanding.

TABLE 18:21 *Grave goods in MP2, MP3, MP4 and MP5*

MP2 & 3	MP4 - B	MP4 - A	MP4 - C	MP4 - D	MP5
spindle whorl	spindle whorl	spindle whorl	spindle whorl		
rice bed	rice bed	rice bed	rice bed	rice bed	
bronze torc		bronze torc			
iron tool		iron tool			
bronze bell		bronze bell			
carnelian			carnelian		
bronze bangle	bronze bangle	bronze bangle	bronze bangle	bronze bangle	bronze bangle
ceramic	ceramic	ceramic	ceramic	ceramic	ceramic
bronze ear ornament	bronze ear ornament	bronze ear ornament	bronze ear ornament	bronze ear ornament	bronze ear ornament
bronze finger ring	bronze finger ring	bronze finger ring	bronze finger ring	bronze finger ring	bronze finger ring
agate pendant	agate pendant	agate pendant	agate pendant	agate pendant	agate pendant
glass bead	glass bead	glass bead	glass bead	glass bead	glass bead
bronze toe ring		bronze toe ring	bronze toe ring	bronze toe ring	bronze toe ring
agate bead		agate bead		agate bead	agate bead
iron spear			iron spear		iron spear
		shell earring			
		bronze ring			
			iron ?hairpin		
			iron winged spade		
				silver/gold earcoil	
		bronze belt	bronze belt	bronze belt	
	iron blade	iron blade	iron blade	iron blade	iron blade
		silver			silver
		gold bead			gold bead
		bronze anklet	bronze anklet		bronze anklet
		bimetallic ring	bimetallic ring	bimetallic ring	bimetallic ring

The exceptionally rich and similar burials of MP4 and the shared use of status markers such as rice beds, bronze bangles, glass beads and agate pendants at a number of sites in the region and beyond contradict the heterarchical characteristics often posited for earlier periods. There is also an apparent focus on lineage in mortuary ritual at Noen U-Loke. Vickery's (1998 cf Wolters 1982) consideration of the pre-Angkorian Khmer inscriptions also suggests that the importance of lineage relations in the prehistoric and pre-Angkorian periods may have been underrated. The evidence suggests that, while the regional Bronze Age mortuary ritual might possibly have had heterarchical characteristics, by the Iron Age, hierarchical tendencies were expressed in mortuary ritual.

A MODEL OF CHANGE AT NOEN U-LOKE

The changing Iron Age mortuary ritual at the site of Noen U-Loke can be summarised in a set of interrelated trends:

1. Grave goods changed dramatically over the course of the Iron Age
While certain artefacts (such as bronze bangles) appeared

in all mortuary phases, and while grave good diversity was relatively consistent, the grave good repertoire at the site changed markedly. This changing repertoire provides an important diachronic framework, and would seem to relate to both changes in interregional, often riverine, trade and to an ongoing demand for exotic goods. The earliest Iron Age phase, MP2, was characterised by faunal remains, most dramatically the tiger canines, and unusual metal artefacts such as the iron bangles. By the end of the subsequent mortuary phase, new imported goods such as portable glass and hardstone beads had been introduced into graves. Bronze, probably derived from sources outside the region, began to be used more intensively in burials, and rice bed burials made explicit the link between agricultural surplus and mortuary ritual. MP4 saw more new grave treatments such as clay-lined graves and an efflorescence of new metal artefacts such as gold beads, bimetallic rings, bronze belts and iron blades. Iron blades and sickles characterised the final phase which contained very few faunal remains, and very few of the kinds of artefacts that had been recovered in the first Iron Age mortuary phase. In general, the changes indicated a shift from naturally or locally derived objects used in graves, to objects made of exotic materials, and in particular bronze. The value of bronze, in contrast to iron, changed from a qualitative one of rarity to one that apparently expressed status quantitatively through sheer numbers of ornaments and which was shared with other communities. The Iron Age sites of the upper Mun River valley formed a dense mesh across the landscape, and the elaborate ornamentation worn in life and death appears designed to impress both members of the community and of neighbouring communities.

In situations where trade in foreign status goods is increasing, changes in grave goods can often be seen as historical processes relating to status aggrandisement (see Kroeber 1927; Veblen 1934; Miller 1985; Cannon 1989). For example, seventeenth century Native American communities in New England used exotic goods in mortuary ritual as a medium for the competitive expression of status and status aspirations.

> "It was not goods that were more generally available or everyday domestic articles that distinguished richly furnished graves from plainer ones. Rather, native actors were apparently selecting particular material classes of [exotic] goods to signify political differentiation' (Brenner 1988:151).

Analogous processes appear to have been at work in Iron Age Northeast Thailand.

2. Age was the most important axis of demographic variation

The difference between subadult and adult was the most notable age-based distinction in the cemetery. These two groups were sometimes buried in separate areas, and certain kinds of grave good – particularly mortuary jars, carnelian beads, bronze anklets and bronze finger rings – were differentially distributed. However, this distinction was perhaps most apparent in earlier graves, and over time, a more complex social structure evidenced by the emergence of especially rich subadult burials emerged. Sex differences played little role in the formation of the cemetery judging by the current sample, with similar distributions of wealth between men and women, and bronze belts the only major sex-limited grave good.

3. The spatial distribution of graves showed a waxing – and waning – of burial clustering

Cluster membership was the most important spatial factor. Burial clustering emerged as a major trend in MP3, continued into MP4 but had largely disappeared by MP5. There are few apparent differences between the clusters in terms of relative wealth of grave goods. All clusters shared similar grave goods. MP4 Cluster A was notable for a greater diversity of goods, perhaps suggesting differential access to trade. The demographic analysis of the burial clusters suggests that each was most likely composed of members of the same lineage and they are perhaps best explained in terms of competitive consanguinal groups. For much of the period of mortuary activity, lineage identity appears to have been a critical part of mortuary ritual.

4. In MP4 mortuary ritual intensified and rich graves were distributed across the clusters

> "All of these elaborate preparations are for that brief moment where the corpse is displayed for the living before disappearing forever. It is in those final moments that the living's memories of the dead person are congealed" (Parker Pearson 1999:7).

Elaborate and varied grave treatments, such as rice bed burials and clay-lined graves, appeared in the cemetery with similar timing to the burial clustering. These changes were accompanied by a remarkable intensification of grave goods in certain graves, a conspicuous disposal of wealth and an overt marking strategy of status (Hodder 1982a:10). But marking what exactly? The great wealth of certain MP4 individuals in the Noen U-Loke cemetery marked them as different from their relatives, yet their wealth resembled that of members of other burial clusters. Why were these particular adults, both male and female, selected for differentiation in death? Was their status in death inherited, achieved, or perhaps ritualistic in nature? It is impossible to say, but a combination of status factors was probably operating, with the bronze belts indicating a particular status associated with certain males. The increasing focus on lineage apparent in the burial clusters of this period and the appearance of rich subadult graves at this time does suggest that familial relationships were increasingly emphasised in the cemetery.

Death provides an important opportunity for individuals "to clarify redundantly and expensively, political roles and relations in a time of instability" (Brenner 1988:176). Consequently, increasingly explicit consumption in burial

ritual has often been linked to periods of significant social stress (Childe 1945:17; Parker Pearson 1982a, 1982b, 1984; Morris 1987; Brenner 1988). Social advertisement in death ritual may be expressly overt where "changing relations of domination result in status re-ordering and consolidation of new social positions" (Parker Pearson 1982a:112). Yet, despite the overt advertisement of the mortuary wealth of certain individuals, it is not possible to conclude that social differentiation was increasing in the actual living community of Noen U-Loke. The trends seen might well represent the advertisement and emphasis of a developing social form with changing relations of domination and status. However, they might also represent a community under significant pressure, with an increasing need to reinforce pre-existing social positions through mortuary display.

Whatever the case, the mortuary evidence indicates that the late Iron Age community of Noen U-Loke was under significant social stress. The nature of this stress can only be determined by more multidisciplinary research in the region, but likely candidates would seem to include environmental pressure, competition for control of resources and changing relationships with other local communities. Whatever the case, it was such that it led to considerable amounts of wealth being lost to the community forever, for the sake of making a strong impression of wealth at the time of burial. Such stress on the Noen U-Loke community was however relatively short-lived. The MP4 – MP5 juncture is an intriguing one, as many of the characteristic features of MP4 dissipated with the onset of MP5. Grave wealth was curtailed. Burials were unclustered and lineage no longer a preoccupation of mortuary ritual. MP5 was also the final mortuary phase at Noen U-Loke, and occupation of the mound ended shortly thereafter.

Yet, other Iron Age communities in the region took a different path. Some grew larger and were occupied throughout the next centuries, and even to the time of Angkor. In the upper Mun River valley the unsteady period after the Iron Age was characterised by changes in settlement pattern that saw the increasing regional importance of communities located strategically for the control of trade and the flow of resources. For example Phimai, the site of the Angkorian period temple of the Prasat Hin Phimai, had clearly been an important site in the Iron Age (Talbot 2002; Talbot and Janthed 2001) and the Citrasena-Mahendravarman inscription suggests that there was probably also an important social focal point at Phimai in the sixth century (Vickery 1998).

THE END OF PREHISTORY AT NOEN U-LOKE

"If a complete record were available, it would be possible to trace the lineage of, say, Jayavarman I from village cultivators, through village headmen, to officials, and eventually to kingship" (Vickery 1998:179).

Early inscriptions are an important source of information in this region where archaeological information is often sparse. Vickery's (1998) analysis of the early Khmer inscriptions casts the early societies of the region in a new light. Many interpretations of early Southeast Asian societies have focused on the ability of individual leaders, stressing achieved status, personal prowess and charismatic leadership. For example:

"Cognatic kinship, an indifference towards lineage descent, and a preoccupation with the present that came from the need to identify in one's own generation those with abnormal spiritual qualities, are . . . three widely represented cultural features in many parts of early Southeast Asia" (Wolters 1999:21).

Vickery's (1998) analysis suggests that quite different characteristics seem to have existed from at least late prehistory in those parts of early Southeast Asia that would eventually become Angkor. In this case, it is as much as possible these early records that should provide context for archaeological interpretation, rather than models of social organization imported from other parts of the world.

An important feature of the development of Angkor was the replacement of an indigenous system of inherited status positions such as *pon* or *fan*, male village leaders who inherited their status from their mother's brother (Vickery 1998). *Pon* were closely associated with communal geographic-economic features, such as fields, ponds, swamps and roads. While not owning such features, they possessed decision-making influence over the communal basis of the economy and were also closely linked with the clan house, a ritual centre. The dominance of *pon* lineages was apparently secured by the appropriation of local gods as deified female ancestors or *kpon*, making domination acceptable to the wider population (Vickery 1998:308) and realising a link between divine and earthly power that would prove a powerful one. Individuals with special qualities were no doubt identified in such communities, but the power of at least some key individuals derived from their ancestors and there was no "indifference" towards lineage descent[12].

By the eighth century, critical structural change was underway. Under Jayavarman I and his successors, one Cambodian elite began to overcome the existing restrictions on the centralisation of power and elite control of land. The greatest limitation to their power was an indigenous matrilineal social system that had inhibited political centralisation. Authority does exist in matrilineal societies, but it is very often diffuse (Dube 1997) or, in other words, heterarchical. In eighth century Cambodia the indigenous matrilineal *pon-kpon* system was systematically dismantled and replaced with practices that allowed greater consolidation of power, such as royal-ascribed *mratan* status and royal patrilineality, with an experiment in direct female succession in the case of the queens of

Shambupura (Vickery 1998). High-status individuals were still linked to divine ancestors, but rather than the indigenous *kpon* goddesses, deities from world religions proved more suitable for elite use in the evolving hierarchies of Angkor. By changing these titles, the rulers of pre-Angkorian Cambodia could change the rules.

The changes that occurred under Jayavarman I and Jayadevi were unique, and would in time lead to the rise of the centralised polity of Angkor. Angkor was a deeply hierarchical society, with its royal decrees, palaces and temples. Yet within the polity, elite power was often contested and agriculture and trade were never fully centralised. Local elites in the upper Mun region remained important, and many seem to have remained largely independent well into Angkorian times. In time the Mahidarapura dynasty would even take the imperial throne, although it continued to focus its attentions to the north, as epitomised by the Prasat Hin Phimai. This temple embodies the wealth and status of the upper Mun River Valley in Angkorian times, although the processes that led to its construction began centuries earlier.

Comparison with this epigraphic evidence suggests that late prehistoric Noen U-Loke might best be considered as a type of "proto-*pon*" community. Use of the title *pon* in the wider region is contemporary with the Iron Age occupation at Noen U-Loke, with the early Chinese historians recording "*fan*" at Funan in the early first millennium CE and the titles *pon* and *kpon* well established by the time of the earliest dated inscription (K.600/611) (Vickery 1998:191; Jacques 1998; Higham 2001). The terms are best documented in Cambodia, with the northernmost contemporary occurrence of a *pon* yet found recorded on an inscription located near the Mekong just to the south of the Dangraek Range (K.341/700), although the Canasapura inscription (K.949/937) traces the dynastic history of an upper Mun elite back to a *pon* (Vickery 1998). With temporal and geographic relevance thus established, it is appropriate to consider Noen U-Loke in the context of what is known about *pon-kpon* societies.

Only men were *pon*, but they obtained their positions matrilineally and their power derived from deified female ancestors called *kpon*. At Noen U-Loke, both men and women were sometimes accorded a rich burial, yet only males wore bronze belts. Mortuary ritual can be both a source of and an expression of social power, and through the increasing use of personal display, elaborate burial treatment and focus on familial relationships apparent in the cemetery of Noen U-Loke, those directly associated with the deceased attempted to enhance their social position. Exactly how certain individuals were selected for special mortuary treatment at Noen U-Loke is unclear, but there was likely a combination of inherited and achieved status and perhaps also the association of certain individuals with ritual power. At the Iron Age site of Noen U-Loke, individuals were marked out from their peers by significant grave wealth, and according to the historical evidence, by the end of prehistory some villages in the region were apparently represented by a single male individual descended from a deified female ancestor.

Synchronisation of moat construction and mortuary ritual intensification is particularly suggestive in the light of the close associations between *pon* and natural or artificial water features called *travan*. According to recent AMS dates (McGrath and Boyd 2001), the initial construction of the moats at Noen U-Loke corresponds to MP3, which was the first mortuary phase at the site to show burial clustering, rice bed burials and the associated intensification of mortuary ritual. The *pon* evidence suggests that water features – and perhaps too other critical economic features of the landscape such as salt resources - may have been associated with certain individuals or groups within the community.

In conclusion, analysis of mortuary ritual at Noen U-Loke suggests a community that came under significant social stress as the Iron Age proceeded, a stress that can be seen in the increasing attention to mortuary ritual and lineage in MP3 and MP4. The cause of this stress requires further research, although likely candidates would seem to include environmental change and changing inter-community relationships of conflict, trade and competition for the control of resources.

By MP5, the stress on the community of Noen U-Loke had been resolved. According to the *pon* model, it is possible that one lineage within the community became unquestionably dominant, with a subsequent decline in the attention given to mortuary ritual. Alternately, it is conceivable that especially rich graves of members of this lineage could lie buried beyond the bounds of the current excavation. Yet it is also possible that another kind of resolution of the stress occurred at the site, one associated with deeper problems. Rather than increasing hierarchisation, it is perhaps more likely that towards the end of occupation opportunities for individuals to gain power within the Noen U-Loke community in fact declined. Shortly after MP5 the site was abandoned, just one of many similar Iron Age sites where occupation ceased. At the same juncture, a small number of other communities grew in size and importance and were indeed occupied well into subsequent centuries. In such a context, it is difficult to forget the iron point piercing the spine of MP5 burial 61, one of the very last burials interred at Noen U-Loke.

FOOTNOTES

[1]On two occasions two individuals were ascribed the same burial number in the field (burials 57.1 and 57.2, and 118.1 and 118.2). Four burial numbers (20, 23, 95, and 109) duplicated other burials (Tayles pers. comm.), burials 7, 51 and 127 were isolated finds of human bone, burial 101 was slightly exposed on the eastern baulk, burials 47 and 83 did not contain bone, and burial 125 was the Bronze

Age inhumation. These are excluded from this analysis of the Iron Age burials. The following burials were defined as "disturbed": 45, 54, 55, 124, 117, 87, 16, 51, 84, 7, 57, 64, 65 and 7.

[2] In a traditional Cambodian funerary procession "the popped-rice girl", a close relative of the deceased dressed in white, scatters rice symbolising bones scattering on the earth, and following cremation, rice is sown on the spot "to signify death and rebirth" (Tholla n.d:5). Among the Tai Yong wet-rice farmers of Thailand, rice and associated white cloth is of great importance at funerals (Trankell 1987). The deceased is placed on a mat covered in two pieces of white cotton, with another piece hanging from the roof used to wrap the body before it is placed in a coffin (see also Lefferts 1996). Feasting is an important part of the ceremony, but only certain 'domesticated' food items related to the annual rice cultivation cycle are included. These include rice, but also buffalo meat, associated with the arduous work of cultivation. The deceased is also symbolicaly fed (Trankell 1987:638). A characteristic white banner (*tung sam hang)* carried in the funeral procession is associated with the spirit of the deceased and with the unhusked rice symbolising new life that is placed on top of the coffin. Relatives and friends again throw popped rice along the way to the cremation site (Trankell 1987:638).

[3]According to one early twentieth century record "Some [indigenous Indochinese] tribes favour a kind of family burial hut, on the floor of which the coffins are laid in rows . . . This mausoleum is always in the middle of a rice or maize field at a convenient distance from the village" (Baudesson 1919:175).

[4] Early in the last century Baudesson (1919:28-29) recorded animistic rice farmer Moi or Karen peoples of highland Indochina using nooses, traps and pits to catch tigers. "The attacks of the tiger on the Moi are so frequent, ruthless, and calculated that a savage [sic] naturally ascribes them to the direct instigation and assistance of some supernatural power" (1919:47). These people never uttered the word 'tiger', an animal regarded with "a kind of holy awe" and raised to the rank of a deity (Baudesson 1919:125). The teeth and claws of wild animals were worn suspended around the neck as talismans (1919:102). Arrows poisoned with secret gums prepared by village "sorcerors" were used to kill elephants.

[5] Ten burials in the cemetery contained one or two, probably accidentally interred, glass beads and are not included.

[6] MP4 Cluster A burial 105 was an adult male in a disturbed clay-capped rice bed burial. The sixty-one goods were not in clear relationship to the body, but included two iron blades, seven pots, a bimetallic ring and many glass beads. Bronzes included a belt, ring, finger ring and forty-two toe rings. A spindle whorl lay at the ankles, and a silver bangle at the left wrist. MP4 Cluster A burial 96 was an adult in a rice bed. A pot and iron blade lay over the face. The forty-four grave goods also included bronzes (torc, two earrings, eight bangles, eighteen finger rings, a belt, and two bells), another blade, iron hoe, glass beads and seven more pots.

[7] Burial 1 contained five kinds of goods and three other burials contained seven. The disturbed grave of burial 10, a senior woman, had several bronzes (nine finger rings, two earrings, three bangles, and an anklet), an agate bead, an iron blade and iron sickle (eighteen artefacts total). Burial 12 was another senior adult female with seventeen artefacts - two pots, bronzes (bangle, earring, three finger rings and eight toe rings), an iron blade and sickle. Burial 59 contained a young adult, and partially extended beyond the bounds of the excavation. Nevertheless, the seventeen artefacts included a bimetallic ring, two bronze bangles, seven finger rings, an iron blade and sickle, four pots and a silver earring. (Note that burial 64 contained gold beads but few other goods – a bimetallic ring, two bronze bangles and four finger rings.)

[8] Subadult diversity was not especially variable with all phases showing steady increases to maxima of less than nine kinds or grave good. The median in all phases was two kinds, and the maximum of eight kinds occurred in both MP4 and MP5. The most diverse MP4 subadult grave belonged to Cluster B burial 25 (a child) and contained six bronze anklets, a bronze bangle, bronze earring and finger ring, glass beads, a pot, two spindles and a rice bed. The next most diverse was MP4 Cluster C burial 91 which contained a neonate interred with an agate bead, bivalve shell, two bronze anklets, six bronze bangles, a bronze earring, two pots and a rice bed. The most diverse MP5 subadult was burial 9, a neonate with two bimetallic rings, two bronze earrings, an iron knife and sickle, a pot and a mortuary jar.

[9] Grave diversity was little differentiated although increasing attention to certain subadult graves may perhaps be seen. In MP2 and MP3, adults usually comprised the most diverse graves, probably partly due to the greater number of goods in most adult graves. By MP4, the diversity of some subadult graves relative to adults had increased, and in the smaller sample of MP5, the most diverse grave of all was that of the particularly rich subadult, MP5 burial 115.

[10]Extremely rare goods limited to one or two graves were excluded from table 18:9. They came from single senior (iron bangle, iron torc, shell earring), mature (tiger canine, shell disc, bronze spear, *Bos* ulna, silver gold ear coils), young (pig tusk, iron winged object, bronze head orna-

ment, gold beads), juvenile (deer ulna) or unknown (iron hairpin) adult graves, and graves of children (egg), infants (ivory bangles) and neonates (*Bos* phalanges, deer antler). Some came from two adult graves – turtle carapace (mature and senior), ochre (young and mature), bone beads (young and senior), or bronze torc (unknown and mature). Bronze bells were found with an adult and a neonate. Bronze rings came from graves of two young, one unknown and one senior adult, two infants and a neonate but are difficult to compare and have been excluded.

[11]Bronze bells, *Bos* phalanges, eggs, ivory bangles, deer antlers and iron ?hairpins were not found in sexed burials. Some goods were limited to a single sexed grave, be it male (tiger teeth, pig tusk, shell disc, bronze spear, *Bos* ulna, deer ulna, bronze torc, iron tools, silver-gold earcoil, iron winged object) or female (iron bangle, iron torc, bivalve shell, shell earring, shell bead). A bronze torc and iron hoe were found in an unsexed burials in MP4 and a silver earring in an unsexed burial in MP5. Other goods had one male and one female representation (turtle carapace, clay lining and gold bead). Red ochre, iron spears and bone beads were limited to men, but were found in only two graves. Most of the goods limited to men were found only in MP2, which comprised just six burials, including the very diverse male of burial 27.

[12] Regional ethnography provides examples of similar leadership practices, such as the Jarai Kings of upland Vietnam who succeeded to office via their mother's brother (Vickery 1998:270-2). To the south, the Temoq people of interior peninsular Malaysia speak a Mon-Khmer language that includes a title *paung*, a possible cognate of pon/fan (Laird pers. comm in Vickery 1998:203, 272). Note that at the time of Funan, Chinese had no /f/ sound, rather /p/, /ph/, or /b/ (Bayard pers. comm.) The title honours deified shamanic ancestors responsible, with their female counterparts, for creating the world and for revealing its true nature to the shaman. A Temoq shaman obtains his position by mystical recruitment to celestial lineages or by inheritence from his mother's brother. It has also often been claimed that matrilineality underlies the existing cognatic Khmer kinship system (see Porée-Maspero 1962-1969; Martel 1975; Martin 1994; Ledgerwood 1995; Oveson *et al.* 1996:53). Contemporary rural kinship systems in Cambodia and Northeast Thailand are matrifocal with adult women and uterine uncles playing important social roles, and (youngest) daughters often inheriting family rice fields in association with care for aged parents (Oveson *et al.* 1996:55; Dube 1997:31-3).

XIX. THE MATERIAL CULTURE

C.F.W. HIGHAM

The material culture from Noen U-Loke has been divided into several subdivisions. The ceramics will be described by J. Voelker, the ornaments by N. Chang, the glass beads by S. Saitowitz, the agate and carnelian jewellery by R. Theunissen, the iron by R. Connelly and structural remains by J. Chetwin. The remaining categories of artefact will be considered below, together with a general description of the distribution of specific items of material culture over time.

INTRODUCTION

Each artefact was given a unique catalogue number, and recorded as to its provenance in the site. Since the cultural sequence at Noen U-Loke is one of the longest continuous records in Southeast Asia, this section will commence with a consideration of the temporal distribution of the major categories of artefact from burial and non-burial contexts.

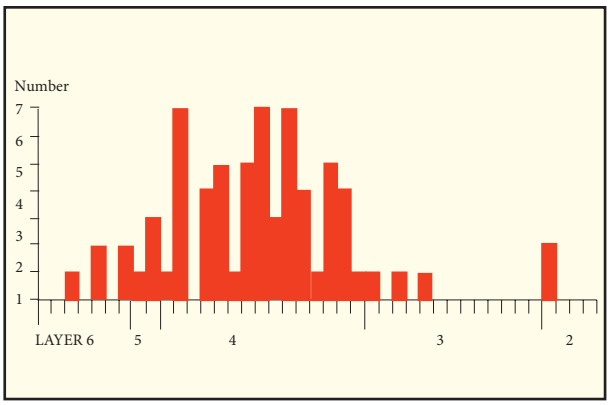


FIG. 19:1 The distribution of spindle whorls by layer

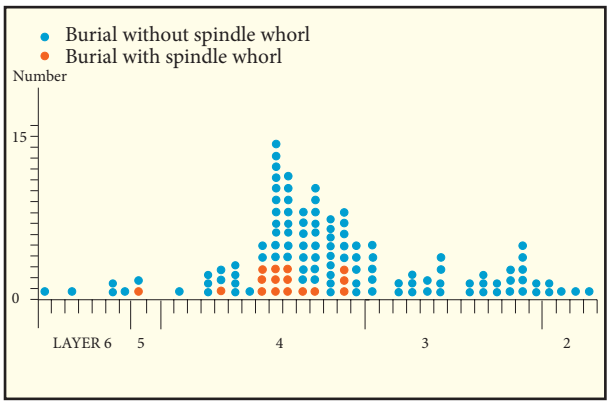


FIG. 19:2 The distribution of spindle whorls in burials

SPINDLE WHORLS

Spindle whorls concentrated in the later phases at the nearby Bronze Age site of Ban Lum Khao. It is evident that they were in use during the earliest phase exposed at Noen U-Loke, and many were found in mortuary phase 2-4 burials. However, it is intriguing to note that the great majority of whorls were found in layer 4, and that they became very rare in layer 3, with only three examples. Yet mortuary specimens concentrated in graves cut from at least basal layer 3 if not higher. The reasons for this are hard to identify. The pre-Angkorian inscriptions often refer to weavers among the temple personnel. It is possible that during the later period of the occupation of Noen U-Loke, spinning and weaving came to be specialised occupations undertaken elsewhere, and that cloth was increasingly an item of exchange between specialised communities. In this context, the placement of spindle whorls in burials might take on a social significance by reflecting individuals with

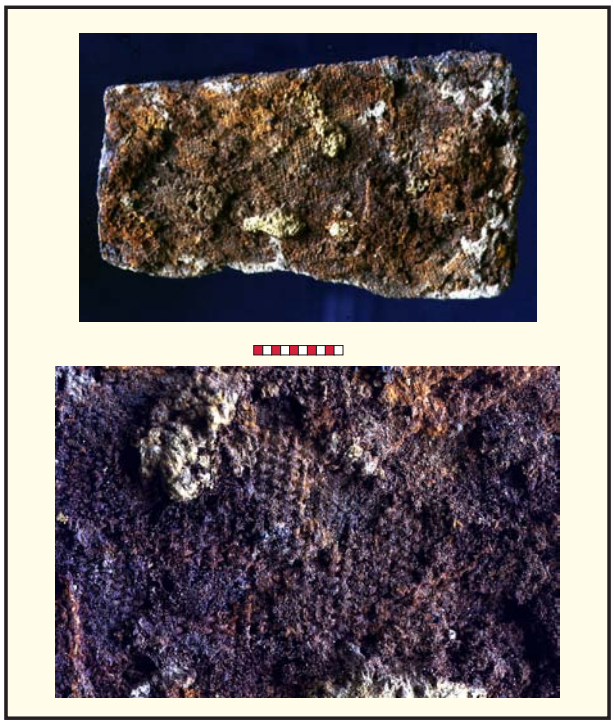


FIG. 19:3 The woven fabric on the surface of the iron knife, cat. 1708, from burial 113. Scale for upper illustration, 1.5 cm

specialised skills.

The presence of woven fabric at Noen U-Loke is attested in the form of pseudomorphs surviving on the surface of metal artefacts. The iron knife, cat. 1708, from burial 113 for example, was covered in such fabric remains (Fig. 19:3).

CERAMIC ANVILS

Given the quantity of pottery vessels found at Noen U-Loke, it is surprising to find that only four ceramic anvils were recovered, none from burials. This contrasts markedly with the quantity recovered from Ban Lum Khao (Higham and Thosarat 2005) and the provision of anvils as grave goods for women at later stages of the sequence at Khok Phanom Di (Higham and Thosarat 2004). The following specimens were found:

Cat. 637, A1 6:5. The top and one side of the face of this solid clay anvil have been worn. The head is almost flat and there are no visible marks on the surface. ML 48.3, DF 54.7.

Cat. 631, A1 6:4. This anvil has a red clay body with a solid handle cracked on one side. There are cord marks on the top of the head. ML 41.0 (all dimensions in mm), DF 56.0.

Cat. 722, B1 5:2. The fragment of the head of a large anvil. The DF is estimated as 105.1.

Cat. 341, B1 4:7. This anvil has a red clay body with a hollow handle partially broken on one side. The working surface is sharply convex and the underside of the head is cracked. ML 65.0, DF 56.0.

STONE ADZES

The continuation of the use of stone in the manufacture of adzes continued well into the Iron Age. Nine of the 15 specimens come from layer 5 and 6, and might thus belong to the Bronze Age phase of occupation, but two stone adzes were found in layer 4 and one in layer 3. Three lying on the very surface of the mound in layers 1 and 2:1 might result from recent activity, such as the finding of an adze and then its loss. The adzes come from the following contexts:

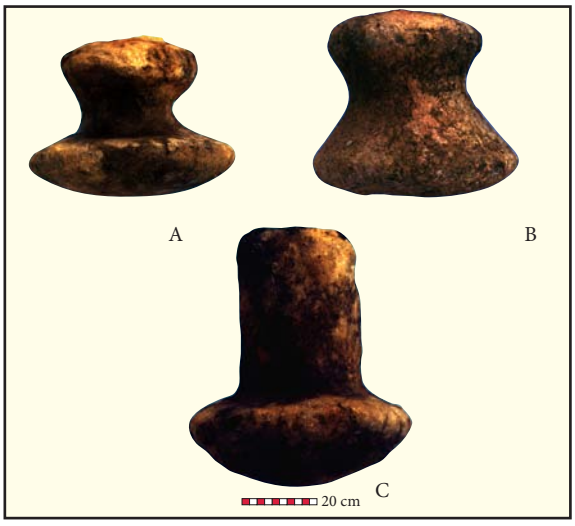


FIG. 19:4 The ceramic anvils. A. cat. 631, A1 6:4, B. cat. 637, A1 6:5, C. cat. 341, B1 4:7

Cat. 727, A1 6:9. This fragment of a polished adze came from the stream bed, and was therefore almost certainly redeposited.

Cat. 1726, B2/C2 6:4. A fine grey adze with a very even rounded shape. There are some flake scars along the edges, and in form, the poll is quite pointed. ML 75.0, MW 41.0.

Cat. 627, A1 6:4. A broken adze with many large flake scars ML 58.0, MW 36.0.

Cat. 1491, C3 6:3. A fragment of an adze, lacking both the blade and poll.

Cat. 1492, C3 6:3. A fragmentary and possibly reworked adze fragment containing part of the shoulder and tang.

Cat. 686, A2 6:1. A fragmentary and possibly reworked adze fragment.

Cat. 1459, A3 5:2. No shoulder is evident on this specimen, which is 16 mm thick. ML 71.00, MW 54.0.

Cat. 1792, X1 5:1. A thick adze with no sign of a shoulder, bearing a number of flake scars. ML 74.0, MW 41.0.

Cat. 742, A2 5:1. Only the middle part of this adze has survived, to a maximum length of 37.0 mm, and maximum width of 50.0 mm.

Cat. 1242, C2 4:7. A shouldered adze with a thick, rectangular tang. There are flake scars on the side of the tang. ML 60.0, MW 47.0.

Cat. 322, A2 4:5 feature 6. This adze is made of a coarse-grained stone. One flake scar is present, along with a series of cross-hatched grooves on the surface. ML 99.0, MW 41.0.

Cat. 1039, A3 3:12. This is the only adze in the assemblage which matches in form and stone, the majority of the adzes from Ban Lum Khao. It has clear shoulders, and several flake scars on the body and the blade. ML 69.0, MW 48.0.

Cat. 827, B3 2:1. This adze has a rounded cutting blade and has been polished all over. ML 65.0, MW 42.0.

Cat. 818, A3 layer 1. A very large adze, 36 mm in depth. ML 110.0, MW 71.0.

Cat. 825, A3 layer 1. A well-polished adze, with flake scars on the blade. There are very slight shoulders. ML 59.0, MW 59.0.

GLASS BEADS

The distribution of glass beads in non-mortuary contexts is seen in figure 19:5A. None was found earlier than layer 4:13, and they became very rare in layer 3. However, it is

recognised that many small glass beads might well have been originally part of a mortuary assemblage, but have since been scattered. A second distribution pattern of beads is therefore shown in figure 19:5B, where all burials are shown according to the depth below datum, those having glass beads being highlighted. When these two distributions are compared, it is clear that the few beads from non-burial contexts could easily have originated as grave offerings. The advent of glass beads at Noen U-Loke is, therefore, quite possibly located in middle to upper layer 4, being the location from which the earlier graves with beads were cut.

CARNELIAN AND AGATE ORNAMENTS

Carnelian beads were found in Mortuary Phase 3B and 4C graves. Those in the former were long and cylindrical. The only specimen from the latter was circular. It is evident from the distribution of these exotic ornaments, that they were only available or exchanged within a constrained timespan. Agate, on the other hand, was not only more abundant, but was exchanged over a longer time span. It is also noted that glass, agate and carnelian all made their first appearance in mortuary contexts at the same time.

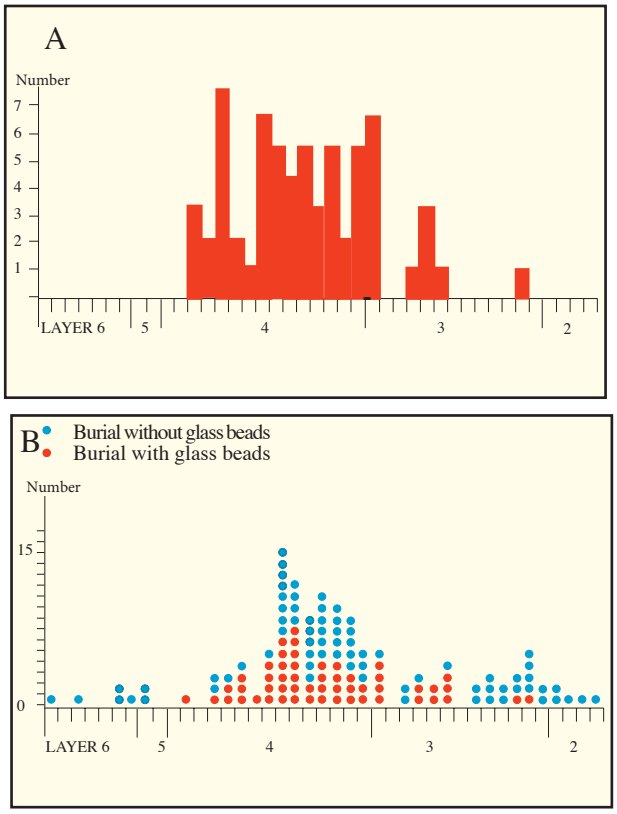


FIG. 19:5 The distribution of glass beads in the non-mortuary contexts (A) and in association with burials (B)

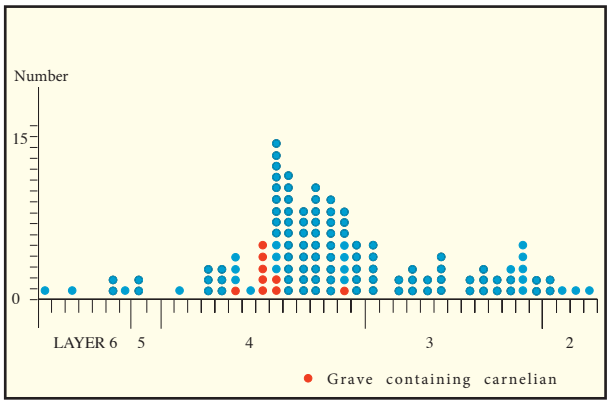


FIG. 19:6 The distribution of all graves on the basis of the layer within which they were found

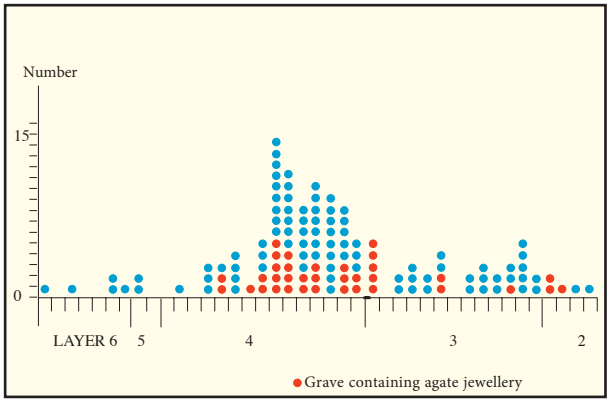


FIG. 19:7 The distribution of all graves on the basis of the layer within which they were found

IRON SLAG

Iron slag, together with any facilities for smelting iron ore, are the best indicators of a local iron industry, and when the excavated part of the site was employed for this purpose. Figure 18:11 shows the distribution of slag in the site. The earliest indication of iron working is in layer 6 with a marked peak in layer 4:10-14. These layers are also characterised by small clay furnaces equipped with tuyeres, while the slag concentrates spatially in their vicinity. It is considered likely that these furnaces were used for forging artefacts rather then smelting. An iron socketed hoe was found in layer 4:10 at A16, and an area of potsherds and iron slag lay in layer 4:14 at D10-12.

PELLET BOW PELLETS

These pellets are found in small numbers (n=26) from layer 6:3 to 2:1.

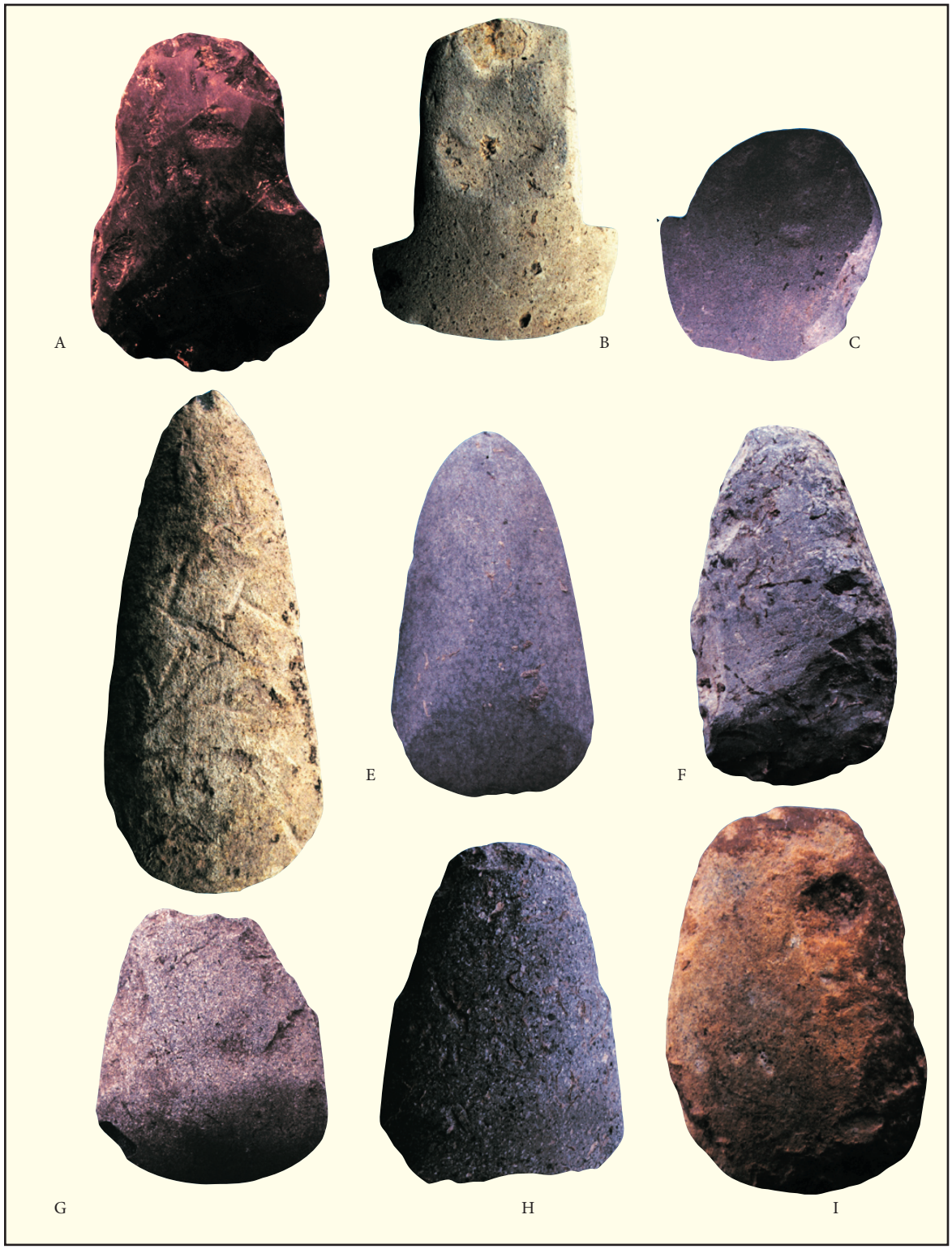


FIG. 19:8 The adzes from Noen U-Loke. A. cat. 1039, A3 3:12, B. cat. 1242, C2 4:7, C. cat. 1492, C3 6:3, D. cat. 322, 4:5 feature 6, E. cat. 1726, B2/C2 6:4, F. cat. 1792, X1 5:1, G. cat. 565, A2 6:2, H. cat. 1459, A3 5:2, I. cat. 827, B3 2:1. Scale 80%.



FIG. 19:9 Adzes from Noen U-Loke. A. cat. 818, A3 layer 1, B. cat. 825, A3 layer 1, C. cat. 1491, C3 6:3, D. cat. 742, B2 5:1, E. cat. 627, A1 6:4. Scale 80%.

KNIFE SCABBARD

The iron knife from burial 85, cat. 1286, was found within the pseudomorph of a woven scabbard.



FIG. 19:10 The woven scabbard on the iron knife from burial 85, cat. 1286

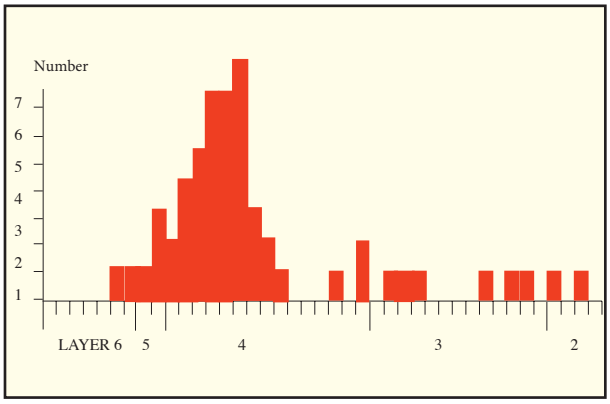


FIG. 19:11 The distribution of iron slag

XX. THE AGATE AND CARNELIAN ORNAMENTS

R. THEUNISSEN

INTRODUCTION

Stone beads fashioned from banded agate and mono-coloured orange-red carnelian first appeared in quantity in Southeast Asia from early in the Iron Age (~500BC to AD 500) period. They are generally thought to have been exotic prestige goods (Glover 1990, 1996:59; Ray 1996: 43) imported, by long distance exchange, from India (Bellwood 1976:276-7; Francis 1989:23; Glover 1990, 1996; Lamb 1965:92-3; Ray 1996:43; Wisseman-Christie 1990:41) where agate and carnelian bead production has existed since the 3rd millennium BC (Francis 1982). Because they are assumed to come from India, archaeologists have interpreted the beads as early evidence of organised Indian trade contact (as opposed to simply drift – see Glover 1996), accompanied by Indian political and religious influence (Ray 1996), and as such they have featured in diffusion based interpretations of Southeast Asian state development (e.g. Francis 1996: 141; Mabbet 1977; Ray 1996).

Just how important this Indian influence was in Southeast Asian state development, depends on the extent of Indian contact during the immediately preceding, Iron Age period, when the complex societies that gave birth to the early historic states first arose (Higham and Thosarat 1998a). However, the evidence for Indian contact and influence in Southeast Asia prior to the mid 1st Millennium AD is very meagre indeed (Glover 1996:58), consisting almost entirely of ornaments made from agate and carnelian, glass, and, for the later Iron Age, pottery sherds called Rouletted Ware identified with South India (Wisseman-Christie 1990:41). Agate and carnelian ornaments from Iron Age sites, such as Noen U-Loke and Non Muang Kao, therefore, form a very important, sometimes solitary (e.g. Pombejra 1998) component of the early evidence for Indian influence in Southeast Asia (Glover 1990; 1996; Wisseman-Christie 1990:41).

But should we unquestioningly assume that agate and carnelian ornaments did indeed come from India? Evidence is already mounting that some Iron Age agate and carnelian beads found in Southeast are of local origin. Certainly by the end of the Iron Age, manufacture of agate and carnelian beads had commenced at coastal sites in peninsular Thailand such as Khuan Luk Pad (Veraprasert 1992) and Khao Sam Kaeo (Srisuchat 1996), and probably also at Oc Eo in southern Vietnam (Francis 1989), as evidenced by finds of half-finished beads and chips of agate and carnelian produced during bead manufacture.

This evidence has been largely ignored, probably because finds of bead manufacturing debris are so rare. Most of the Iron Age agate and carnelian beads known in Southeast Asia come either from illegal looting operations and from a very few properly excavated cemetery sites (Glover 1990), neither of which would be expected to yield bead manufacturing debris. In the absence of conclusive proof of local production in the form of unfinished beads or bead debris, researchers have been content to "accept a more conventional Indian origin" (Bellwood 1976: 276). As a consequence of this acceptance, the time depth of sustained Indian trade contact preceding early historic state developments and the perception of Southeast Asia as a passive receptor in this trade are, rightly or wrongly, highlighted (Wisseman-Christie 1990:41-2) and the importance of Indian influence in Southeast Asian state development is emphasised (e.g. Ray 1996).

The issue of whether or not the beads derive from India is also relevant to their status as exotic prestige goods in Southeast Asia. Certainly, as rare items of personal adornment the beads are assumed to have functioned as prestige goods, exchanged to foster inter-elite alliances and worn to symbolise the acquired or attributed status of the individual (Higham and Thosarat 1998a), but were they all perceived as exotic throughout Southeast Asia and did they really function in organised exchange networks spanning the Bay of Bengal (e.g. Glover 1996:80; Ray 1996:43)? And what about the role of agate and carnelian beads in prestige goods exchange within Southeast Asia? This has never been explored in any depth (except see Theunissen 1998) despite the fact it has been recognised for some time that the introduction of new prestige goods from external sources may cause restructuring of existing prestige goods exchange and subsequent increases in social complexity (Higham 1984:250-4).

The agate and carnelian ornaments from Noen U-Loke and Non Muang Kao have the potential to contribute much new data on these issues of Indian influence and the role of exotic prestige goods exchange, on both a broad regional scale and the more limited perspective of the upper Mun River basin where these sites are located. In the case of regional scale analysis, for example, it is important to note that all the larger (>100 pieces) published collections of agate and carnelian ornaments in Southeast Asia come from coastal sites (e.g. Khuan Luk Pad – Veraprasert 1992, Khao Sam Kaeo – Srisuchat 1996, and Giong Ca Vo/Phet – Nguyen Kim Dung 1995) or sites which were near coastal during the period of their occupation (e.g. Ban Don Ta Phet – Glover 1990). In contrast, Noen U-Loke and Non

Muang Khao lie well inland on the Khorat Plateau. Study of the ornaments from these sites therefore promises to fill an important void in our knowledge of the distribution of agate and carnelian ornaments within Southeast Asia.

This inland/coastal distinction may have important implications for these ornaments as evidence of Indian influence and also for our understanding their role in prestige goods exchange within Southeast Asia. Those ornaments that were imported from India almost certainly came via ship across the Bay of Bengal (Hall 1985; Glover 1990). Surely though, as the ornaments were traded inland from port sites on the Southeast Asian coast down-the-line into more isolated inland areas, such as that around Noen U-Loke and Non Muang Kao, any Indian cultural influence accompanying them would have been much reduced while their rarity, and perhaps their subsequent prestige value, increased (Theunissen 1998).

As already mentioned, it appears that at least a few of these Southeast Asian ports were also producing their own ornaments, and these ornaments needn't imply any Indian influence, except at the centre that produced them – that is, if they were inspired by Indian craftsmen or represent copies of imported Indian beads. In such cases, it is likely that locally produced ornaments were regarded as less valuable than imported types at, and around, these ports and that locally produced ornaments may have been selectively traded to inland areas where they would be perceived as exotic and valued for their rarity regardless of origin (Junker 1990). Comparison of the agate and carnelian ornaments from inland sites such as Noen U-Loke and Non Muang Kao with those found around the coast would help us to determine whether this is an accurate reconstruction of the nature of Iron Age coastal-inland prestige goods exchange within Southeast Asia.

More importantly for understanding the nature of Iron Age prestige goods exchange and the role of agate and carnelian ornaments within this exchange, the ornaments from Noen U-Loke and Non Muang Kao have been recovered, *in-situ*, from well preserved and well-dated human burials (Higham and Thosarat 1998a). Most Iron Age agate and carnelian ornaments from Southeast Asia are unprovenanced, or they come from cemetery sites where the human burials have not survived (e.g. Ban Don Ta Phet – Glover 1990; Giong Ca Vo – Nguyen Kim Dung 1995) or industrial/port sites (e.g. Khao Sam Kaeo – Srisuchat 1996) without the attendant social information associated with human burials. In contrast, at Noen U-Loke and Non Muang Kao we can see for the first time in an Iron Age society how agate and carnelian ornaments were displayed on the body at burial, how restricted their distribution was and who, in terms of the sex, age and wealth (by reference to other accompanying burial offerings) possessed these ornaments. These data should be invaluable for determining the value of these ornaments and how they functioned in society, for example, as indicators of wealth and high status or perhaps even as badges of rank.

Clearly then, the ornaments from Noen U-Loke and Non Muang Kao are of considerable importance for our understanding the later prehistory of Southeast Asia, on every level from international relations, through the nature of prestige goods exchange in the Southeast Asian region, to a very specific and intimate insight into the particular societies who created these sites. I do not hope to address all these issues fully here, but aim to describe the agate and carnelian ornaments from these two sites, concentrating on those aspects which might provide clues as to their origin and use in regional exchange and within Noen U-Loke and Non Muang Kao society. While this is primarily a report on the ornaments from Noen U-Loke and Non Muang Kao, effective interpretation along these lines requires that I also describe these ornaments in the context of the distribution of other agate and carnelian ornaments from elsewhere in Southeast Asia and occasionally beyond. I will also attempt, through comparison with these other ornaments, and reference to the NUL/NMK ornament's own characteristics and context, to say something of their origin and what they actually reflect in terms of indigenous development of social complexity or external cultural influence (Glover 1990:15-20; Lamb 1965).

My discussion will also examine the limited available evidence for the social function of the artefacts, and their role in the local development of social complexity. While, as has already been suggested, the sites have the potential to yield detailed information on the distribution of the ornaments within Noen U-Loke and Non Muang Kao society, I have not yet completed the detailed analysis of the ornaments in their relationship to the human burials. The amount of contextual data in terms of date, burial phase etc, I can bring to bear on this issue here is, therefore, extremely limited.

TERMINOLOGY AND METHODS

In this study the term 'agate' refers to any polished stone with obvious parallel banding. Under the general heading of 'agate' I also use the more specific term 'onyx' and this requires some explanation. Francis (1997 - Beadtown homepage www.thebeadsite.com.) discusses the problem of 'onyx', noting that three definitions exist - one equating with alabaster, one with jet black stone, and the third applying to parallel banded agate where the contrast between bands is especially striking. The third is the definition most suited to semi-precious stone ornamentation in Southern and Southeast Asia and appears to be the one assumed by most writers on the subject. Onyx of this kind occurs very rarely in nature and virtually all such stone used for personal ornamentation has been 'manufactured' from normal agate. Brown onyx was created by soaking the stone for weeks in a sugar syrup then heating

(creates brown and white bands), while black onyx (black and white bands) is dropped in acid rather than heating (Francis 1982). Here I have chosen to only apply the term onyx to the more distinctive black onyx.

Carnelian is really a form of mono-coloured agate, ranging in colour from red through orange to pink. The colour derives from heating (iron in the stone reddens it) and this is done artificially by roasting the stone, or, in volcanic areas, may occur naturally before the stone is mined (Francis 1982). Subtle banding is occasionally present.

The terminology used to describe bead shapes is vast and variable. In this report I've tried to use the more self-explanatory terms such as 'barrel'. Where I mention that the bead is also faceted it means that the surface is made up of discrete flat areas - for example, a faceted barrel could be likened to an actual wooden barrel with wide flat staves. Perhaps the most ambiguous shape name used here is 'bicone' which is simply two cone shapes joined base to base.

Prior to recording the agate and carnelian artefacts from NUL and NMK, I spent some time talking with knowledgeable researchers and conducting a literature search, followed by a trial run making and recording observations on material held at the Bangkok National Museum. The purpose of this was to identify, in advance, characteristics or variables of agate and carnelian ornamentation that might be relevant to the issues of origins and social function. In particular, I set out at NUL and NMK to record each artefact's find number and context, their type (i.e. a bead or pendant, and their shape as in 'barrel'), size, colour, raw material, details of manufacture - especially relating to perforation (the hole drilled to string the bead), polish (method used, whether tumbled or rubbed), and other features (i.e. etching or evidence of re-use/repair).

Ornament 'type' often equates to ornament shape and is of interest because, when considered in relation to the types represented in other regional samples, it might suggest a possible origin or inspiration for the artefacts (as for glass beads, see Bronson 1990; Lamb 1965). The study of shape alone is limited, however, because the hardness of agate and carnelian greatly limits the range of shapes possible. Many specific shapes, like spheres and faceted bicones, have been produced at various locations around the globe for thousands of years with little detectable variation (Bellwood 1976:277; Francis 1982). Size and colour characteristics, together with manufacturing marks, are therefore important in the definition of ornament types, and in discriminating between otherwise similar types. Measurement of size and shape also allows an assessment of the standardisation applied in ornament manufacture. It may be argued that highly standardised ornaments result from centralised, elite-sponsored, production, whilst diverse, non-standardised, ornaments are more typical end products of dispersed 'cottage industry' production (Earle 1996).

Manufacturing marks that result from polishing and perforation processes are of particular interest because they may also be of chronological significance. For example, rubbing (parallel striations) is considered an earlier innovation than tumble polishing (fine-pitting), and fine parallel-sided perforations of less than 1.5 mm diameter suggest the use of diamond drills, not much known before the Christian era (Francis 1992:12). The way the ornament was perforated might also suggest something of the level of skill involved in manufacture (i.e. it is more difficult to bore a pendant through its longest dimension than through a corner) – how the ornament is perforated may also affect the way it was worn or presented (Theunissen 1998).

In the field I used pre-printed record sheets to prompt for information on these variables for each piece of agate or carnelian found - including any general observations or comments not suited to a particular variable (i.e. evidence of repair work or subjective assessment of quality). I examined all artefacts using a 10x eye loupe as this magnification helped reveal polishing striations or pitting. All the ornaments were thoroughly cleaned using an acetone solution and the perforations checked for internal discontinuities that betray that the ornament had been drilled from both ends. In addition, I also took casts of most of the beads and pendants from the two sites using a dental silicone compound. These casts were brought back to Australia for gold-coating and subsequent examination using a scanning electron microscope (SEM). This method allows detailed examination of surface features and manufacturing marks, but most importantly, it effectively turns the perforation inside-out, so that it can be examined and measured directly (Williams 1984).

The overall dimensions of the artefact and diameter of the perforation I measured (both ends if there was a large discrepancy) using vernier callipers. I adapted the way I measured overall dimensions to the shape of each artefact. For beads I simply measured length (L) in parallel with the perforation and thickness perpendicular to this measurement half-way (centre of bead) along the bead (Tc). Where this thickness varied a lot along the length of the bead I also took a thickness measurement at one of the ends (Te). For pendants and pendant fragments I called the longest dimension 'length' (L), then measured the 'width' (W) perpendicular across the 'face' of the pendant and thickness between the 'faces' (T).

To supplement the written recording process, I also took macro photographs of the agate and carnelian ornaments, individually or in groups according to find number, and made sketches of the ornaments. These sketches help to show characteristics which are difficult to describe by the written word or which do not show up well on the photographs, such as the position of the perforation, and asymmetric features, such as flattening on one side of a

bead or grooving along one edge of a pendant.

Finally, a selection of the ornaments from NUL and NMK were also transported to Australia to have their chemical composition characterised, along with other ornaments and raw agate and carnelian from potential sources, as part of a project to identify the origin of Iron Age agate and carnelian beads found in Southeast Asia. This project is on-going and many of the results have not yet been fully assessed, however, a description of the method used along with preliminary results and conclusions which refer to the samples acquired from NUL are published (Theunissen, Grave and Bailey 2000) and I will refer to these in the discussion section of this report, where appropriate.

A section on my general observations of the Noen U-Loke and Non Muang Kao ornaments, is presented below, based around a description and quantitative summary of ornament types found at the sites (Table 20:1) - representative photographs of the types described are included in the text. Features related to ornament manufacture, that help to define these 'types', are described, as are those features of manufacture that go beyond, or are incidental to, the types identified.

OBSERVATIONS: ORNAMENT CHARACTERISTICS AND TYPOLOGY

The 1996/7-1997/8 excavation seasons at Noen U-Loke (NUL) yielded a sample consisting of 130 semi-precious stone ornaments, 116 fashioned from agate/onyx and 14 from carnelian. The 1996/7 excavation season at NMK yielded 50 semi-precious stone ornaments, all fashioned from agate. Most of these artefacts are associated with specific burial contexts, some occurring in direct association with other grave-goods such as glass and possible bronze beads/pendants. None of the beads show any evidence of having been etched - a form of decoration popular in contemporary Indian beads where patterns are painted on the beads using a soda based solution and then the beads baked until these patterns turn white (Mackay 1933;

TABLE 20:1 *The distribution of agate and carnelian jewellery at Noen U-Loke and Non Muang Kao*

Type	Sub-type	NUL n	NMK n
Carnelian Bead	long faceted barrel	12	-
	long faceted cylinder	1	-
	spherical	1	-
Agate Bead	small barrel/cylinder with light central band	37	37
	large barrel/cylinder with light central band	8	2
	small bicone with light central band	1	-
	small onyx cylinder, white with fine black end banding	23	5
	small barrel/cylinder, multi-banded or no light central band	12	4
	large barrel/cylinder, multi-banded or no light central band	2	-
	onyx button bead (Bhabagori cat's eye)	1	-
Notched Agate Pendant	trapezoidal with 2 notches on straight lower edge (complete)	6	-
	(partial-probable)	2	-
	trapezoidal with 2 notches on 'arched' lower edge (complete)	7	-
	(partial-probable)	1	-
	axe-blade shape with 2 notches on curved lower edge (complete)	2	-
	(partial-probable)	3	-
	trapezoidal with 1 notch on straight lower edge	1	-
Plain Agate Pendant	trapezoidal (complete)	2	1
	(partial-probable)	3	-
	trapezoidal with faint groove/s on lower edge	2	-
	(partial-probable)	2	-
	axe-blade shape (complete)	1	-
	(partial-probable)	1	-

Note: 1) in the agate beads, 'small' refers to beads less than 12mm in length and 'large' to beads >12mm. 2) axe-blade refers to pendants generally shaped like an axe blade strung from its hafting hole, but also ranging from boomerang-like to roughly triangular with one point hanging downwards (these latter types also called 'leech' beads in the literature) – the key feature is a long curved lower edge. 3) trapezoidal here refers pendants which have four primary 'sides' and that range in shape from square to rectangle with varying degrees of symmetry

Williams 1984). Most appear to have been perforated using a drill tipped with diamond (Williams 1984).

Employing a combination of characteristics, including size, shape, and colour, the beads and pendants were divided into types/sub-types (Table 20:1.). While this process is admittedly subjective, I have attempted to emphasise the presence or absence of recurring features that may relate to 'style' or cultural preference, such as notches on pendants and white central banding on agate beads, that might provide clues about the origin of the ornaments.

All the carnelian beads come from the site of Noen U-Loke, and thirteen of these are all of the same basic type, which I will call 'long faceted barrel' (Fig. 20:1), although one NUL cat. 768, figure 20:1L, has little or no central bulge and might be more appropriately called a faceted cylinder bead. Their shape is vaguely similar to the more common faceted bicone, but the NUL carnelians show no evidence of an abrupt change in facet direction at the mid-point along the bead as in classic bicones. The number of facets present varies from 6 to 12, and the general quality (or skill applied in manufacture) of faceting and polishing varies dramatically from that seen on an exceptionally fine bead 40mm long and only 3.5mm thick (cat. 454, Fig. 20:1B), to that seen on another bead with heavily chipped ends and mangled facets (cat. 673, Fig. 20:1I). The remaining carnelian is spherical (cat. 1684, Fig. 20:1G).

All the faceted carnelians show evidence of drilling from both ends with the bores meeting together in the middle with varying degrees of accuracy. In one example (cat. 674, Fig. 20:1J) the bore almost broke through the side of the bead before the maker changed ends, and this wayward drilling stands in contrast to the incredible skill and control required to perforate the fine narrow bead cat. 454, figure 20:1B) mentioned earlier. The edges of the facets are sharp and an eye-loupe shows striations running in parallel to the facet edges. These striations and sharp facet edges are particularly obvious on the SEM micrographs taken on surface casts of the faceted carnelian beads (Fig. 20:2). This demonstrates that the beads were polished by rubbing them lengthwise on a polishing surface such as teak, rather than them being tumbled (Francis 1989:22) - tumbled beads show fine pitting rather than striations and have rounded facet edges (Francis 1992:12). The lone spherical carnelian exhibits this fine pitting and was almost certainly polished by tumbling rather than rubbing (Fig. 20:2 right). All the carnelian beads appear to have been perforated using a diamond tipped drill. The use of a 'tipped' drill is betrayed by the presence of a spiral cutting edge along the full length of the perforation, as seen on SEM micrographs of perforation casts (Fig. 20:3). This drilling technique also produces a parallel-sided 'cylindrical' perforation as seen in this example – other techniques, such as the use of an untipped drill with loose abrasive result in a conical bore with no evidence of a

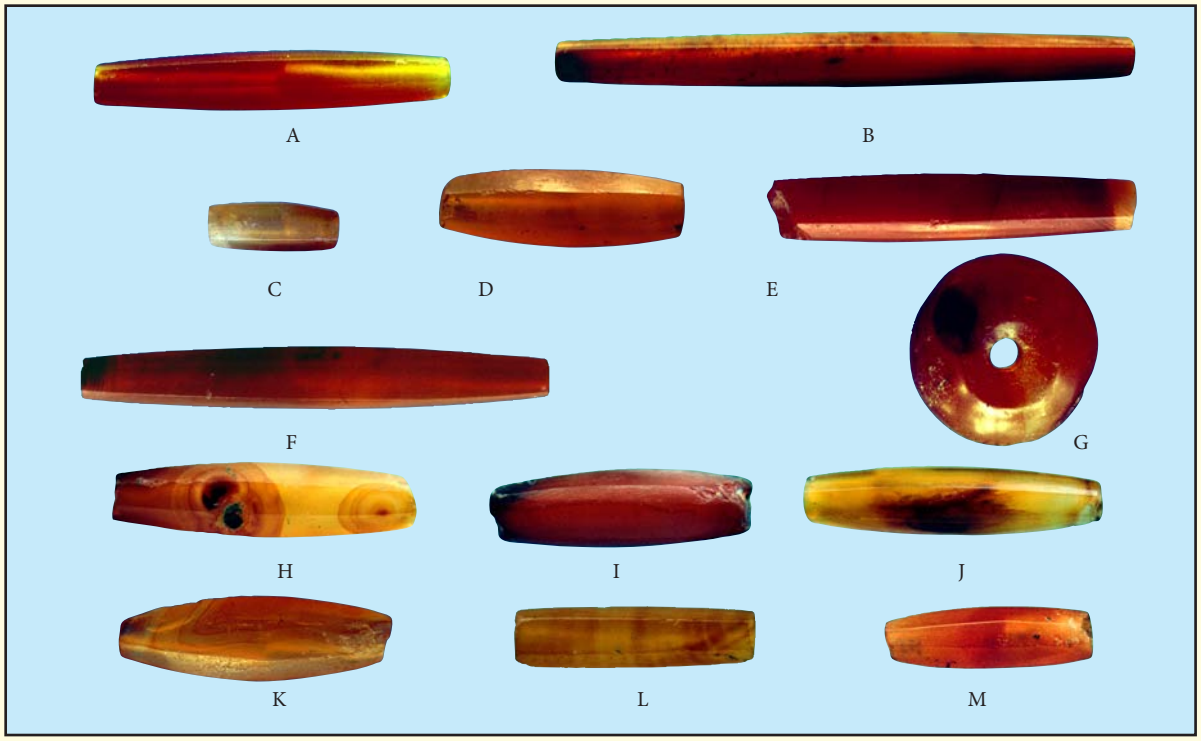


FIG. 20:1 Carnelian beads from mortuary phase 3B burials. A. Burial 32 cat. 508, B. Burial 32 cat. 454, C. cat. 729 4:12 feature 1 D. Burial 48 cat. 1933, E. Burial 50 cat. 708, F. B2 4:7 feature 1 cat. 436, G. Burial 118 cat. 1684, H. B2 4:6 feature 10 cat. 416, I. Burial 53 cat. 673, J. Burial 53, cat. 674, K. B2 4:8 cat. 620, L. Burial 49 cat. 768, M. Burial 52 cat. 621. Scale 2:1

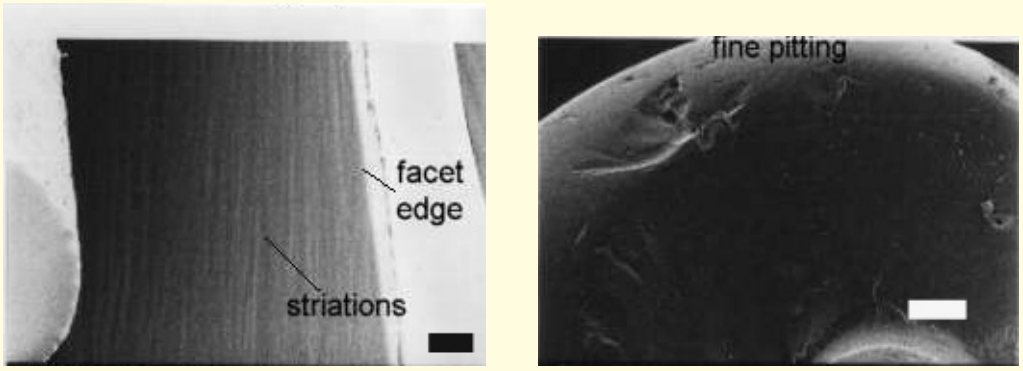


FIG. 20:2 Micrographs of carnelian beads from Noen U-Loke. Left, cat. 508, a faceted bead showing striations and facets. Right, cat. 1684, a spherical bead showing fine pitting. Scales 100 microns

cutting edge.

The agate/onyx ornaments from Noen U-Loke and Non Muang Kao consist of both beads and pendants, with the pendants divided into two main types, either plain or notched, and the agate beads further divided into a series of sub-types, shown in table 20:1 and explained below. Agate/onyx beads are clearly the most common hard-stone ornaments present at these sites, with Noen U-loke yielding a sample of 84 agate/onyx beads, well over half the total agate and carnelian from that site, and Non Muang Kao producing 48 from a total of 50. Virtually all the beads have shapes which could be classified as either barrel or cylinder depending on the degree of central bulge present. The banding is always perpendicular to the perforation (which is also drilled from both ends), and, unlike the carnelians, none are faceted (Fig. 20:4, NMK cat. 158 and Fig. 20:5, NUL cat. 1709).

What distinguishes the sub-types of agate/onyx beads is more their colour and banding pattern, and to some extent their size, rather than their shape. The first and by far the most common variety (Table 20:1) are distinguished by the presence of a single central light-coloured (either white or grey) band present on each bead. This central light band is often flanked by end bands of honey and translucent dark brown respectively (Fig. 20:6, NUL cat. 185), though many are also opaque with end bands ranging in shade from brown to black (Fig. 20:7 cat. 1667). The predominance of this banding pattern is such that it must be an intentional product of the craftsperson who produced them.

While most of these agate beads with light central banding are small, around 5-10mm in length, a few are considerably larger, for example the rightmost bead in figure 20:8, NUL cat. 1436. In fact, when the dimensions, length versus thickness, of the NUL agate beads are plotted on a scattergram (Fig. 20:9) the distribution allows the further division of these beads into 'small' and 'large' subtypes, with the division neatly occurring around 12mm in length. The distinction in size is also sufficiently sharp to argue that it may result from the purposeful choice of the manufacturer to produce beads of two different sizes.

The remaining agate (not including onyx) beads, those that don't have a light central band, can also be divided into 'small' and 'large'. I am uncertain, however, as to whether these should really be identified as a separate type to those beads that do exhibit a light central band. Some may have been purposefully fashioned to appear as simple two band, bi-colour, beads (Fig. 20:10 – NUL cat. 274), but the distinction between those beads with and those without a light central band is not always clear – for example, cat. 1253 (right bead in figure 20:11) which has numerous light bands. The numbers of this subtype are also sufficiently low in comparison to agate beads with a light central band (in the 'small' category at NUL there are 37 with white central band versus 8 without, whilst at NMK the ratio is 37 versus 4), that they may simply be

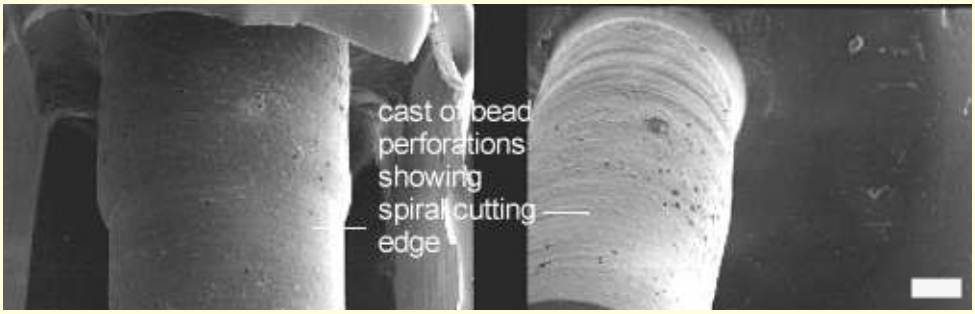


FIG. 20:3 SEM view of perforations on carnelian beads from Noen U-Loke. Left, cat. 508, a faceted bead and right, cat. 1684, the spherical bead. Scale 500 microns

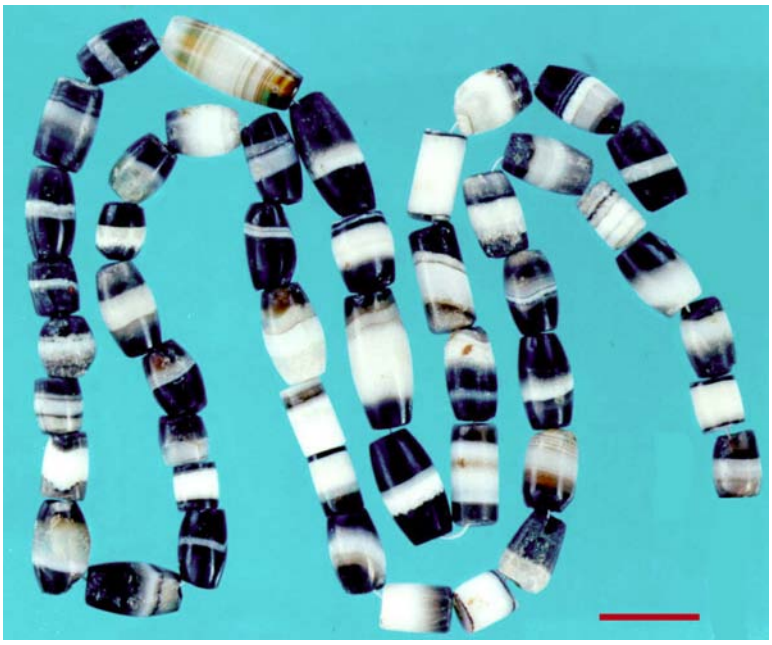


FIG. 20:4 Non Muang Kao burial 9 cat. 158 agate beads. Scale 1 cm

'left-overs' cut from agate rods which had been portioned up to produce beads with light central bands.

The other major sub-type of hard-stone bead found at these sites are fashioned from onyx. They are opaque with an off-white base colour and with fine black banding usually appearing at the ends of the bead (see left and upper beads in figure 20:12). Referring back to the scattergram of bead size (Fig. 20:9) these beads are also somewhat smaller than those bead varieties already described. The distinctiveness of this subtype leaves little doubt that it was purposefully produced and perceived as distinct by the bead makers, and presumably wearers, though it is worth noting that mixtures of this type, along with small agate beads with and without light central bands, were found together in single bead necklace finds at both NUL (Fig. 20:5 cat. 1709) and at NMK (Fig. 20:4 cat. 158).

There are two remaining agate/onyx beads both from Noen U-Loke that I have assigned to their own sub-type. The first (NUL cat. 117, the lower left bead in figure 20:13) is a biconical agate bead with light central band. This bead might be included along with the other agate beads with light central banding, but it is also the only example of a clear, purposeful, bicone shape, and so I have chosen to separate it here. The other remaining bead, cat. 323 from burial 20, in no way resembles any of the other beads found at either site. It is fashioned from onyx and is button shaped and has bands of alternating black and white reminiscent of 'etched' beads (Fig. 20:15A). This rare and distinctive variety has been identified in India and is sometimes referred to as Bhabagori Cats Eye (Francis 1982:52).

All the agate beads also appear to have been drilled using a diamond tipped drill – the spiral cutting edge is quite clear on bead casts observed under the SEM (Fig. 20:3 right). While the general finish of the agate beads varies considerably there are no examples that demonstrate the technical mastery required to produce some of finer carnelians (as in figure 20:1B and F). Many, particularly the opaque beads and those identified as onyx, are very coarsely polished or have been corroded. Onyx beads, such as the white cylinders with fine black banding, in particular exhibit a crazed surface, and polishing detail has been obscured - I suspect the fabric of the stone has been weakened by the prior immersion of the beads in an acid bath to create onyx.

Interestingly, when it can be detected, the manner of polishing varies from bead to bead, despite the beads often appearing visually very similar. Some show the longitudinal striations and sharp edges which suggest rubbing, and others fine pitting and rounded edges suggesting tumbling (Fig. 20:14) – an associated pattern also emerges among the smaller agate beads with and without white central band (those from Noen U-Loke at least – those from NMK appear to be mostly tumble polished) in that the hand-rubbed beads have much smaller perforations (0.9-1.2mm) than the tumble-polished beads (1.5mm-2.0mm), see figure 20:14.

Figure 20:15 shows some typical examples of the agate pendants recovered from Noen U-Loke. There are thirty-two whole or fragmentary examples of these pendants

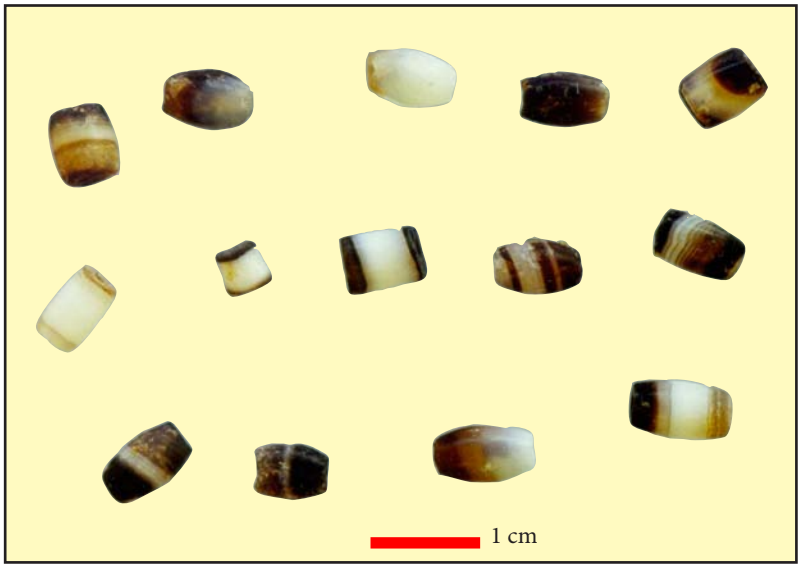


FIG. 20:5 Agate beads from Noen U-Loke burial 113, cat. 1709

from Noen U-Loke and two from Non Muang Kao which I have divided into 'Plain' and 'Notched' types (Theunissen 1997; 1998). All are fashioned from agate (or onyx) generally showing parallel bands running across their surfaces. Most are perforated through their full length using a diamond tipped drill, although there are a few exceptions that I will discuss later. Polishing appears to be variable, as with the agate beads, with some showing striations and faceting along their edges and others showing fine-pitting and very rounded edges. Many, such as NUL cat. 570 in figure 20:15B, are the fragments of once larger pendants that have been broken in antiquity.

Most agate pendants are of the Notched variety (21 of these at NUL and 1 at NMK) and have a very distinctive shape, appearing as roughly square to rectangular (trapezoidal) and flat, with their lower edge - as suspended from their perforation – interrupted by a pair of notches (for example NUL cats. 695, 1752 and 1711, Fig. 20:15FF, K and L).

I have further divided these notched pendants into three sub-types; those with a straight lower edge between the notches (examples are NUL cats. 1751, 100 and 337 in figure 20:15J, K and L); those with an arched lower edge between the notches (examples include NUL cats. 602 and 695 in figure 20:15D and G) and the less common axe-blade shape, with the notches on a lower 'blade' edge, an edge that forms a continuous curve (examples are NUL cats. 616 and 1225 in figure 20:15C and M).

Superficially it might appear that there is not much difference between the first two sub-types - those with straight and those with arched lower edges between the notches – but the difference becomes more obvious and important when the method of manufacture is considered. In the case of those with a straight lower edge between the notches, the notch itself is simply formed by abrading the

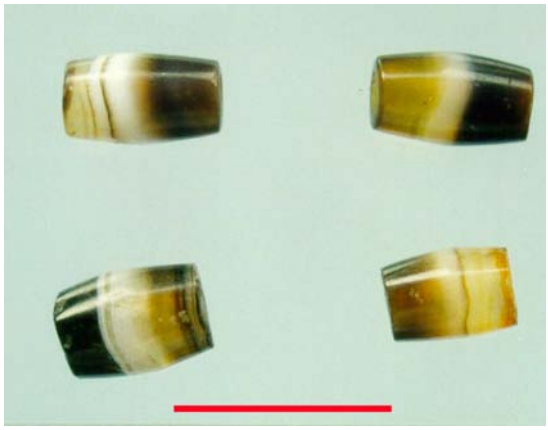


Fig. 20:6 Agate beads from Noen U-Loke burial 5, cat. 185. Scale 1 cm

existing bevelled edge (perhaps even as a later addition) at right angles to that edge (see notch of NUL cat. 1932 in figure 20:16). The polishing of these pendants generally seems to have been achieved by hand rubbing which produces sharp edged facets along the edge of the pendants with the striations running parallel to the pendant edge.

In contrast, the pendants with an arch between the notches are much more rounded with fine pitting suggesting a tumble polish, and with deep notches created by drilling through the pendant's thickness and then applying abrasion to smooth the notch. Remnants of this pre-drilled notch are apparent on several examples such as NUL cat. 602 in figure 20:15D, and more obviously on NUL cat. 166, shown here in figure 20:17 along with an SEM micrograph of the drill-hole used to pre-form the notch. These remnants confirm the use of a diamond tipped drill, a specialist tool, which suggests the notches on these pendants were formed at the time of manufacture. The more simple, abraded notches on the pendants with a straight lower edge on the other hand, may have been added to plain pendants or fragments of broken pendants (common at these sites, see figure 20:15B, R, Z, BB, CC, DD) in order to emulate the notched pendants with an arched lower edge described here.

The axe-blade shaped pendants, like the straight lower edge sub-type, are notched by simple abrasion (refer again to NUL cats. 616 and 1225 in figure 20:15C and M). Again

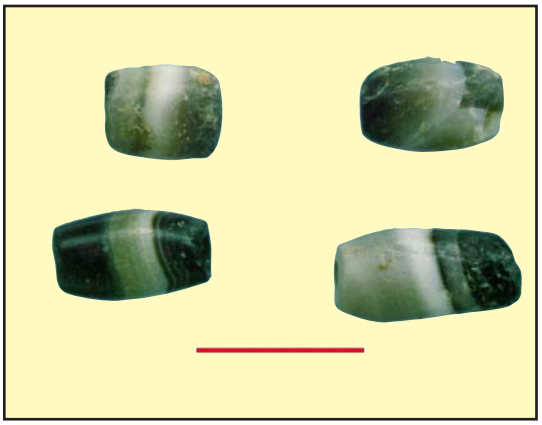


FIG. 20:7. Agate beads from burial 80, cat. 1667. Scale 1 cm

this may reflect recycling of plain pendants or pendant fragments to emulate the other notched varieties. This recycling/emulation activity may have been conducted locally at or around NUL and NMK; certainly there is evidence that some modification of agate pendants with abraded notches (both straight edge and axe-blade sub-types) was done well away from the original manufacturing centres. For example, NUL cats. 616 and 337 in figure 20:15C and L

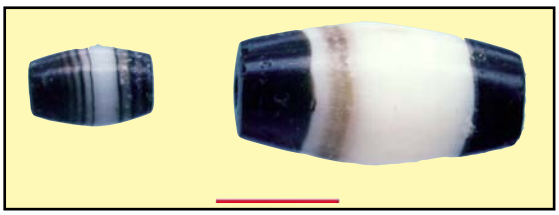


FIG. 20:8 Agate beads from burial 94, cat. 1436. Scale 1 cm

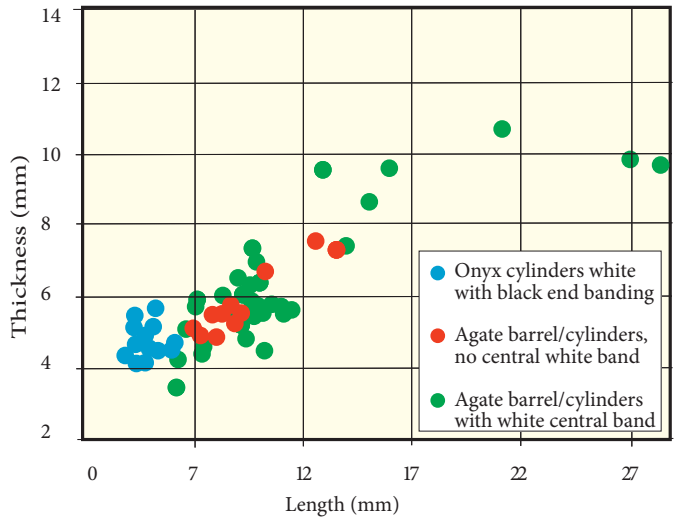


FIG. 20:9 The size of agate beads from Noen U-Loke

were both perforated, not with diamond tipped drills, but instead by using an untipped drill bit and loose abrasive to laboriously grind through the thinnest dimension of the pendants – creating a conical bore with no cutting edge as seen on the SEM micrograph of the perforation on NUL cat. 337 in figure 20:18. On these two examples there is no evidence of an original diamond-tipped drill perforation (as I will describe shortly on two examples of the plain pendants), though one or more edges appear to have been coarsely ground and finished, perhaps concealing a broken edge where just such a perforation once existed.

Lastly, with regard to notched pendants, there is one example – allocated its own sub-type - of a possibly complete pendant with only one notch (cat. 679, Fig. 20:15O). This is an exquisite, roughly rectangular, pendant with dead straight banding, parallel to the long edge, and a single notch at one end. The well polished and rounded edges and the depth of the notch link this pendant with the sub-type having an arched lower edge between the notches. One end is coarsely finished compared to the other edges and it is possible that a second notch previously existed, though if it had the shape of the pendant would still be unique and would not sit well in any of the other notched sub-types described.

Of plain pendants there are 11 whole or fragmentary examples from the site of Noen U-Loke and a single complete specimen from Non Muang Kao. These pendants are too few, too fragmentary, and too varied in their characteristics (in shape, features and raw material – for example, some are onyx and some translucent agate) to make division into further sub-types particularly meaningful. Many are broken and so they may have originally been part of larger notched pendants. This possibility is given some support from the observation that these plain pendants are generally smaller than the notched type (Fig. 20:19).

Most could simply be described as trapezoidal (in that they are basically four sided), such as the onyx examples NUL cats. 1652 and 1389 in figure 20:15P and Q. When these are closely examined, however, some of these 'plain' trapezoidal pendants have a faint groove or grooves on their lower edge. 'Complete' examples include a roughly square, badly crazed, onyx piece (NUL cat. 694, figure 20:15EE) which shows a barely perceptible, but real, notch on the lower edge just in from one end, and a long translucent agate pendant (NUL cat. 598 in figure 20:15F), which has faint grooves on its lower edge just in from each end.

Two broken, roughly rectangular, agate pendants, NUL cats. 1092 and 1109 (Fig. 20:15R and S), were also found to include faint abraded grooves on their lower edge – note the SEM micrograph view showing the groove on the left most pendant in figure 20:15R, NUL cat. 1092. These may represent abortive attempts to create notched pendants. Whether the grooves are all purposeful features placed on the pendants for a reason, or alternatively, an incidental result of the manufacturing process – rubbing against a vice for example – is unclear at this time.

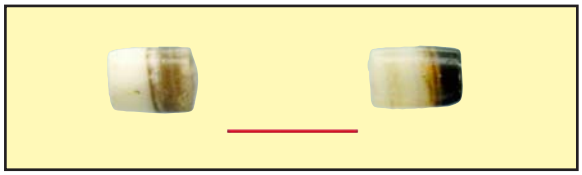


FIG. 20:10 Agate beads from burial 46, cat. 567 (left) and from burial 15, cat. 274. Scale 1 cm

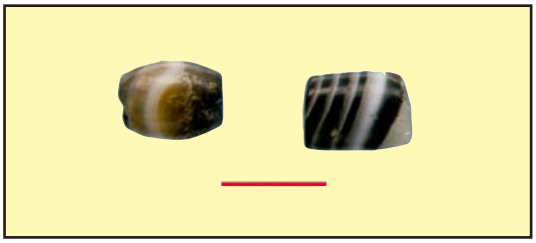


FIG. 20:11 Noen U-loke cat. 1253, multi-banded agate cylinder, from burial 97. Scale 1 cm

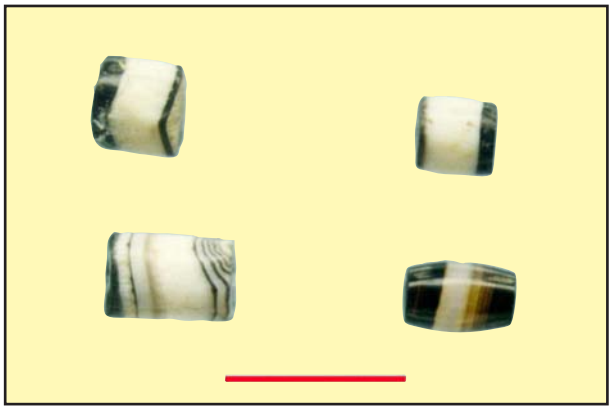


FIG. 20:12 Noen U-Loke agate beads from burial 9, cat. 148. Scale 1 cm

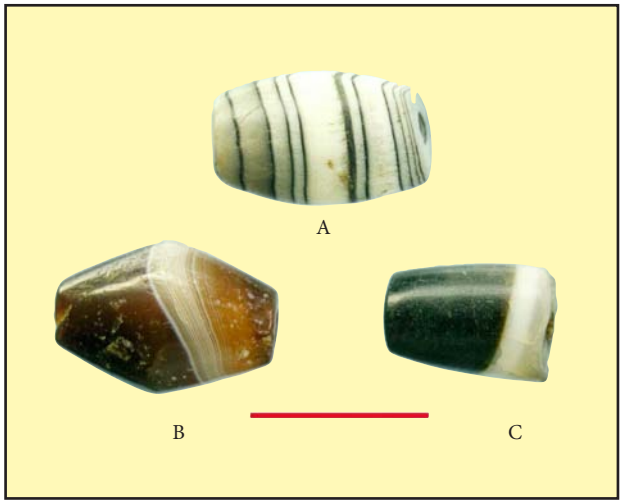


FIG. 20:13. Noen U-Loke agate bead from burial 10, cat. 117 (B). Scale 1 cm

One other plain trapezoidal pen15Tdant worthy of special mention is the single, complete (albeit in two halves), agate pendant found at the site of Non Muang Kao (NMK cat. 120 in figure 20:15GG). This rather fine (only 3.5mm thick) pendant was broken in half during antiquity along the path of the original perforation – traces of this perforation are still clearly visible along the fractured edge of each pendant half. The pendant was repaired by gluing the two halves back together with some now decayed organic fixative, and then drilling through the full length of the pendant again, but at 90° to the original perforation. What is unusual about this repair work, is that the second perforation also appears to have been made using a fine diamond tipped drill, suggesting the breakage and repair occurred at the original production centre.

Finally, I have also placed two plain pendants into their own sub-type on the basis of an axe-blade shape, though their correspondence with this shape is not so close nor as consistent as that of the notched examples with this name. The first pendant (found in two pieces NUL cats. 179 and 196 in figure 20:20) is a very unusual piece, because of its large size, concentric banding pattern (suggesting it came from a slice of a complete agate nodule), and also because it is very fine, being only 2.6mm thick. Not surprisingly, this pendant also broke during antiquity along the line of the original (diamond-tipped drill) perforation that ran the full length of the pendant. Remnants of this perforation can still be seen all along the upper edge of both pendant fragments. The pendant was then repaired by drilling through its thinnest dimension with an untipped drill and loose abrasive, again as indicated by the conical shape of the perforation produced. Presumably this was done through both of the upper corners, though one of these corners is now lost. The break between the two pieces that remain does not appear to be fresh, so we can assume it too was repaired sometime during the past using a medium which has long since decayed.

The other example of this sub-type is a translucent honey and brown banded agate pendant that has also been broken and then similarly repaired by being pierced through its corners using an untipped drill and loose abrasive (NUL cat. 1723 in figure 20:15V). In this case, however, these later perforations were made by drilling into one face of the pendant and then drilling down from the (now) upper edge to meet this new perforation at an angle of ~90°. The most interesting feature of this pendant is that a section of the original diamond-tipped drill perforation remains intact and is visible though the translucent stone. The angle of this perforation in relation to the remaining stone suggests that this piece was originally part of a much larger pendant.

DISCUSSION

As stated earlier, my aim is to identify characteristics of these ornaments which might shed light on the issues of where the ornaments originated and how they came to be at NUL and NMK, their social function at these sites in the past, and, more generally, their role in the local development of social complexity. These issues provide the basis for the discussion that follows.

My approach to the first problem, of origins, involves comparing the NUL and NMK samples with other samples of agate and carnelian in order to evaluate relationships of similarity and difference that might reflect a common or distinct origin respectively. I will also refer

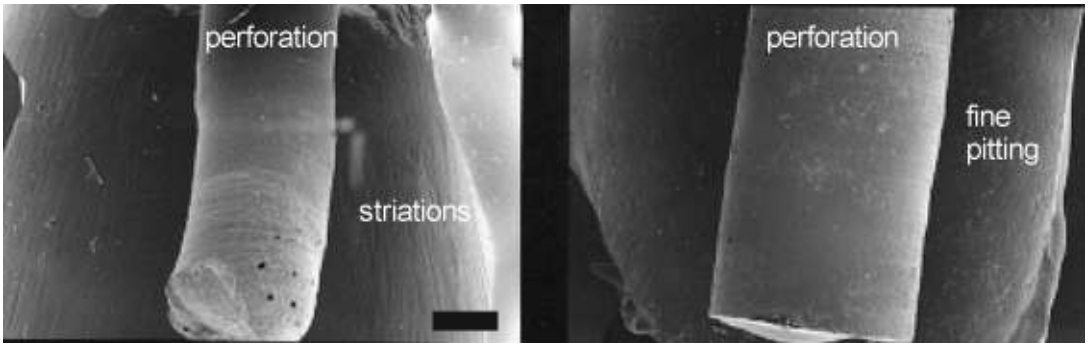


FIG. 20:14 SEM micrograph of casts taken of the boring through agate bead cat. 1709. Scale 500 microns

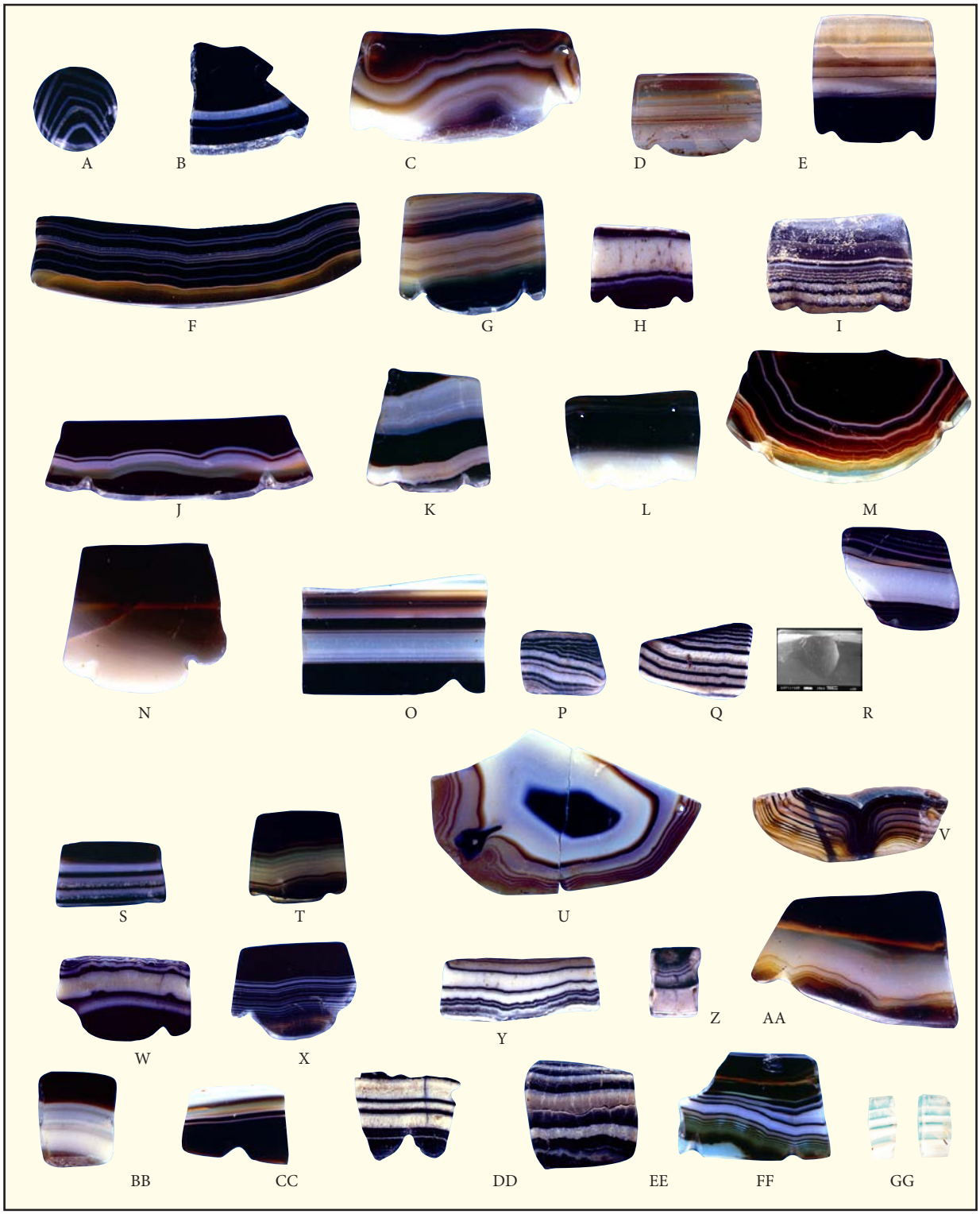


FIG. 20:15. Agate pendants from Noen U-Loke and Non Muang Kao. A. burial 20, cat. 323, B. burial 33, cat. 570, C. burial 45, cat. 616 D. burial 37, cat. 602, E. burial 40, cat. 598, F. burial 30, cat. 557, G. burial 52, cat. 695, H. burial 120, cat. 1752, I. burial 113, cat. 1711, J. burial 122, cat. 1751, K. burial 4, cat. 100, L. B2 4:3 F12 cat. 337, M. burial 91, cat. 1225, N. burial 6, cat. 166, O. B2 4:11 cat. 679, P. burial 104, cat. 1652, Q. X1 3:8 F1 cat. 1389, R. burial 73 cat. 1092, S. burial 62, cat. 1109, T. B2 4:6 cat. 1932, U. burial13, cat. 179, V. burial 99, cat. 1723, W. burial 86, cat. 1127, X. burial 104, cat. 1649, Y burial 113, cat. 1747, Z. burial 120, cat. 1753 AA. burial 120, cat. 1754, BB burial 14, cat. 293, CC B2 4:6 F1cat. 430, DD burial 35, cat. 579, EE. burial 52, cat. 694, FF. B2 4:12 F1 cat. 729, GG NMK cat. 120. Scale 1:1

to some preliminary elemental characterisation analysis results that provide a more objective geo-chemical basis for assessing the origin of at least the carnelian ornaments from NUL.

The actual issue of where the ornaments came from and how they came is addressed through the exercise of trying to find plausible explanations for the relationships observed. I present these observed relationships and some of the explanations that follow immediately below. This discussion of ornaments and origins overlaps with the inter-related issue of social function, and I continue on this issue by discussing in detail the characteristics of some specific ornaments, with occasional, albeit limited, reference to the distribution of ornaments in relation to the human burials.

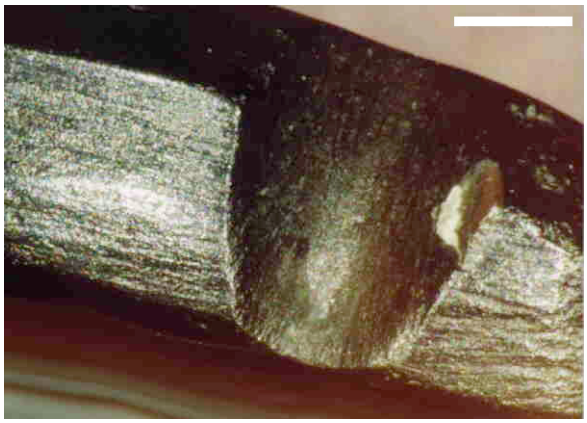


FIG. 20:16 Close up view of the notch on cat. 1932. Scale 1mm

THE WIDER CONTEXT AND ORIGINS

As might be expected with two Iron Age sites separated in space by only a few kilometres, the samples from Noen U-Loke and Non Muang Kao have much in common. Both are dominated by agate beads, especially small agate beads with a single light central band, and both also include the distinctive notched agate pendant type. While NMK does not have any carnelian beads, this may well be due to sampling bias; carnelian beads only form about 10% of the much larger NUL sample derived from >120 burials, whereas the ornaments from NMK come from 11 interments. For the purposes of comparison with agate and carnelian ornaments from elsewhere, the ornaments from NUL and NMK are treated here as a single sample.

The general techniques of manufacture employed on the artefacts found at both NUL and NMK - chipping and grinding to produce shape, drilling from both sides, the ubiquitous use of diamond tipped drills (suggested by the small diameter and parallel sides of the bores - Adhyatman anad Arifin 1993:21) - are the same as those techniques employed in India from at least 2000 years ago to the present era (Arkell 1936; Francis 1982; 1992:13), and appear also to be the same techniques used to make most beads found in Southeast Asia (Francis 1989:21-7). Many of the NUL and NMK artefacts, however, also appear to have been tumble-polished and this is inconsistent with the belief that tumbling only began to replace hand-polishing in the second millennium AD (Francis 1989:24-25). There is no doubt as to the age of these well-excavated specimens (first half of the 1st millennium AD or even earlier) and so I must conclude that this technological transition occurred considerably earlier, at least in the area/s responsible for producing the NUL and NMK hard-stone ornaments.

On the subject of manufacture, what stands out most about the NUL and NMK ornaments is the wide range of quality or apparent skill applied, and the high incidence of repair and the often fragmentary condition of the finds, in comparison with that which I observed on similar ornaments in museum collections elsewhere in Southeast Asia. There is of course the possibility that museum curators selectively display what they consider to be the finer examples of bead types available to them - though this does not appear to be the case with the BDTP beads at the National Museum, Bangkok as the numbers on dis-

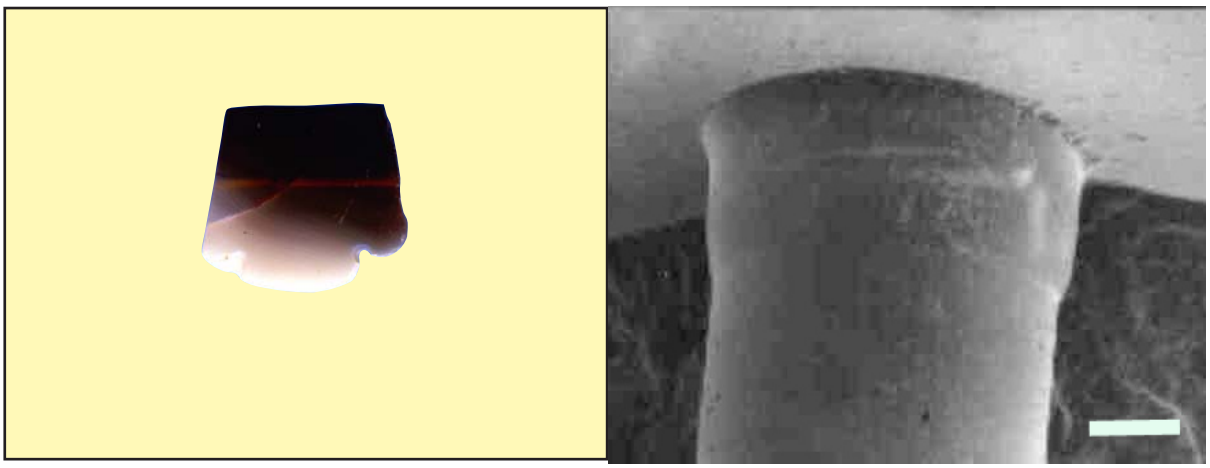


FIG. 20:17 Agate pendant cat. 166 with an SEM of notch. Scale of complete pendant, actual size, scale of SEM, 500 microns

play roughly correlate with that reported by the excavators (Glover 1990).

The agate and carnelian ornaments from NUL and NMK also exhibit a number of other distinctive features, as a group, in the ratio of agate to carnelian and the limited diversity of ornament types represented, in comparison with other Southeast and South Asian site assemblages. For example, at NUL/NMK, agate outnumbers carnelian by >10 to 1 whereas at Ban Don Ta Phet (BDTP) in Thailand (pers. obsv. National Museum Bangkok), Sa Hunyh culture sites in Southern Vietnam (Nguyen Kim Dung 1995), peninsular Malaysian sites (pers. obsv. National Museum Kuala Lumpur 1998) and late-prehistoric sites throughout Indonesia (Adhyatman and Arifin 1993; pers. obsv. National Museum, Jakarta), this ratio is reversed in favour of carnelian.

One collection within Thailand that does match NUL/

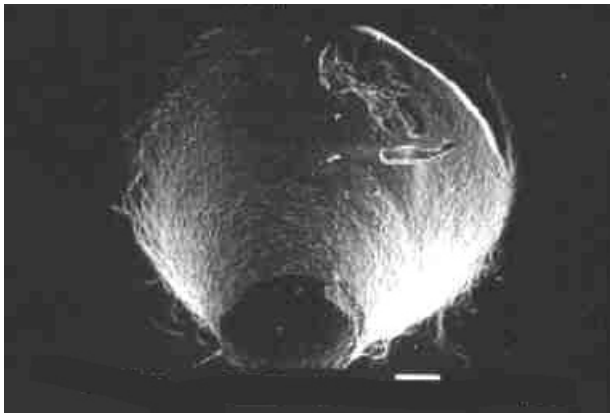


FIG. 20:18. SEM of the conical bore on cat. 337. Scale 200 microns

NMK's preponderance of agate over carnelian is that from the site of Ban Prasat (pers. obsv. National Museum Phimai 1997; 1998), a site which is located only a few kilometres from NUL and NMK and which remained occupied into the Iron Age period. There are also some poorly provenanced mixed assemblages at the National Museum, Bangkok of indeterminate age and provenance, which are dominated by agate and which include similar ornament types. The limited diversity of the NUL/NMK sample is demonstrated by the fact that over 80% of the ornaments found can be allocated to only four types; notched agate pendants, onyx cylinder beads, faceted carnelian barrel beads, and agate beads with a single light central band. Several of these ornament types are particularly distinctive and restricted in their distribution. Notched pendants are rare or absent from most other Southeast Asian sites - even from some Thai sites with abundant agate and carnelian such as BDTP – and those from NUL/NMK appear to be among the first properly excavated examples of the type. Looted examples, purportedly from the Lopburi

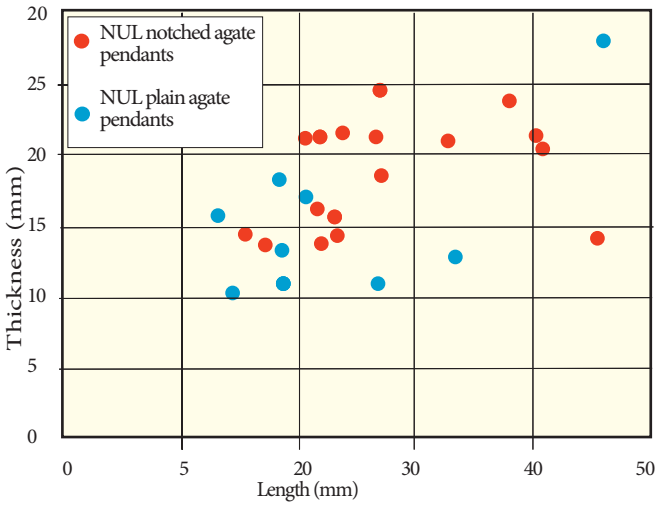


FIG. 20:19 The dimensions of notched and plain agate pendants

area, are sold in Bangkok's Chatuchak markets (pers. obsv. 1998) and Higham (pers. comm. 1997) reports that he was shown notched pendants by villagers in Chonburi province.

In fact, apart from the above areas of Thailand, the only other location where I have heard reports of notched pendants like these being found is at Oc Eo in southern Vietnam (pers. comm. Bellina 1999), a site where stone bead making took place (Francis 1989:23). Francis (1989:27) suggests that these pendants were made at Arikamedu for export to Thailand. The ones found at Arikamedu, however, do not have the notches on their lower edge, and more recently Peter Francis Jnr (pers comm. e-mail 28th Feb 1997) conceded that these pendants may have been a speciality of another site, attached to Arikamedu. The white onyx cylinder beads with fine black end bands are another uncommon variety with a distribution similar to that of the notched agate pendants. That is to say they are rare outside of inland areas of Thailand (pers. obsv. 1997-9) except for a few examples occurring in the Oc Eo culture sites of Vietnam (pers. comm. Bellina 1999).

The lack of diversity in the carnelian beads - 13 of the 14 being long faceted barrel shapes (though one is more a faceted cylinder than barrel) - is perhaps even more significant because carnelians elsewhere in Southeast Asia and abroad in India are made in a wide range of shapes of which plain spheres and faceted bicone shapes are the most common. The long faceted barrel type carnelian bead found at NUL is quite rare. There is not one such bead among the 415 carnelians from BDTP held at the National Museum, Bangkok (pers. obsv.) or the 680 carnelians excavated from Giong Phet and Giong Ca Vo (Nguyen Kim Dung 1995). Nor did I see any on display in the Ban Prasat (BP) assemblage at the National Museum, Phimai, although the museum did show a photograph of one from the site in their guide-book. I have also encountered a few looted examples at the Chatuchak markets in Bangkok, again supposedly from the Lopburi area (pers.

obsv. 1998).

In Indonesia, I observed a single faceted barrel bead amongst the 96 carnelians on display at the National Museum, Jakarta, but it was so much larger (60mm by 15mm) than any of the NUL carnelians that it was really a different order of artefact entirely. There is one undated example closer in shape and size to the NUL carnelians shown in Adhyatman and Arifin (1993:23) provenanced only to east Java. Apparently, long faceted barrel shaped carnelians were a speciality of Vijaya (modern Palembang in Southeastern Sumatra), the centre of the Srivijaya "empire" in the 1st Millennium AD (Peter Francis Jnr pers. comm. 1997), but I have not seen any of these beads and so cannot comment on their similarity to the NUL beads. Outside of Southeast Asia, this bead type has occasionally been recorded in small numbers from sites in India, such as at Ahichchhatra where 3 were found (Dikshit 1952:40).

Agate beads with a single light central band like those found at NUL and NMK are more common and have a much wider distribution throughout Southeast Asia appearing also in India and even China (pers. obsv. Hong Kong Museum of Natural History 1997; 1998; 1999). One unusual aspect of the agate beads from NUL and NMK, however, is their remarkable uniformity in size (Fig. 20:21). When this is considered along with the obvious effort made to produce visually similar beads, in terms of banding pattern, it suggests a high degree of standardisation was employed in their manufacture.

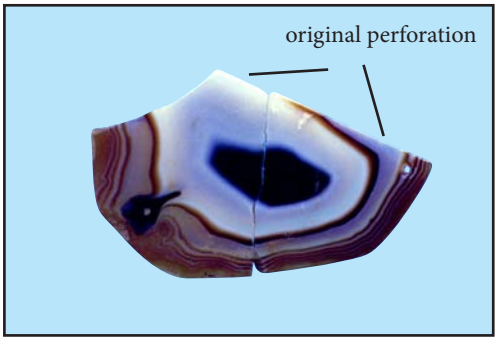


FIG. 20:20 Agate pendant cats. 179/196, showing the original perforation. Scale 1:1

This 'standardisation' also applies to those agate beads without a single central light band and to the onyx cylinder beads. The thickness of the beads is remarkably consistent, rarely deviating more than a fraction of a mm either side of an average thickness of 5mm. This level of standardisation suggests the beads were the product of a highly organised manufacturing centre/s of the sort expected to be working under the control of an elite sponsor. Alternatively, it may simply result from the conscious selection of similar sized beads, either by the people of NUL/NMK or the persons who sold or exchanged the beads, to make pleasingly uniform bead necklaces – this is given some support by the observation that the NMK

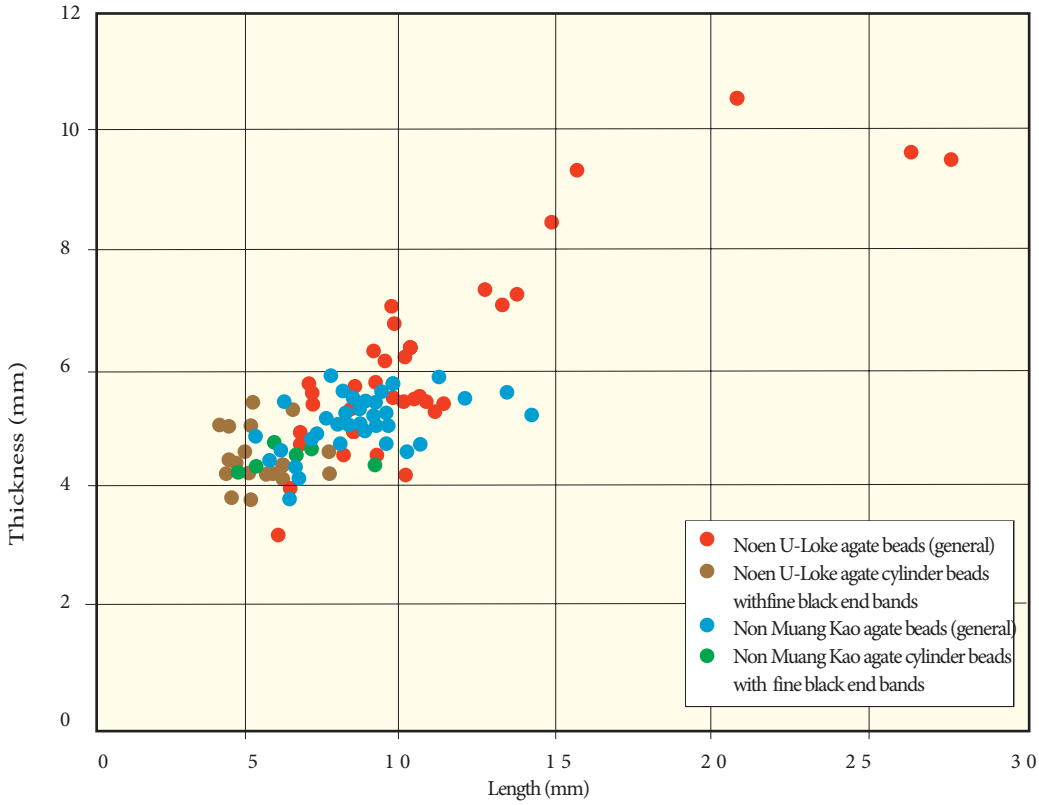


FIG. 20:21. The dimensions of agate/onyx beads from Noen U-Loke and Non Muang Kao

agate beads, all derived from a single bead necklace (Fig. 20:4), are even more uniform in size (especially, thickness) than those from NUL (Fig. 20:21).

To summarise the above, the NUL/NMK sample is diverse in terms of 'quality' with a high incidence of damage and repair, has a high agate to carnelian ratio, and is restricted to only a few relatively uncommon and in some cases, highly standardised, types. More importantly, in terms of these characteristics the ornaments from these sites, as a sample, have little in common with other Southeast Asian assemblages, excepting perhaps the material from the nearby site of Ban Prasat (BP).

On the question of where the agate and carnelian ornaments at NUL originated and how they came to be at NUL, the preceding observations are no doubt important, but a more wide-ranging and comprehensive regional synthesis of the material for comparative purposes is needed to realise their full significance. I will therefore restrict myself to proposing a few, admittedly speculative, scenarios that are at least consistent with the available evidence.

Numerous explanations could be put forward to account for the dominance of unusual ornament 'types' in the NUL sample. One possibility is that NUL and NMK only had access to the agate and carnelian ornament trade or exchange for a brief period of time, when these particular types happened to be fashionable. This would, however, seem an unlikely explanation given the general longevity of most bead types in Southern and Southeast Asia (some, like spheres, remaining popular for millennia - Francis 1989) and the fact that some of the ornament types, notably the agate pendants, appear through several phases of occupation at NUL, suggesting a sustained popularity over several centuries. There is also the possibility that the NUL/NMK sample characteristics are purely the result of strong local preference for certain bead types. For example, in the Philippines and parts of Indonesia specific types of bead are favoured for their perceived spiritual or medicinal qualities (Adhyatman and Arifin 1993:21-22).

Perhaps, as suggested earlier in the background section, the predominance of these few uncommon types and the limited type diversity at NUL/NMK (and also Ban Prasat - BP) compared with other Southeast Asian site samples, is the result of NUL and NMK's inland location. NUL and NMK would certainly have been isolated from the international maritime trade/exchange in these ornaments, whereas most other Southeast Asian sites yielding large collections of agate and carnelian occur along or near to the coast, areas with direct access to maritime trade. NUL and NMK may have instead obtained its beads from a regional (Southeast Asian) bead-making centre that specialised in certain ornament types manufactured using local and/or imported material. This bead-making centre may have brought in exotic beads from elsewhere as well, but they would have predominantly traded their own limited and presumably, to them, less valuable, bead products to the surrounding hinterland in order to gain primary produce for trade off-shore (Hall 1985, Junker 1990).

If this regional centre specialised in agate/onyx ornaments, especially the notched pendants, agate beads with single light central band and onyx cylinder beads, then we would expect the inland sites on the periphery of, and trading with, this centre to yield collections formed mostly of these types, just as we see at NUL/NMK and BP. This scenario would also explain the absence of etched beads at NUL and NMK. Assuming these etched beads were indeed made in India (Glover 1990) they would almost certainly have been absorbed by the regional bead making centre.

A possible candidate for this hypothetical regional bead-making centre would be Oc Eo or another centre located around the Mekong River mouth (although see Welch 1989:25-26). Stone beads were made here from at least the 3rd century AD (Francis 1989:23), and as mentioned earlier, notched agate pendants, agate beads with a single light central band, and onyx cylinder beads, similar in form to those from NUL and BP also occur at these sites (pers. comm. Bellina 1999). Trade in its bead products may well have flowed inland from Oc Eo up the Mekong River and west along the Mun River to the Khorat Plateau and the sites of NUL and BP.

The distinctive, rare, long faceted barrel carnelian beads from NUL fit less well with this scenario, as I have no evidence that Oc Eo ever manufactured such beads. It seems extremely unlikely that any long faceted barrel beads which may have come to Oc Eo from Indonesian (Srivijaya) or Indian sources would have been selectively traded inland without other carnelian bead shapes accompanying them. Of course, there is no reason to think that the carnelian beads came from the same source or manufacturing centre as the agate. In fact, there is a known, but as yet undated, carnelian quarry in central Thailand at Khao Mogul (Glover 1990:17), and it is possible that some if not all the carnelian at NUL came from production centres in the Chao Praya valley utilising this source – remembering that examples of this type turned up at the Bangkok Chatuchak markets, supposedly looted from the Lopburi area in the Chao Praya River basin (pers. obsv. 1998).

This suggestion has recently been given some support from the results of a geo-chemical analysis of the NUL carnelian beads and potential source material from a number of sites, including Khao Mogul (Theunissen, Grave and Bailey 2000). These results show that the chemical composition of the NUL carnelian beads is very similar to that of the raw carnelian from Khao Mogul, and at the same time also shows that the NUL carnelian differs in its composition to carnelian from the major Indian production centres in south, northwest and northeast India.

Perhaps then, the presence of only a few, uncommon, ornament types in the NUL and NMK sample results from

the site's peripheral access to ornaments produced at two regional production centres, one located in the Chao Praya river basin, and one corresponding with the Oc Eo culture sites of the Funan state. The peripheral nature of this trade or exchange is further suggested by the low numbers of agate and carnelian beads which appear at the sites - at NUL for example, we find a mere 130 beads and pendants for roughly the same number of burials excavated. There is also the high incidence of repair and curation of these ornaments which suggests they were very difficult to obtain and replace.

The perceived variation in the 'quality' of ornaments at NUL and NMK, however, suggests that the issue of ornament origin may be yet more complex, involving some emulation of imported types on route to NUL and NMK or possibly even some local production or, at least, modification. In the case of the faceted carnelian beads, the geo-chemical data already referred to contains evidence that the few high quality examples may have a different origin to the other carnelian beads from the site. While I have mentioned the similarity in composition between the NUL carnelian and the Khao Mogul carnelian, two of the high quality NUL beads do exhibit a rather different chemical composition, a composition unlike the other NUL carnelians, the Khao Mogul carnelian, or the Indian carnelian tested. One possibility is that these high quality beads were imported into NUL via the Chao Phraya basin from another more distant source and that they were crudely copied, on route, using Khao Mogul carnelian, somewhere in Lopburi area.

One, of course, might ask whether the variation in quality in the NUL/NMK ornaments might simply be accounted for by the differences in skill between masters and apprentices? This would seem an unlikely explanation because the differences in quality are usually paralleled by differences in manufacturing technique and/or procedure rather than just skill.

I have already mentioned how the notches on many pendants appear to have been added, by abrasion of the edge, almost as an afterthought on an already completed pendant. This style of notching is also associated at NUL/NMK with pendants which were repaired, or in two examples possibly re-produced (NUL cats. 616 and 337 in figure 20:15C and L), using untipped drills and loose abrasive. This activity could in fact have taken place locally at NUL, NMK, or another nearby site, as the required skills are not particularly specialised – untipped drilling was used from the Bronze Age to repair marble bracelets, and shaping of hard-stone chalcedony adzes has a long local history (Higham 1996a). The most likely explanation then of this pattern at NUL/NMK is that the differences in quality observed, at least in the agate pendants, are the result of the local curation, local modification, and possibly even local emulation of pendants imported from a distant, though probably Southeast Asian, hard-stone bead manufacturing centre which employed diamond-tipped drilling technology.

While notched agate pendants do appear in Oc Eo culture sites, they are not as common there as plain agate pendants (pers. obsv. Bellina 1999) and their distribution remains tightly centered around the lower Northeast and Central Thailand. It would appear that whatever the ultimate origin of the pendant material, the notched form circulated mainly in these areas of Thailand. It appears likely that local preference for notched pendants was sufficiently strong to encourage the local modification (using local technology) of imported plain or 'leech' (Liu 1999) pendants to match this desired form.

At least some of the agate beads may also have been made at more than one centre, and again local reproduction of imported types is a possibility. It has already been noted that the small agate beads from the site of NUL were made in two distinctly different ways. Some have a fine perforation (0.9-1.2mm diam.) and a surface polished by hand-rubbing, and the remainder sport a coarse (1.5-2.0mm diam.) perforation and were tumble polished, though both types were perforated with a diamond tipped drill (Fig. 20:14). Because the manufacture of hard-stone beads involves a long apprenticeship and much standardisation of the techniques used (Kenoyer, Vidale and Bhan 1991; Roux, Bril and Dietrich 1995), the differences observed here are unlikely to have resulted from two different tradespeople, rather it suggests two entirely different lapidary traditions – either separate production centres, or alternatively, a chronological change at one. Given the similar appearance of these beads, if two centres were involved, it suggests that at least one of them was engaged in reproduction. Perhaps our hypothetical regional bead-making centre reproduced agate beads to supplement those obtained from an external source such as India or China (for these beads certainly appear there) and that they were sufficiently similar that both varieties ended up combined in necklaces which were traded or exchanged further inland\upriver.

Finally, on the issue of origins it may also be worth noting that there are a few examples of burials found with 'matched sets' of beads. Examples include: a) three agate bicones in NUL cat. 729 found together in Square B2/4.12 feature 1 (Fig. 20:22), which appear to have been manufactured to identical specifications, and, given the similarity in banding and colour, perhaps even using the same nodule of agate; and b) The two exquisitely made hexagonal faceted barrel carnelian beads found in Burial 32 (NUL cats. 454 and 436, figure 20:1B and F) also appear to have been manufactured using the same template and are the same distinctive opaque red-brown colour. These beads may have been traded or exchanged together from their source as a set, and this provides some small evidence in favour of a fairly direct path from source to NUL (i.e. from a regional centre rather than from India or China)

as the chance of the beads being split up would increase with the amount of down-the-line exchanges they passed through.

In sum, while we do not know with certainty the precise details of where the NUL and NMK ornaments came from and how they came, the evidence presented here does suggest complex, multiple origins. NUL and NMK appear to have had only peripheral access to agate and carnelian ornaments manufactured in at least two, most likely Southeast Asian, bead-making centres (perhaps Oc Eo producing agate ornaments and a centre in the Chao Praya valley producing carnelian). A few exotic imported Indian ornaments may also have passed through these regional bead-making centres on route to NUL and NMK, but on the whole the sample at these sites was limited to the varieties produced at the Southeast Asian bead-making centres. Rather than being entirely passive recipients in this trade, however, the people of NUL and NMK appear also to have locally transformed or recycled certain ornaments, to suit strong local cultural norms and preferences - for example, to create notched agate pendants.

These observations and speculative hypotheses concerning the origin of the agate and carnelian ornaments at NUL and NMK, presented above, have implications for the issue of the extent of Indian influence and its role in the growth of social complexity in the area of these sites (and to some extent the rest of Southeast Asia). Certainly we should not infer Indian influence at NUL and NMK simply from the presence of agate and carnelian beads, as is commonly practiced (see Bellwood 1976:276-7; Francis 1989:23; Glover 1990, 1996; Lamb 1965:92-3; Ray 1996:43; Wisseman-Christie 1990:41). Many of these ornaments were likely to have been made in Southeast Asia and even those that were imported from India were first 'filtered' through port-based Southeast Asian middlemen (whose own exposure to Indian culture in the early centuries AD was still quite superficial – see Mabbett 1977:153; Wisseman-Christie 1990) before reaching inland areas of Southeast Asia.

Furthermore, the predominance in the sample of just a few ornament types, especially the notched pendant type which seem to concentrate in Thailand, suggests that indigenous control/selectivity over the artefacts was high. The ornaments may have played a role in the development of social complexity in the area, but Indian cultural influences associated with the ornaments were minimal. Wherever the ornaments may have originated, their meaning and value was quickly co-opted into the indigenous culture of Southeast Asia.

I suspect, that these ornaments were perceived by the people of the area as 'exotic' and imbued with the power and mystery of distant realms (Schortman and Urban 1994) regardless of whether these realms were Indian or Southeast Asian. Certainly at the sites of NUL and NMK, agate and carnelian ornaments are also extremely rare and access to them must have been limited, and this – together with their 'exotic' associations - would have invited (demanded?) controlled acquisition and distribution of the ornaments by early group leaders (Helms 1993). The peculiar features of the ornaments, in terms of extreme rarity and their origin outside the existing exchange system, may have led to an expansion of the existing prestige goods exchange networks and the emergence of a new layer of social stratification as centres with more direct access to these new, high status, ornaments rose to prominence in the local hierarchy (Haselgrove 1982; Higham 1984). I discuss more on this issue in the following section on the evidence of social function.

SOCIAL FUNCTION

Little is known about the social role of agate and carnelian ornaments in Iron Age Southeast Asia, though they are generally accepted as exotic prestige goods, and along with glass, gold, silver, and bronze ornaments, as evidence of the wealth and/or high status of the individuals with whom they are interred (Higham and Thosarat 1998a). The relative value of these different prestige goods is rarely, if ever, considered, yet on this issue it could be argued that in Southeast Asia agate and carnelian ornaments were generally attributed an extremely high - though quite variable - value, beyond that accorded other contemporary prestige goods (Theunissen 1998). This argument is based on the rarity of the raw material, the extremely labour intensive process of agate and carnelian ornament manufacture, the need for highly-skilled tradesmen (Kenoyer *et al.* 1991; Roux, Bril and Dietrich 1995), and the relative rarity of these ornaments at Southeast Asian archaeological sites in general.

Attributed value would also vary because of differing accessibility, a factor which varies not only with geographical distance to the source/manufacturing centre (Helms 1993), but also with the directness of trade, differences in skill/labour investment accompanying different manufacturing technologies, and with deliberate sociopolitical strategies that move material into and out of (burial) circulation (Appadurai 1986). As extremely valuable items of personal adornment, agate and carnelian ornaments may even have played an 'active' role - as opposed to passively indicating wealth/status or contact with India - in the development of social complexity. For example, as visible symbols of rank or power, they perhaps legitimised unequal access to resources, and/or, through their exchange, they may have helped overcome environmental heterogeneity by fostering inter-elite ties in the region (see for example Earle 1996:174-5).

In my analysis of the agate and carnelian ornaments from Noen U-Loke and Non Muang Kao, I sought to identify aspects of the ornaments that might inform about these issues. The observation that a few ornaments

were reproduced or modified by people without the full range of necessary skills/tools (i.e. diamond tipped drilling), does imply that whatever their ultimate source, the manufacture of most of these ornaments was an 'exotic' and specialised activity (as most were perforated with diamond-tipped drills) and that they were obtained from far away (be that the Chao Praya Valley, Oc Eo or India). Their resulting exotic connotations and rarity would lead to the ornaments having a high prestige or status 'value', and perhaps a specific symbolic/religious 'value' as well, and this would, in turn, largely determine their social function (Schortman and Urban 1994).

An immediately obvious indication of their high value is suggested by their extreme rarity - 180 pieces found from approximately 140 burials at Noen U-Loke and Non Muang Kao - in comparison with other ornaments of glass and bronze numbering in the thousands (Higham and Thosarat 1998a). The ornaments also appear to be restricted to a small, possibly elite, segment of Noen U-Loke and Non Muang Kao society; less than one quarter of the 126 burials excavated at Noen U-Loke in the past two seasons were found to contain any agate or carnelian, whilst at Non Muang Kao 48 of the 50 ornaments found belonged to a single individual. In addition to the 'wealthy' individual from NMK, there was one interment at NUL (burial 113) that contained nearly a quarter of all agate and carnelian ornaments found at the site, and this suggests an individual whose wealth and status was an order of magnitude higher than that of her peers. The assertion of a high value for the agate and carnelian, and the individual's great wealth/status, is also independently supported (see for e.g. Haselgrove 1982; Renfrew 1986) by the unusually high diversity and quantity of other prestige goods accompanying this burial.

This distribution pattern is consistent with the controlled acquisition and distribution by elites as mentioned above, but it also needs to be understood in the light of the variation in the distribution of agate and carnelian ornaments, and of burials, in time and over space at the sites. For example, most ornaments occur in Phase 3B burials and square B2 at NUL. A key question is why? Unfortunately the analysis required to answer that question is outside the scope of this chapter.

Most of the ornaments were found *in-situ* in the neck region of the burials, suggesting they were almost certainly worn in necklaces as highly visible indicators of status, and perhaps rank (Higham and Thosarat 1998), as opposed to simple indications of wealth as might be suggested if the ornaments were provided as offerings, say, in an accompanying container (see Earle 1996; Renfrew 1986). The ornaments, both agate and carnelian, often appear alone or in groups of two or three, apparently as centerpieces in necklaces made mostly from glass beads. That these ornaments of agate and carnelian were more highly valued at NUL and NMK than the glass beads is supported by an ethnographic parallel in the recent practice of the Kelabit people of Sarawak, who place their most ancient, revered and 'valued' carnelian beads at the centre of less valuable glass bead necklaces (Janowski 1998:225).

In Kelabit society, the primary factor determining ornament 'value' is age (Janowski 1998:219). At NUL and NMK there is also considerable evidence that age was an important/desirable attribute given both the high incidence of repair observed and also the often fragmentary condition of the ornaments. Agate and carnelian is extremely durable and so has greater capacity to accumulate this desired quality of age. The fact that many of these durable ornaments have been broken, and that some have been repaired several times, attests to their high value and also suggests that some may have been in circulation for many generations (as with Kelabit carnelian beads – Janowski 1998).

As centerpieces of necklaces, agate and carnelian ornaments would have been effective, highly visible, symbols of status or perhaps rank. On this issue it is interesting to note that one of the 'repaired' agate pendants could have been suspended using what remained of the original perforation, but instead its corners were laboriously pierced using an untipped drill so that its longest dimension would be suspended horizontally. I suggest that this as an example of a symbolic value, as in a badge of office or rank, attributed to a specific pendant form by the people of Noen U-Loke (see Earle 1996:176). That certain specific ornament forms were preferred and perhaps attributed a symbolic value at Noen U-Loke is also supported by the dominance of just a few relatively rare ornament types at the site - in particular the agate pendants with a notched lower edge, uncommon outside the region of Noen U-Loke, and parts of central and western Thailand (Theunissen 1997).

Finally, returning to the issue of ornament value, there may also be evidence at NUL and NMK to demonstrate what a complex attribute 'value' was, changing with perceived rarity, labour and skill investment in ornament production, and perceptions of exoticness. For example, there are several alternative interpretations which can be made of the different manufacturing methods used to produce agate beads as shown in figure 20:14. If these agate beads were made at two different centres, were the people of Noen U-Loke and Non Muang Kao aware of the difference and did they place different values on the ornaments corresponding to their different origin? – because of differences in their accessibility, exoticness or other trait (Helms 1993).

Alternatively, application of both hand-rubbing and tumble polishing may represent a shift towards mass production of the beads at a single manufacturing centre. Hand-rubbing to produce a polish on hard-stone beads requires an enormous time investment as it is usually undertaken one bead at a time. Tumble polishing also re-

quires a long period of time to complete, but is much more efficient, often accounting for hundreds of beads at a time (Kenoyer, Vidale and Bhan 1991). The adoption of tumble polishing over the hand rubbing techinique would have increased the availability/accessibility of the ornaments and decreased the labour/skill investment – though these reductions in energy investment (corresponding to value) may have been partially offset by the greater technological investment of tumble polishing and/or the opening of new markets creating increased demand (see for e.g. Appadurai 1986).

To summarise then, this section on social function, the evidence of repair and curation showing that the agate and carnelian ornaments were not made locally, along with their relative rarity and restricted distribution among the burials, suggests that the people of Noen U-Loke attributed an extremely high value to agate and carnelian ornaments. Furthermore, this value probably exceeded that attributed to other ornaments fashioned from bronze and glass (for which evidence of local production exists).

In addition, their use in personal adornment, clearly designed to have a particular style or form of presentation, further suggests that some specific ornament types - notably the notched agate pendants - also held a symbolic value as emblems denoting high status, perhaps even a specific rank. As such, they probably functioned to legitimise the position of elites and their unequal access to resources (Earle 1996:174-5). The two different manufacturing procedures used to make small agate beads may indicate the local reproduction of imported beads or a trend toward mass-production techniques. In either case, it is clear that the accessibility of different agate and carnelian ornaments, and hence their perceived value, must have varied over space and through time.



FIG. 20:22 Three large agate beads, cat. 729. Scale 1 cm

CONCLUSIONS

This chapter on the agate and carnelian ornaments from Noen U-Loke and Non Muang Kao is the first detailed description made on a large collection of agate and carnelian ornaments from inland Southeast Asia. The sample of agate and carnelian from NUL/NMK is shown to be distinctive in comparison with other Southeast Asian samples: agate greatly outnumbers carnelian at the sites, the sample is dominated by just a few uncommon ornament types, and there is also considerable evidence of curation and much variation in the quality (and technology) of manufacture. These characteristics I have interpreted as evidence of NUL and NMK's peripheral contact with the centres producing the beads. A complex multi-path origin for the ornaments is proposed, with most ornaments coming from (at least) two Southeast Asian sources (possibly Oc Eo for agate and a centre in the Chao Praya Valley for carnelian beads), some from international sources, and, finally, some being modified or even reproduced locally from recycled agate at or near the sites of NUL and NMK.

The rarity of the ornaments, the high incidence of repair, and their appearance as centre-pieces in necklaces dominated by glass beads, suggest that the ornaments were attributed a very high value at NUL and NMK, beyond that accorded to other ornaments of glass and bronze, and perhaps extending to a symbolic role as badges of rank. The small amount of information available on their distribution within Noen U-Loke society also supports a scenario of controlled acquisition and distribution of these ornaments by early elites at the site.

Taken together, these observations demonstrate that agate and carnelian ornaments should be considered as something more than just another type of prestige good, or as an indication of Indian cultural influence – as quite clearly, in the case of inland sites such as these they are not. Rather, I suggest that agate and carnelian ornaments fulfilled an 'active' role as a catalyst for the development of social complexity in Southeast Asia, probably through their impact on existing prestige goods exchange networks.

The scenario I propose is that when this new and highly valuable prestige good was injected into the existing system of prestige-goods exchange (see Welch 1989), it caused the elaboration/expansion of these prestige-goods exchange systems and a subsequent increase in social complexity. The high value and external source of the beads inviting controlled acquisition and distribution by local elites at sites with direct access to the new goods. These elites would have risen to prominence in relation to their neighbours, while at the same time adopting strategies, such as local reproduction, to usurp or stabilise the supply of the new goods (Haselgrove 1982; Higham 1984). My work is ongoing to further investigate this hypothesis through a more thorough study of the distribution - spa-

tial and chronological - of agate and carnelian ornament types and manufacturing methods in Southeast Asia, supplemented where possible with sourcing data derived from the continuing geo-chemical analysis of both potential sources and ornaments.

XXI. THE SHELL, SILVER, GOLD, BRONZE AND BONE PERSONAL ORNAMENTS

N.J. CHANG

This report provides an overview of the major types of personal ornaments recovered from Noen-U-Loke (NUL) and gives a detailed description of individual artefacts from each category. However, it does not give an exhaustive account of every artefact recovered; this information will be provided in a later report along with information on the descriptive terminology employed - although it should be noted that this latter detail is available, at least in part, elsewhere (Chang 1998). The system of styles used here is based on an extended version of that employed by Pilditch (1993) for Khok Phanom Di (see also Chang 1998).

A major aim of this analysis is to compare Noen-U-Loke's Iron Age assemblage with similarly recorded Bronze Age and Neolithic personal ornament assemblages from elsewhere in Thailand. Such a comparison shows up several obvious trends. First, the immense amount of time and expertise directed to the manufacture of shell beads and bangles at the coastal Neolithic site of Khok Phanom Di is not repeated. In fact shell disc-beads occur only once in a burial (cat. 770, B. 42) at NUL. Shell bangles are rare and when present are almost always fragmentary. *Trochus* sp. shell, common at the nearby Bronze Age site of Ban Lum Khao, is virtually absent at NUL. Also, T-sectioned marble bangles are common at Bronze Age sites such as Nong Nor (coastal) and Ban Lum Khao but once again, disappear at NUL. Such absences are made up for by the introduction of a complete new range of materials and ornament styles. Glass and crypto-crystalline quartz, particularly agate and carnelian, are popular materials for beads and pendants. Bronze work is more sophisticated; bangles, anklets, earplugs and bells are all represented in a variety of forms. New metals; lead, gold, silver and iron, appear in the jeweller's inventory. That this difference is, at least in part, a function of time is indicated by the presence of fragmentary bangles of tridacna-shell, marble, slate, and fired clay in the lower levels. These all but disappear in the upper levels where they are replaced by bronze, and occasionally iron, bangles. Alternatively, it may be the case that different materials were used for everyday wear than for mortuary or ritual wear as almost none of these non-metal bangles are clearly associated with burials. Further analysis will help to distinguish these hypotheses, however, both are intriguing possibilities.

Perhaps the most obvious difference between this Iron Age assemblage and those of earlier periods is number. There is an order of magnitude difference in the amount of jewellery items included as grave goods and this will be an important variable in further analysis.

One final note before looking more closely at the personal ornament categories. The word 'bronze' is employed rather freely in this report. It should be noted that this refers to all copper and/or copper alloys, as identified by visual means. It is likely that a number of distinct alloys shelter under this umbrella, and only detailed laboratory analysis will separate and describe them.

SHELL ARTEFACTS

Shell occurs as beads, bangles, a single earring and large earplugs. All are probably made from *Tridacna* sp. shell.

Shell bangles

None of the bangles was complete nor were any definitely associated with human remains. The vast majority were found in layer 4 or deeper. Most have D-shaped x-sections (style 15). Style 11 bangles (simple bands with a rectangular cross-section) are also relatively common. Only one is not of *Tridacna* sp. shell and it is burnt, making identification of the shell difficult.

Shell beads

A single modified cowrie shell has been found. It could have been used either as a bead or sewn onto cloth.

Cat. 492, B. 37 is four shell disc beads associated with five orange glass beads.

Cat. 770, B. 42 is made up of two bone disc beads associated with seven orange glass beads. Diameter: 3.8 mm, length: 2.2 mm, perforation: 1.7 mm.

Cat. 343, B. 47 is a single shell disc bead and a single bone cylinder bead (see bone beads below). Shell - diameter: 3.4 mm, length: 1.0 mm.

Cat. 513, B. 41 is a single shell bead associated with at least 36 glass beads in the general area of this burial.

Cat. 770, B. 42 is a find of fifteen shell disc-beads, recovered from the head area of burial 42. Many are best described as thick discs or short cylinders but some are true flat discs.

Cat. 1628, B. 116 is made up of 29 shell disc beads associated with three black glass beads. Eleven orange and another 89 black glass beads were found around the neck of this individual.

Shell earrings

Cat. 1556, B. 110, is a simple split-ring earring of tridacna shell. The end, at one side of the split, comes to a point while the other end is square. R.H.: 5.2 mm, R.W.: 3.6 mm, I.D.: *c.* 7.0 mm, O.D. 13.9 mm, split width: 2.6 mm.

TABLE 21:1 *Shell bangles*

Cat.	Context	R.H.	R.W.	I.D.	Shell	Style	Notes
534	A2, L4:14	11.6	6.3	*c.* 40.0	tridacna	15	fragments of 2 different bangles
		9.8	4.5	*c.* 40.0	tridacna	15	
680	A2, L4:15	9.0	5.6	*c.* 42.0	tridacna	15	well worn, smooth surfaces
684	B2, L4:12	10.1	7.4	*c.* 45.0	tridacna	15	
707	B2, L4:12	3.8	2.1	*c.* 60.0	tridacna	15	very light-weight bangle
739	B2, L4:14	7.8	6.7	*c.* 50.0	tridacna	15	
771	B. 41/44	6.9	5.0	*c.* 55.0	tridacna	15	
810	A2/B2, L4:13	7.2	3.0	*c.* 40.0	tridacna	?15	very weathered
811	A2/B2, L4:15	7.6	5.8	*c.* 40.0	tridacna	15	very weathered
1371	C3, L4:10	10.4	5.9	*c.* 40.0	tridacna	15	1/3 fragment
1386	C3, L4:1 fea.1	7.9	5.1	*c.* 45.0	tridacna	15	1/3 fragment; again ends appear cut straight
1473	C3, L4:12	8.0	5.1	*c.* 50.0	tridacna	15	1/4 fragment
1484	C3,5:2F.1	7.0	3.6	*c.* 60.0	burnt??	11	1/5 fragment
1517	C2, L4:12	2.3	6.8	*c.* 32.0	tridacna	15	1/3 fragment
1552	C2, L5:2	12.9	5.9	*c.* 45.0	tridacna	15	1/3 fragment; well finished
1558	C2, L6:2	8.2	5.7	*c.* 42.0	tridacna	15	1/3 fragment; well finished;
1564	C2, L6:sf.3	10.9	4.8	*c.* 32.0	tridacna	15	very tall D-shape at area measured; scars from cutting out core visible
1565	C2, L6:sf.3fea.1	9.2	4.8	*c.* 55.0	tridacna	11	well finished
1566	C2, L6:3	22.9	6.2	-	tridacna	15?	very tall, narrow, D-shape; very short fragment
1568	C2, L6:sf.3 fea.1	6.3	3.7	-	tridacna	15	well finished; inner surface
1571/ 1574	C2, L6:sf.3fea.1	8.1-8.3	4.2-3.7	*c.* 40.0	tridacna	15	these two fragments are from the same orignal bangle, well finished
1583	C1, L4:10	8.0	5.6	*c.* 55.0	tridacna	15	well finished
1591	C1, L4:13	7.6	4.2	*c.* 40.0	trochus?	17?	shell i.d. not certain

sf: surface, fea: feature, all measurements are given in centimetres

Shell earplugs

These artefacts are presumably made from tridacna shell. Each is in the form of two discs, one slightly smaller than the other, joined by a narrow waist. There is no perforation.

BONE ARTEFACTS

Cat. 317, B2, 4:5 fea. 17 whole pot residue, is a single small bone bead.

Cat. ?711, B2 L4:10 includes six possible bone beads. The three discs and three short cylinders are arranged in an alternating pattern. They are associated with five orange glass beads.

Cat. 343, B. 47 is a single bone cylinder bead associated with a shell bead (see above). Diameter: 4.1 mm, length: 4.3 mm.

Cat. 559, B. 33 includes three possible bone beads associated with over 400 glass beads as a necklace.

Animal teeth

These artefacts are relatively rare and in somes, perforations or other suspension devices are not obvious. However their location relative to the body and the na-

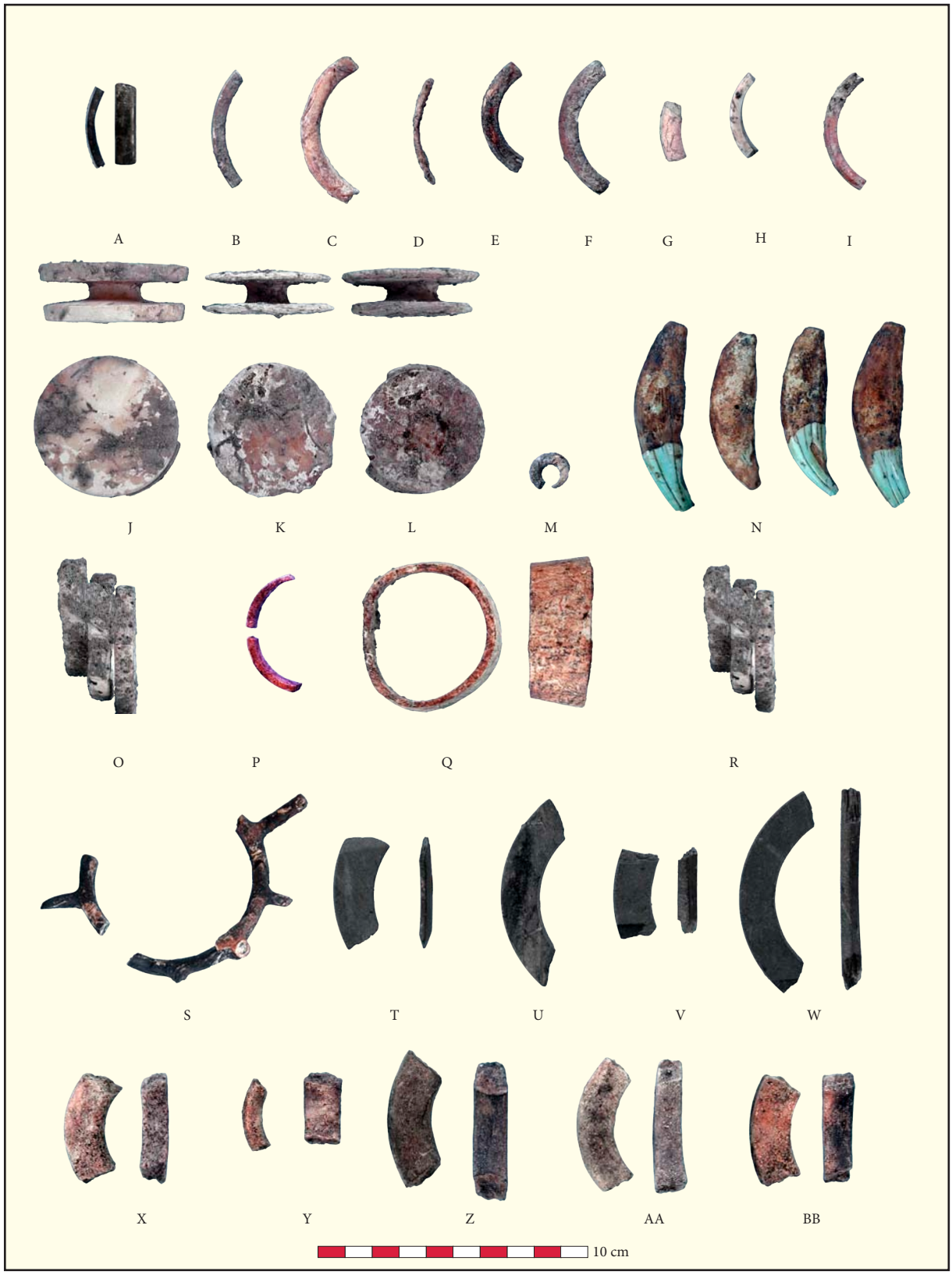


FIG. 21:1 Shell bangles: style 11: A. cat. 1484, B. cat. 1565. style 15: c. cat. 684, D. cat. 707, E. cat. 1371, F. cat. 1552, G. cat. 1566, H. cat. 1568. style 21: I. cat. 1591. shell earplugs: J. cat. 479, K. cat. 485, L. cat. 489. shell earring: M. cat. 1556. tiger canine pendants: N. cat. 483. ivory bangles: O. cat. 453, P. cat. 494, Q. cat. 1206, R. cat. 1257. ivory or turtle carapace bangle: S. cat. 561. slate bangles: T. cat. 594, U. cat. 1495, V. cat. 1501, W. cat. 1510. clay bangles: X. cat. 572, Y. cat. 703, Z. cat. 744, AA. cat. 1746, BB.

TABLE 21:2 *Shell beads from burial 42, cat. 770*

D.	Th.	P.D.
3.5	2.3	1.7
3.4	2.5	2.0
3.6	4.1	1.5
3.8	2.0	2.0
4.0	1.2	2.0
4.2	2.6	1.6

ture of the artefacts themselves makes their designation as ornaments secure.

Cat. 483, B. 27 comprises four tiger's canine pendants pierced for suspension. Lengths: 54.6 mm, 58.0 mm, 65.4 mm & 63.0 mm respectively.

Cat. 1416, B. 102 found inside pot, Cat. 1399, is a young pigs tusk that may have been used as an ornament. The root is broken away and no perforation survives. Length: 43.0 mm.

Cat. 1434, X1, L3:8, feature 1, is also a young pig's tusk. Other features are similar to cat. 1416, above. Length: 37.5 mm.

Ivory bangles

This is a relatively common artefact, especially considering the unpopularity of the other non-metal bangles. These are often associated with children.

Decoration is not common and this provides a contrast with the ivory bangles from Ban Lum Khao.

SLATE AND CLAY BANGLES

As with the shell bangles these are only represented by fragments and are not associated with burials. It is interesting to note that slate is present but not marble, a much more popular bangle material in prehistoric Thailand.

No clay bangles have been found whole or directly associated with a skeleton and as such their designation as bangles can be disputed. Their form however, so closely parallels that of bangles in other materials, that this seems their most likely use. An alternative explanation as pot handles is handicapped by the singular absence of pots with handles in the larger assemblage. The fragments recovered are generally from the lower levels of the excavation.

BRONZE ARTEFACTS

Bronze is the most common material for ornaments at this site. A wide variety of artefacts are made from this material. Most are bangles, of which there are several major forms (including anklets), however other artefacts include earplugs, torcs (necklets), belts and, perhaps the most numerous, finger and toe rings.

Bronze torcs

Cat. 481, B. 27, comprises a set of three bronze torcs, one fragmentary, corroded together in their original orientation. Each is cast with a spiral pattern around the surface in imitation of a twisted rope. These are all split rings with large gaps between the ends. The fragmentary torc indicates that they are of solid bronze without cores of clay or some other material. One interesting feature is that the two complete torcs were worn such that the diagonal lines formed by the spirals converged rather than ran parallel. Dimensions are given for the two complete artefacts, the third was probably of similar size. 1) R.H.: 11.4 mm, R.W.: 11.5 mm, I.D.: 102.1 mm, O.D.: 113.7 x 123.7 mm, split width: 57.0 mm and, 2) R.H.: 11.8 mm, R.W.: 10.5 mm, I.D.: 104.0 mm, O.D. 112.3 x 121.6 mm, split width: 59.2 mm.

Cat. 1518b, B. 96, is a powdery fragment that may be part of a bronze tor*c.* Bagged with cat. 1518a (bronze bangle fragment). R.H.: 9.2 mm, R.W.: 7.8 mm.

Bronze belts

Cat. 208, B. 14, is made up of three bronze belts. Each band is of solid bronze with a circular radial x-section. These are not complete circlets; each has a clasp fashioned by beating or otherwise fashioning one end into a long flat strip which is then turned in a spiral to form a tube. The other end which is tapered to a long point is inserted into the tube to complete the circlet. The exact details of this construction are unclear and there is at least some varia-

TABLE 21:3 *The shell earplugs*

Cat.	Context	D. disc 1	D. disc 2	D. waist	Length	Comments
479	B. 27	48.7x48.7	51.2x51.7 18.0x18.0		20.2	2 earplugs; 1 complete, 1 fragments only; discs, at *c.* 6 mm thick are thicker than other earplugs
485	B. 27	44.2	46.5x47.0	14.2x14.6	15.4	1 complete; rt. of skull
489	B. 27	42.0x43.9	47.5	16.8x17.2	15.8	1 complete; left of skull

TABLE 21:4. *Ivory Bangles*

Cat.	Context	R.H.	R.W.	I.D.	F.L.	Style	Notes
453	B2, L4:6	17.5	3.8	*c.* 40.0	-	11	1/2 fragment; NUL or BLK?
494	A2, 4:12	8.0	3.1	*c.* 40.0	-	11	1/3 fragment; ivory or shell?
542	B1, 4:7	15.0	2.6	*c.* 45.0	-	11	1/3 fragment
561	B. 27	10.5	5.5	*c.* 40.0	29.0	12	maybe turtle shell; burnt; remains of one point (broken) which projects out at right angles
706	B2, L4:12	16.0	5.3	*c.* 40.0	31.1	11	undecorated
1128	C2, L4:5	15.1	3.9	-	*c.* 38.8	11?	3/4 fragment; narrower at one end than the as retains shape of the original tusk
1206	C3, L4:7	19.9	*c.* 4.0	38.4x41.8	52.6	11?	I.D. is a minimum measure and O.D. is a maxi mum; the bangle is narrower at one end than the other due to natural shape of the tusk; not well finished
1257	B. 97	6.9	5.1	-	-	11	set of 3 bangles; well finished; very
		9.2	4.6	30.7x35.7	-	11	fragile; right hand
		10.4	4.4	-	-	11	
1258	B. 97	9.3	5.3	-	52.5	11	set of 3 bangles; heavily concreted;
		10.0	4.0	-	-	11	well finished with original tusk
		9.6	3.9	-	-	11	shape maintained; left hand
1263	C2, L4:sf.8 fea. 1	15.7	3.8	-	*c.* 40.0	11?	1/4 fragments only; very well finished
1339	A3, L4:11	17.4	3.7	-	-	11	1/3 fragment; very well finished with significant bevelling

tion. On one belt the long point appears to be made up of two intertwined strands of bronze.

All three belts have similar overall dimensions - I.D.: *c.* 25.0 x 26.0 cm, R.H.: *c.* 7.0 mm, R.W.: *c.* 7.0 mm, length of clasp: *c.* 10 cm, diameter of clasp: *c.* 9 mm, inner diameter of clasp tube: *c.* 3 mm.

Cat. 959, B. 69, is a fragment of the spiral-form clasp of a small bronze belt, including the portion of core that the spiral is wrapped around. Diameter of clasp (spiral): 7 mm, max. diameter of core: 2.3 mm, length of fragment: 23.9 mm.

Cat. 1046, B. 69 is a set of four belts from the waist of this individual. Each is a long rod of bronze, with a circular cross-section, bent into an oval belt. One end is tapered to a narrow tail. The other end was formed, perhaps forged, into a long narrow strip that was then turned, as a spiral, into a tube. The tail is inserted into the tube as a clasp. Belt 1) RH: 6.3 mm, RW: 7.2 mm; belt 2) RH: 6.3 mm, RW: 6.1 mm; belt 3) RH: 5.7 mm, RW: 5.7 mm; belt 4) RH: 6.5 mm, RW: 6.7 mm. Belt 1) ID: 180 mm x 270 mm, OD: 210 mm x 285 mm, diameter of clasp: *c.* 8.0 mm.

Cat. 2000c, B. 69 is a fragment of spiral clasp from a bronze belt. It is probably from the same artefact as cat. 959 above. Diameter of clasp (spiral): 9.4 mm, length of fragment: 20.2 mm. See also cat. 2000a (bangles) and 2000b (rings).

Cat. 1947a, B. 96 is a fragment of bronze belt clasp with the tail still inserted. Other small fragments of the spiral are also present. Diameter (spiral): 8.0 mm x 8.1 mm, diameter (tail): 4.3 mm decreasing to: 2.0 mm, length: 25 mm. See also cat. 1947b (bangle).

Cat. 1456c, B. 105 (grave cut) is the fragmentary re-

TABLE 21:5: *Slate Bangles*

Cat.	Context	R.H.	R.W.	I.D.	Style	Notes
1495	B3, L6:4	5.8	13.8	*c.* 55.0	9	1/3 fragment; grey/green slate; scars from removing core visible
1501/ 1510	A3, L6:5/6	6.6	13.1	*c.* 58.0	9	2 fragments join to form 1/2 the original bangle; grey/green slate; scars from removing core vis ible

TABLE 21:6 *Clay Bangles*

Cat.	Context	R.H.	R.W.	I.D.	F.L.	Style	Notes
703	A2, L6:2	13.1	6.4	*c.* 35.0	25.3	11	rounded at top and bottom; yellow/orange/brown inside, black core
744	B2, L5a:2	18.6	15.6	*c.* 50.0	48.1	8	irregularly formed; grey & brown surface, black core
1746	B2/B3, L6:5	10.7	12.5	-	47.6	10	light grey/brown surface, black core
1790	X1, L6:4	9.4	13.2	*c.* 45.0	38.0	8	dark sandy-brown surface & core

mains of a small belt of familiar form. It was probably worn by a child. It is associated with bangles (1456a) and rings (1456b). Diameter of clasp (spiral): 5.7-6.5 mm, diameter of core: 3.5-4.7 mm.

Cat. 1536, B. 105 is a fragment of bronze belt that does not include the spiral clasp. It is probably from the same belt, or same set of belts, as cat. 1456c (above). Diameter: 2.9-4.7 mm, length of fragment: 80.6 mm.

Cat. ??, B. 105 is a curved fragment of bronze rod gently tapering to a point at one end. It is probably a fragment of bronze belt. RH: 3.6 mm, RW: 4.4 mm, length of fragment: 28.2 mm.

Cat. 1585, B. 111 (next to B. 105) is a fragment of bronze rod that is probably from a belt. RH: 5.2 mm, RW: 5.1 mm, length: 44.8 mm.

Cat. 1661, A2/A3 4:10 is a fragment of bronze spiral. While it is probably from a belt it does not exactly resemble the others recovered. The original metal is relatively heavy and tightly coiled. It is possible that it is a bronze spiral bead. Diameter of spiral: 11.0 mm, ID: 3.8 mm, length: 19.6 mm.

Cat. 1661, A2/A3, L4:10 is a short fragment of spiral tube that looks much like the clasp of a belt. However, the ends are well finished so it appears to be the complete artifact. It is perhaps a broken belt that has been reworked for use as an earplug or bead. OD: 10.3 mm x 10.6 mm, ID: 3.5 mm, length: 19.4 mm.

Bronze bangles

This is a very numerous artefact. The numbers are perhaps inflated by the often arbitrary distinction between bangles and anklets. Only artefacts that were found worn on the ankles have been included in that section. Anything else of the right size, and form, to be either an anklet or bangle has been included as a bangle. This is because the variety of forms is virtually identical for both parts of the body (although the more ornate forms, few in number, may be restricted to use as bangles) so unless found in the original context they cannot be distinguished.

The most common forms are simple bands (style 11), and bangles with roughly square (style 10) or circular (style 18) cross-sections. One relatively common variation on the simple band, when viewed as worn, has complementary scalloped edges creating an impression of a series of overlapping ovals around the circumference of the bangle (style 24). A common distinction, but one for which the meaning is difficult to assess, is between split rings and complete circlets. This does not appear to correspond with any particular form of bangle and the only relatively predictable aspect is that if one bangle in a set is split then the rest are likely to be also, and vice versa.

Finally, it is common for multiple bangles to be worn on either arm and in many cases the combination appears to have been deliberately put together to create a harmonius balance.

Bronze anklets

The only variable that distinguishes anklets from bangles is their location on the body. For this reason all the comments about bangles (above) apply equally well here. Also, the number of anklets included is probably smaller than it should be as any artefacts not clearly associated with a particular part of the body have been included in the bangle section. It is important to keep this in mind when comparing the two artefact types.

Spiral bronze/metal earrings

These artefacts are common in this site. They were made by turning a length of circular bronze (or other metal) wire in a spiral to form a tube. The ends of the original wire come to points resulting in a flat end to the tube. While these spirals have been interpreted as ear plugs they are often orientated vertically with respect to the body rather than horizontally as would be expected. Given this, an alternative interpretation as hair ornaments is just as well supported.

Cats. 291 and 292 from B. 14 stand out for two reasons. First, they are made from silver and second, the wire appears to have been clad in gold; fragments of gold foil survive between the spirals.

Flat spiral ear ornaments

Cat. 577, B. 30 is a flat spiral made up of bronze rod located at the right ear. Three and a quarter turns remain. RH: 1.9 mm, RW: 4.0 mm.

Cat. 584, B. 35 is a simple flat spiral ear ornament. RH: 2.2 mm, RW: 2.6 mm.

Cat. 626, B. 39 is a very large spiral ear ornament pre-

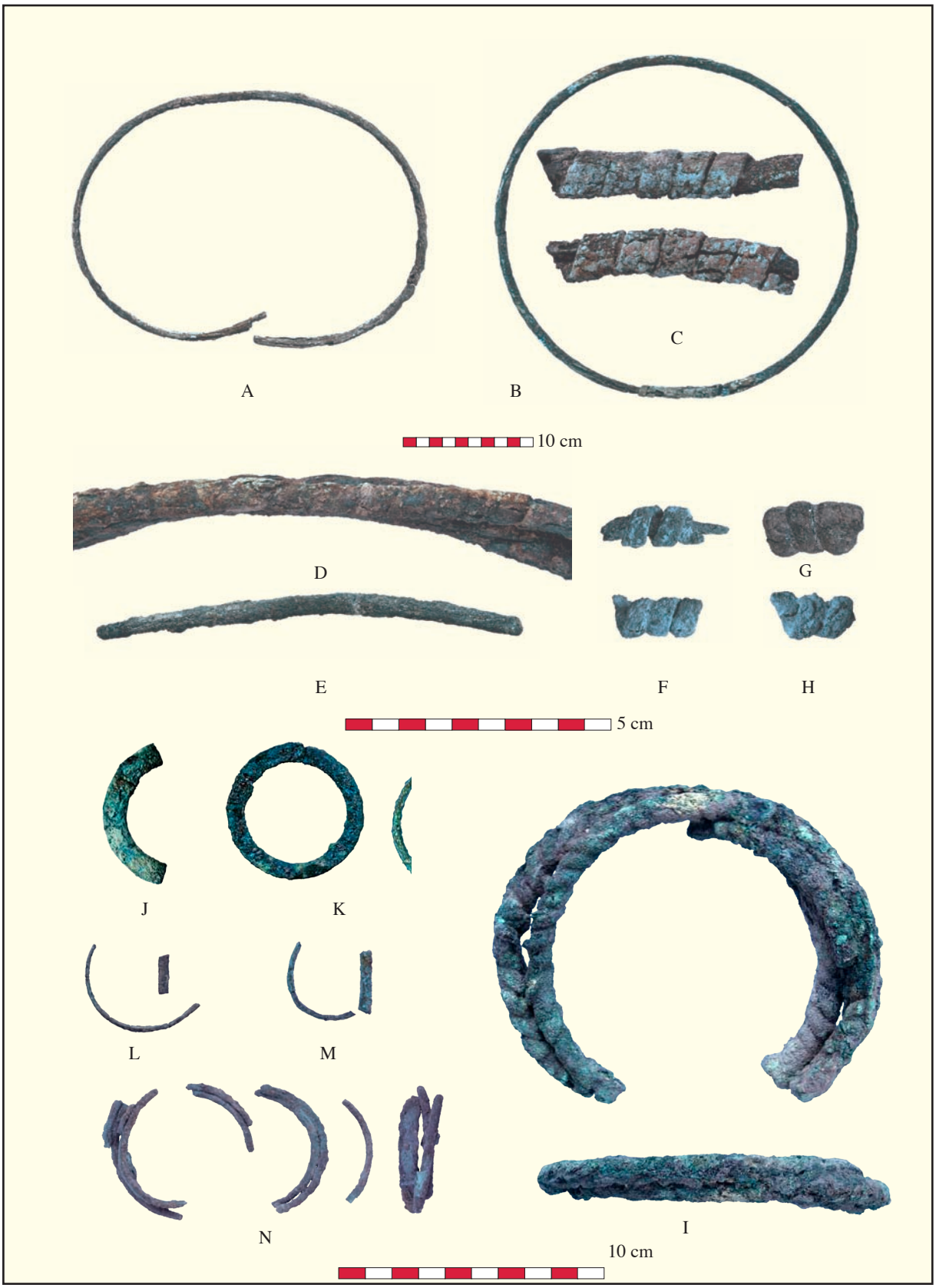


FIG. 21:2 Bronze belts and torcs: bronze belts: A. cat. 1046, B. cat. 208. bronze belt clasps - close-ups, C. cat. 208 (1:1), D. cat. 1046, E. cat. 1536, F. cat. 1947a, G. cat. 1661, H. cat. 1562. bronze torcs: I. cat. 482. bronze bangles - style 4: J. cat. 417. style 5: K. cat. 441. style 11: L. cat. 853, M. cat. 1618. style 11 & 15: N. cat. 801

served by virtue of remaining plastered to the right side of the skull. At least nine full turns remain making this a very impressive artefact. Its positions suggests that it is not an ear ornament but perhaps worn attached to a headband or cap. RH: 2.4 mm, RW: 3.6 mm, diameter (overall): 104.4 mm x 105.0 mm.

Bronze earplug

Two bronze earplugs were recovered from burial 69, one from either side of the head. They are spool-shaped with a large perforation. Each is decorated with concentric incised circles on the flared surfaces.

Cat. 1044, B. 69 was located on the right side of the skull. It has three concentric circles incised on the wider surface with just one partially visible on the narrower surface. It has a somewhat battered appearance. Cat. 1044 is an earring from the left ear. The original form was probably a short tube made of very thin, sheet-like, bronze and is probably an earplug. RH: 7.0 mm, RW: 0.8 mm, OD: *c.* 20 mm.

Other bronze earrings

Cat. ? (2/91) is a single fragment of what is probably a U-shaped earring with a roughly rectangular cross-section. RH: 3.6 mm, RW: 1.8 mm.

Cat. 102, ?(2/113) is a small split ring, the ends of which overlap. It is assumed to be an earring based on form. RH: 2.0 mm, RW: 1.9 mm, ID: 11.5 mm, OD: 12.2 mm x 15.3 mm.

Cat. 155, B. 10 comprises two otherwise plain bronze rings identified when excavated as earrings. 1) R.H.: 3.1 mm, R.W.: 2.1 mm, I.D.: *c.* 20.0 mm and, 2) R.H.: 3.3 mm, R.W.: 1.5 mm, I.D.: *c.* 22.0 mm.

Cat. 188, B. 9 is a single U-shaped earring from the left ear. It is not well formed, being bent rather than curved. RH: 3.1 mm, RW: 2.7 mm, length: 13.3 mm, width: 9.3 mm.

Cat. 189, B. 9 is a single U-shaped earring from the right ear. It matches cat. 188 (above) in form and completes the pair. RH: 3.3 mm, RW: 3.4 mm, length: 17.4 mm, width: 9.7 mm.

Cat. 192, B. 9 is a large bronze split ring with a convex triangular cross-section.The free ends overlap each other and the radial dimensions are slightly greater near the ends. RH: 3.5-4.2 mm, RW: 3.8-4.2 mm, ID: 42.3 mm x 42.9 mm, OD: 51.1 mm x 51.7 mm.

Cat. 324, B. 20 is a simple ring earring, based on location. It may be a split ring. RH: 2.4 mm, RW: 2.7 mm, ID: *c.* 20 mm.

Cat. 330, B. 12 is a three quarter fragment of a simple ring earring from the left side. It may be a split ring. RH: 3.5 mm, RW: 1.6 mm, ID: 18.9 mm.

Cat. 510, B. 31 is what appears to be a scalloped bangle but was described as a left earring when excavated. RH: 8.0 mm, RH in dip: 7.2 mm, RW: 2.0 mm, ID: 38 mm x 41 mm, OD: 42 mm x 46 mm.

Cat. 932, B. 62 is a very small fragment of a simple split ring earring with a D-shaped cross-section. Noted as from the right ear. RH: 1.5 mm, RW: 1.5 mm, ID: 6.5 mm.

Cat. 963, B. 61 is made up of fragments of a simple ring described as a left earring when excavated. It has a rectangular cross-section. RH: 2.7 mm, RW: 1.3 mm, ID: *c.* 30 mm.

Cat. 984, B. 71 is a simple split ring earring of bronze.

TABLE 21:7 *The Bronze Bangles*

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
5	A1, L2:5	2.5	2.5	-	-	18	mis-shapen fragment; bangle or wire?
7	A1, L2:6	3.8	4.0	*c.* 60		15	fragment of 1 bangle
15	B1, L1 fea. 1	5.4	4.8	37.3x37.6		22	diamond x-section but not thicker near split; split ring; assoc. with burnt clay feature
144	3:11	5.2	1.4	c .50	-	?	simple rectangular cross-section; repoussee design (circular bumps raisedon outside surface by beating out from inside surface)
174	3:5	4.4	1.7	-	-	11	fragments of 1 bangle
177	A2, L4:1	5.0	2.7	*c* .55	-	11	fragment only
195	B2, L3:6 5.2	2.2	*c.* 50	-	-	11	fragment of 1 bangle
369	B1, L4:sf.14,fea.4	4.1	2.2	-	-	15	fragment only
404	B2, L4:5 13.1	2.4	-	-	-	11	fragment of 1 bangle
417	A2, L4:7	2.7	8.3	*c.* 40	-	4	1/2 fragment

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
427	B2, L4:sf. 6 fea. 1	2.0	2.3	*c.* 50		18	fragments of at least 1 bangle
428	A2, L4:sf. 8	4.3	3.0	*c.* 60		15	fragment of 1 bangle
441	A2, L4:8	1.5	6.3	33.5	46.3x46.6	5	1 complete bangle
442	A2, L4:8	4.4	4.4	*c.* 60		?	fragment of 1 bangle?, triangular cross-section, flat on one face and pointed on the other
450	B2, L4:6	8.7	3.0	*c.* 80		11	fragment of 1 bangle
459	A2, L4:9	9.6	3.8	*c.* 80		?	simple band with convex x-section (outer surface)
574	B1, L4:sf. 10 fea. 1	3.2	2.6	*c* .50		15	fragment of 1 bangle
607	B1, L4:sf. 10 fea. 1	8.4	3.1	*c.* 65		11	fragment of 1 bangle
649	B2, L4:8	4.4	1.9			11	1/3 fragment;
667	A2, L4:13 fea. 2	2.3	2.5	*c.* 65		10/11	many v. small fragments
668b	B2, L4:9	8.4	3.2	-		11	v. short fragment; see also cat. 668a (bronze frag.)
677	A2, L4:13 fea.2	3.0	2.6	-		15	1 bangle only; very light radial dimensions
681	A2, L5:1	6.3	6.4	*c.* 60		15	1/3 fragment (2/136)
681	A2, L5:1	6.9	6.6	*c.* 60		18	1/3 fragment
738	B2, L4:11	21.5	3.3	*c.* 45.0		11	very wide band; fragment;
778	A1/B1, L3:3	3.1	3.7	*c.* 55		15	fragment only
801	A2/B2, L3:8	8.0	3.1	?*c.* 50		11	remains of 7 bangles; the first five
		7.5	2.7	?*c.* 50		11	were corroded together in original
		3.3	2.4	?*c.* 50		15	orientation, each comprising only
		3.3	2.6	?*c.* 50		15	1/2 the original bangle; the last 2
		4.0	2.9	?*c.* 50		15	were also 1/2's but were not
		4.3	2.7	?*c.* 50		11	attached; small (children's?)
		4.4	2.8	?*c.* 50		11	bangles
853	C2, L3:2 fea.1	4.7	2.1	*c.* 40		11	fragments of 1 bangle
853	C2, L3:2 fea.1	4.0	1.6	*c.* 55		11	fragments of 1 bangle (2/136) see also 853 (bronze frags.)
854	C2, L3:2	4.0	1.1	*c.* 40		11	1 bangle (1/141);
854	C2, L3:2	4.5	2.0	*c.* 45		11	single bangle; split ring (1/153)
1033	C1, L3:10	6.7	3.6	*c.* 70		11	fragment
1143	B3, L4:sf. 4	9.6	3.7	-		11	fragment
1185	B3, L4:5 7.8	3.9	-	-			1 small fragment
1197	C1, L4:6	3.8	2.9	*c.* 40		11	1/8 fragment
1212	C3, L4:7	4.1	3.5	-		15	fragment of 1 bangle
1274a	B3, L4:9 5.2	2.2	-	-		11	v. small fragment; see also 1274b (rings) & 1274c (bronze fragments)
1280	C3, L4:8 fea.1	7.7	2.7	*c.* 40		?	simple band; convexly curved (outer surface); very small projecting knob may be original
1347	X1, L3:3	6.3	2.0	-		11	single fragment
1365	B3, L4:10	6.2	5.5	*c.* 45		15	
1420	B3, L4:13	3.5	2.1	*c.* 48		11	fragment; appears to have a catch
1424	B3, 4:14	4.0	4.0-4.3	*c.* 40		27	1/2 fragment of a unique bangle from NUL; circular cross-section decorated with 1 row of spherical knobs around the outside edge (*c.* 5 mm diameter)

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
1433a	X1, L3:8	5.4	3.1			11	fragments of at least 3 bangles;
	fea.1	3.5	4.7			8	loose bronze; see also, cat. 1433b
		3.2	3.8			8	(bronze rings); also, 1 green glass
							large pit
1439	C1,	4:8	5.8	4.0		10	fragment of 1 bangle
1618	B2/C2,	3:5	5.0	1.9	*c.* 30	11	many frags = at least 2 bangles
1646	C1/B1,	4:1	3.5	3.3	33.6x43.6	15	split ring
1656	B2/B3,	4:1	4.4	3.1	*c.* 66	15/18	
Burial 1							
81		4.4	4.2	*c.* 45		10	stack of at least 4 bangles;
		3.5	2.9	*c.* 50		10	c/s vary but all close to
		3.1	3.1			10	square; rt. distal forearm
		3.2	3.5	*c.* 70		10	
85		3.8	3.4			11	fragments of *c.* 9 bangles;
							at least 1
		5.4	4.1			11	of form 21; dimensions are
							of large
		4.3	4.4			21	fragments; rt. elbow
		4.3	3.7			21	
88		5.6	4.4	62.0x72.0	69.6x84.7	11	8 bangles in a
							stack; 6 of form 11; 2
		5.5	3.9			11	of form 21 (groove around
							outside);
		4.4	3.6			21	lft. elbow
Burial 4							
137		5.0-7.8	5.6-6.6	46.6x50.0	59.4x62.6	22	split ring with radial dimen
							sions greatest either side of
							the split; diamond
							shaped x-section with a
							carination on outer and in
							ner edges; left arm
138		5.4-7.1	5.1-6.7	48.2x50.2	60.6x61.9	22	same description as cat.
							137; gap at split: 1.7mm;
							right arm
Burial 7							
150	B. 7	2.7	2.2	*c.* 55		15	fragments of at least 2 bangles
		3.3	2.9			15	
Burial 10							
156	B. 10	2.6	4.4	*c.* 55.0		8	fragments of 3 bangles; rt. arm
		2.2	2.4		*c.* 50.0	10	
		3.1	2.7	*c.* 55.0		10	
Burial 14							
209	B. 14	2.7	4.6	*c.* 70	85x90	8/9	arm band; left arm; made up of *c.*
		3.1	4.3			8	75 individual bangles all of the same
							form; measures given here from
							either end of stack
267	B. 14	5.0	2.3	*c.* 70	80x110	9	arm band - *c.* 24 cm long; rt. arm;
							made up of *c.* 75 individual bangles
							\all of the same form; appear to
							graduate in size from end to end
213	B. 14	3.6	3.0	*c.* 70		18	1/3 fragment; foot area

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
Burial 15							
275	B. 15	3.6	4.5	*c.* 60		7/15	1/4 fragment; area of B. 15
1490a	B. 15	8.5	2.1	*c.* 40		24	fragments of 3 bangles; 1st - RH in
		2.4	3.5	*c.* 70		4	dip: 7.2 mm; 3rd may be a ring; see
		6.3	2.1	*c.* 30		11	also 1490b (rings)
Burial 16							
247	B. 16	3.2	3.4	*c.* 50.0		10	fragment only
Burial 20							
326a	B. 20	3.8	5.4	*c.* 50		7	at least 2 bangles; see also 326b
		3.9	5.4	*c.* 52		7/8	(rings)
Burial 26							
543	B. 26	3.2	1.9			20	wire-like fragment only
543	B. 26	3.1	2.2			20	double entry?
Burial 27							
481	B. 27	28.4	2.4	51.0x86.0	59.0x96.0	11	1 very wide band; the circlet has been squashed; appears to be a split ring with the ends crossed over when squashed; has at least one spike of bronze on inner surface; matting impressions on outer sur faces; left wrist
Burial 30							
472	B. 30	4.7	4.1	49.0x52.0	57.0x 63	4	bangles (3 complete); left wrist;
		2.3	4.1				split rings; all similar dimensions
		4.0	3.2				
		2.3	4.2	*c.* 35			
Burial 31							
1657	B. 31	9.2	2.6	*c.* 45		24	3.4 fragment of 1 bangle; rt. elbow; RH in dip: 7.6 mm
1658	B. 31	9.2	2.2	*c.* 48		24	1 wide bangle; left elbow; RH in dip: 7.4mm, WL: 5.6mm
Burial 32							
467	B. 32	23.2	3.8	*c.* 55			small fragments of at least 2
		8.4	3.5				bangles
Burial 33							
560	B. 33	11.5	3.1	58.0x66.0		11	1 large bangle; split ring; left wrist
630	B. 33	3.7	2.4			?	fragments only
Burial 35							
581	B. 35	4.0	3.0	48.0x50.6	53.8x57.4	11/15	4 bangles; left wrist
		4.4	3.4	44.0x48.5	51.9x55.4	11	
		4.3	3.5			10/11	
		4.4	3.3			11	
582	B. 35	3.7	2.8	57.6x58.2	60.0x63.5	15	2 bangles; rt. wrist
		4.3	3.0	57.6x58.2	60.0x63.5	15	
Burial 40							
600	B. 40	14.1	1.9	c .55		25	3 bangles; left wrist; all similar
		13.0	2.3	38.5x44.5		25	dimensions & form

Table 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
		12.6	2.3	41.2x48.6	46.0x53.0	25	
Burial 46							
549	B. 46	3.9	3.1	*c.* 40		15	1 bangle
552	B. 46	9.2	4.0	*c.* 40		25	1 bangle; V-shaped cross-section
Burial 48							
650	B. 48	4.7	2.0	*c.* 50.0		11/15	fragments of at least 5 bangles;
		4.5	1.9	*c.* 50.0		11/15	measurements indicate variety
		4.7	1.6	*c.* 50.0		11/15	only
		4.5	1.8	*c.* 50.0		11/15	
		4.7	2.0	*c.* 50.0		11/15	
Burial 49							
689	B. 49	3.4	2.4	*c.* 60.0		15	fragments of at least 2 bangles;
		3.0	2.1	*c.* 60.0		15	right forearm
Burial 52							
682a	B. 52	18.6	3.9	*c.* 40.0		11	very wide band; 1/4 fragment; see also cat. 682b (bronze frag.)
696	B. 52	11.9	3.5	55.0x56.8	62.5x64.0	11	3 identical bangles; each decorated
		10.9	4.0	54.6x57.0	62.8x64.8	11	with incised vertical lines around
		11.4	3.5			11	the outer edge; left forearm
697	B. 52	11.0	3.3	49.0x55.9	57.1x64.3	11	2 bangles practically identical to
		12.2	3.6	51.1x57.5	59.1x65.4	11	cat. 697; decorated with same in cised vertical lines around outer edge; right forearm
Burial 59							
874	B. 59	4.9-6.5	4.8-6.4	42.0x46.0	52.7x58.6	23	complete bangle; which arm?
879	B. 59	5.5-6.8	5.1-6.5	43.0x53.0	57.5x64.0	23?	complete bangle: rt. wrist
Burial 61							
897	B. 61	3.3	3.0	*c.* 50.0		10	fragments of a single bangle
995	B. 61	3.3	2.8	*c.* 55.0		15	single bangle; left arm
Burial 62							
912	B. 62	3.7	2.8	48.0x53.5	57.4x59.6	15	at least 10 bangles; 7 complete or
		4.4	3.6	50.0x52.0	57.5x59.0	15	almost complete; left wrist
913	B. 62	5.5	3.6	47.0x48.0	54.0x57.0	11?	fragments of at least 15 bangles; 13
		4.0	3.6	45.0x?-	52.0x60.0	10	still in a stack - measurements given for bangles at either end of stack; all split rings; all similar dimensions; rt. wrist
?a	B. 62	4.6	3.6	*c.* 80			1 fragment; see also ?b (rings); (2/70)
Burial 63							
928	B. 63	6.2	2.9	31.0x31.4	38.2x38.9	11	stack of 6 bangles, one has come
		5.8	3.4	32.4x30.8	38.3x38.4	11	loose (3rd set of measurements),
		5.8	2.9	31.0x31.9	39.2x40.0	11	others are 1st and 5th in stack; left wrist
928	B. 63	5.9	3.8	31.2x32.0	38.5x38.8	11	stack of 6 complete bangles?; all
(2nd)		5.8	3.0	31.2x33.2	36.8x40.5	11	complete; dimensions for 1st & 6th in stack; where from?
933	B. 63	5.1	3.6	30.1x31.9	38.2x39.6	11	complete; rt. of rt. wrist
972	B. 63	6.0	3.6	28.6x31.2	37.0x38.5	11?	single complete bronze bangle
Burial 65							
975	B. 65	3.4	2.6	*c.* 70.0		10?	remains of at least 3 artefacts;
		3.1	3.9			10?	2 (measurements given) are bangles;

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
							the remainder possibly a bangle or some other bronze ring
1941	B. 65	3.6	1.8			11	fragments from at least 2 bangles
		3.2	3.8			8	
Burial 67							
1031a	B. 67	4.1	3.1			10	fragments; see also 1031b (ring)
1031c	B. 67	4.0	3.0			10	fragments; see also 1031d (ring)
Burial 68							
978	B. 68	4.8	1.9			11	fragments of at least 2 bangles
		4.0	2.4			10/11	
979	B. 68	3.7	2.1	*c.* 70		11	1/4 fragment
Burial 69							
993	B. 69	3.5	4.0	67.0x85.0		8	stack of at least 11 bangles; all simi lar dimensions to those given; rt. elbow
1602	B. 69	2.9	3.8	79.6x73.4	87.2x79.1	10	stack of 9 bangles; all virtually
		3.0	3.1	78.5x74.0		10	identical; dimensions given for 1st and 7th in stack; left elbow
1942	B. 69	4.0	3.1			10/11	fragments of 1 bangle
2000a	B. 69	2.7	4.1	*c.* 80		7/8	fragments of 2 bangles; rt.
		4.7	3.0			9	armband; see also 2000b (rings) & 2000c (belt)
Burial 75							
1121	B. 75	9.1	2.6	*c.* 70		11	very small fragment of 1 bangle; see others of this cat. number (earrings & rings); (2/74)
1121	B. 75	9.0	2.0			11	fragment of 1 bangle (2/133)
Burial 77							
1943	B. 77	8.2	2.2			24	fragments of at least 1 bangle; RH in dip: 6.1 mm
Burial 78							
1073a	B. 78	5.8	3.8	*c.* 60		15	small fragments of 2 bangles; see
		6.8	1.8			24	also 1073b (rings)
1116	B. 78	7.4	2.2			24	small fragment of 1 bangle; RH in dip: 6.0 mm
Burial 79							
1147	B. 79	7.6	3.1	35.8x37.3	41.9x42.8	11	complete bangle; possibly scal loped? - not clear
1148	B. 79	6.9-8.4	3.2	36.2x40.0	42.8x47.0	24	complete; upper left arm; heavy
1149	B. 79	3.3	3.1	31.0x33.0	37.8x38.7	18	left wrist
1150	B. 79	10.3	4.7	32.1x32.2	45.5x47.7	11	complete; right arm
1151	B. 79	5.3	3.0	26.6x30.9	34.1x36.1	11	complete; right wrist; unusual split ring with the ends beaten into over lapping sub-circular tabs
Burial 80							
1664	B. 80	5.4	2.8	30.0x31.7	37.5x39.0	11	stack of 10 bangles; rt. hand
		5.4	3.8	29.5x30.6	37.5x38.6	15	
		5.5	3.7	29.7x32.2	36.6x38.8	15	
		5.5	3.8	32.4x33.0	40.4x42.1	15	
		5.4	3.6	32.5x33.1	40.5x42.4	15	

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
		5.8	4.0	30.2x31.6	38.9x39.2	15	
		6.2	2.9	similar	similar	11	3/4 frag.; split ring
		5.1	3.8	33.3x35.6	41.5x44.2	15	split ring
		4.8	4.5	40.2x42.2		15	split ring
		4.3	3.8	28.4x32.2	37.0x40.9	15	split ring
1665	B. 80	4.9	3.9	31.3x32.7	39.4x40.9	10	stack of 6 bangles; dimensions not
		5.0		41.9x42.0		10	given for 6th (frags.); 2nd & 3rd
		5.0	3.4	32.1x34.5	40.6x41.8	15	maybe split rings; left hand
		4.2	4.4	32.3x33.6	39.1x41.9	10	
		3.1	3.8	*c.* 33.0		10	
1945a	B. 80	2.8	4.4	*c.* 50		8	1/4 fragment; from flot; see also 1945b (rings)
Burial 81							
1437	B. 81	6.8	1.7	c .50		24	1/3 fragment; RH in dip: 5.1 mm; under skull
1438	B. 81	7.8	1.8			24	small fragment; RH in dip: 5.2 mm; located over femur
1473	B. 81	5.0-6.7	1.7			24	1/3 fragment; scalloped
1946	B. 81	3.5	1.7	*c.* 55			fragments from grave fill
2001a	B. 81	3.9	2.3	*c.* 50		11	small fragments of at least 1 bangle; see also 2001b (spiral earrings)
Burial 82							
1215	B. 82	4.9-7.2	1.4	*c.* 45.0		24	1/2 fragment
1216	B. 82	5.4-6.7	1.3	*c.* 40.0		24	fragment
1222	B. 82	4.3	4.5	46.2x47.3	55.6x56.4	15	at least 6 rings; 4 in stack; split
		4.3	4.4	46.8x47.8	55.7x57.6	15	rings; rt. wrist
1223	B. 82	4.8	4.5	47.0x48.0	54.0x56.0	18	stack of 7 bangles; measurements
		3.8	5.0	46.0x51.5	55.4x60.8	18?	given for bangles at either end - these 2 are split rings, the rest not; all similar dimensions; left wrist
1227	B. 82	4.2	4.0	47.0x48.2	56.2x56.7	10	stack of 4 identical bangles; two
		4.4	4.5	45.0x47.6	54.4x56.8	10	complete; all split rings; rt. wrist
		4.3	4.3	*c.* 50.0		10	
Burial 84							
1241a	B. 84	8.5	2.0			24	small fragment of 1 bangle; RH in dip: 6.9mm; see also 1241b (rings)
Burial 86							
1336	B. 86	9.3	3.9	36.2x36.4	44.2x44.4	24	split ring; scalloped; which arm?
Burial 91							
1226	B. 91	5.1	3.9	*c.* 35.0		15	fragments of at least 3 bangles;
		7.1	2.6	*c.* 50.0		24	2 scalloped; left wrist
		6.1-6.8	2.2	*c.* 50.0		24	
1227	B. 91	5.3-6.6	1.3			24	fragments of at least 2 bangles (bag
		8.5	9.8	*c.* 42.0		24	says 3); one heavier than the other; rt. wrist (1/159)
1227	B. 91	8.8	2.5			24	fragments of at least 3 bangles; rt
		6.8	1.6			24	wrist; (2/125)
Burial 95							
1249	B. 95					24	small fragment
1364a	B. 95	6.3-7.7	2.5	*c.* 40.0		24	small fragment; from flot.

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
1364b	Burial 95	7.1	1.4			24	fragments of at least 2 bangles;
		5.1	2.5			11	from flot.; RH in dip (1st): 5.8 mm
1921a	Burial 95	5.8	2.3	34.9x35.6	40.5x40.8	11	at least 6 bangles (3 complete) ; see
		5.8	6.1	24.8x26.0	37.9x38.0	15	also 1921b (rings) & 1921c (bell)
		6.8	6.1	*c.* 24	*c.* 37	15	
		3.1	2.6	*c.* 90		15	
		5.0	3.5	*c.* 55		15	
		6.3-8.2	1.8			24	
1363b	Burial 95	7.8	2.0			24	fragments of at least 3 bangles; B.
		6.2	2.5			11	95; see also 1363a (rings)
		3.1	2.9	*c.* 65		10	
	Burial 96						
1481a		2.8	3.3			7	very small fragments of at least 3
		1.8	2.8			7	bangles; see also 1481b (rings)
		8.1	2.1			11	
1504a		3.1	3.9	*c.* 80		7	1/4 fragment
		2.2	2.9	*c.* 70		7	1/5 fragment
		8.1	2.1			11	very short fragment; alltogether fragments of at least 3 bangles; see also cat. 1504b (bronze rings); grave area
1516b		6.4	1.8	*c.* 40		11	very short fragment
1518a		2.9	3.2	*c.* 70		7	1/4 fragment; see also, cat. 1518b (bronze torc)
1519		2.8	3.3			7	1/4 fragment
1520		2.1	3.4	*c.* 70		4	fragment
1595		2.9	3.3	*c.* 75		7	1/2 fragment; under pelvis
1947b		2.5	3.1	*c.* 90		8	fragments of 1 bangle; see also 1947a (belts)
	Burial 98						
1356		5.8	5.4	46.8x50.1	58.2x62.0	18	set of 7 bangles; measurements
		5.7	5.5	49.0x51.0	60.2x62.9	18	given for 2 at either end of stack; all? split rings; left wrist
1360		5.3	4.8	44.6x45.6	55.2x58.0	18	split ring; complete; rt. wrist
1413		5.1-6.8	1.4	*c.* 60.0		24	fragment; split ring (original end present); rt. wrist
	Burial 99						
1220		8.8	2.8	*c.* 55.0		11	fragment
1387		9.0	2.8	*c.* 45.0		11	fragment; split ring (original end present)
1682		8.7	5.3	64.8x58.8	75.3x69.4	11*	stack of 4 bangles; complete; each
			72.4x68.3			11*	decorated with a row of circular
			72.9x69.7			11*	(*c.* 5mm dia.) nubs around centre of
		8.2	4.6-5.1	63.2x58.5	73.4x68.3	11*	outside circumference
1683		3.1	3.8	49.7x57.4	58.3x65.1	7	set of 7 bangles, measurements for
		3.9	3.7	47.0x49.5	55.8x57.3	4	either end of stack given; graduate in size from one end to the other; split rings; right wrist
1703		7.7-10.4	3.0	43.0x43.6	50.0x51.9	24	very heavy for this style; complete; neck area
	Burial 102						
1469		5.7	3.1	33.0	41.0	11	3/4 fragment
1470a		6.8	3.1	*c.* 33.0		11	at least 1 bangle; fragments; see also cat. 1470b (ring) & cat. 1470c (bimetallic ring)
1472		6.3	3.1	35.5x34.5	41.9x42.9	11	stack of 3 bangles; first complete;
		6.6	3.0	*c.* 38.0		11	2nd - 1/3 frag.; 3rd - split ring

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
		4.0	3.9	*c.* 40	15		
1416a	X1, L3:13 fea.21	10.1	5.1	34.0x35.0	43.0x44.0	11?	fragments of at least 3 bangles, 1
		8.6	3.6	32.0x30.0	37.0x37.0	11?	scalloped; see also, cat. 1416b & c
B. 102?	Burial 105	7.4-	9.1	2.3	*c.* 50	24	
1456a		9.9	3.4	*c.* 45		11	fragments of at least 5 bangles;
(grave cut)		6.4	3.0	*c.* 40		11	scalloped bangle is a large
		9.4	2.8	*c.* 50		24	example; see also 1456b (rings) &
		3.0	3.7	*c.* 60		10	1456c (belt)
		2.8	2.8	*c.* 50		10	
1456y	B. 105	9.4	3.0	*c.* 50		11	fragments (1/4 or less) of at least 4
		5.8	2.5	*c.* 35		11	bangles; the last given here may
		2.1	3.0			8	be a spiral bangle of at least 2
		9.2	2.1			24	turns; see also 1456z (rings);
		3.5	3.8	*c.* 55		13/18	(1/127)
1468a	X1, 3:13						
B. 105?		7.2-8.6	2.0	*c.* 55		24	fragment of 1 bangle; RH in dip: 6mm; lo cated east of B.105 with scattered human bone & beads; see also 1468b (rings) (+ chips of glass & silver?)
Burial 109							
1471		2.7	3.2	*c.* 46.0	52.6x53.8	5	split ring; very regular shape; unusual x-sec tion
Burial 113							
1523a		3.6	4.2	*c.* 55		7	fragments of at least 2 bangles; see
		2.6	3.8	*c.* 68		7	also 1523b (rings)
1539		2.0-3.8	3.9-4.0	49.0x56.0		8/10	at least 17 bangles in a stack; at least 15 are of either style 8 or 10, very similar;
		4.3	8.3	51.0x54.2		8	split ring; more extreme x-section than others of this form; penultimate at distal end
		5.1	5.0-11.6	36.3x50.0		23	circular x-section that thickens significantly towards split; bangle on distal end of stack
1707		3.3	3.6	54.5x64.3	64.2x72.0	8	stack of at least 21 bangles;
		3.4	4.2	50.0x58.0		8	right hand; appear to decrease
		4.5-12.3	4.2-12.5	37.5x50.7	53.9x62.2	23	in size from prox. to distal end of stack; di mensions given for 1, 20 &21; 21st bangle (distal end different form)
Burial 115							
1598a		5.9	3.8	28.2x28.5	37.2x37.4	15	at least 9 bangles; left arm; 4
		5.9	3.5	26.5x28.0	36.7x37.1	15	relatively small (1st 4 measures
		5.4	4.8	*c.* 32	*c.* 41	10	given here); remainder, large (last
		4.4	4.7	*c.* 35		7/10	3 measures given here)
		3.4	3.8	*c.* 41		7	
		4.7	4.4	51.2x53.0		10	
		3.3	3.7	37.1x37.4	44.5x45.6	7	
1598b	5.5	4.2	*c.* 35			11	small fragments of at least 4
		4.2	3.9	*c.* 38		15	bangles
		5.4	4.5			10/15	
		3.2	3.8	*c.* 50		10	
1609		4.8	3.3	23.4x26.8	34.5x35.6	11	at least 18 bangles; rt. arm; fall
		5.6	3.7	36.0x37.0		11	into 3 groups - distal group rep. by

TABLE 21:7 *The Bronze Bangles* (cont.)

Cat.	Context	R.H.	R.W.	I.D	O.D.	Style	Notes
		c. 4.5	3.9	32.5x39.2		15	the 1st 4 measurements given here,
		4.5	3.2	33.2x33.8			n=8, smaller; mid. group rep. by
		3.1	3.7	50.4x51.2		7	next 3 measurements, n=6, larger;
		2.6	3.6	43.6x*c.* 4	50.9x51.2	7	prox. group rep. by last measure.,
		3.3	3.6	42.3x42.3	49.9x50.3	7	n=4, smaller again; each group
		c. 5.4	3.5	28.1x31.8	35.8x39.0	10/11	quite consistent.
Burial 118							
1688		9.9	2.8	*c.* 55		24	fragments of at least 4 bangles; rt.
		3.6	4.8	*c.* 110		8/10	hand
		4.4	1.9	*c.* 70		11	
		3.6	1.9	*c.* 40		15	
1689		5.0	5.1	45.0x56.3	57.0x68.7	10	stack of 7 bangles; left wrist;
		5.0	4.8	48.7x57.5	59.7x70.0	10	dimensions for 2nd & 7th given; decorated with rope pattern (corroded); all split rings
1952	B. 118	4.0	2.4	*c.* 60		11/15	fragments of at least 2 bangles
Burial 120							
1740		2.7-3.2	2.4-3.7	27.6x30.8	35.3x36.9	13	spiral of 6 turns, 26cm long; x-section: 7/15; associated with green glass beads (seed)
1743		3.0	6.6	*c.* 42		6	1/2 fragment; decorated with short vertical incisions around outside edge
		3.3	3.1	*c.* 45		15	1/3 fragment
		3.3	2.8			10	1/16 fragment
Burial 122							
1763		7.8	2.1	*c.* 40		24	small fragments of 3 bangles; noted
		9.1	2.1			24	on bag as rt. earring - which ring?;
		5.4	2.4			11	1st- RH in dip: 6mm, 2nd- RH in dip: 8.5mm
1764b		5.0	2.5	*c.* 50		11	small fragments of at least 2
		4.7	5.0	*c.* 35		10	bangles/rings; see also 1764a (earrings)
1765		2.8	8.0	*c.* 35		9	at least 19 bangles; rt. hand; 14
		4.8	3.4	*c.* 36x*c.* 46		11	still in stack; 1st & 14th measures. given here; 1st measure. here (distal bangle) is unique form; re mainder style 11; next 5 or 6 smaller; remainder simil ar in size to the 2nd measure given here; some, at least, of large = split rings
1766		2.4	5.7	*c.* 40		9	at least 16 bangles; left arm;
		5.1	3.1	*c.* 45		11	matching bangle set to cat. 1765; 1st given here is 1st in stack, unique; remainder all style 11, very fragile/ misshapen; example measure. given only
1953a		8.6	2.1	*c.* 45		24	fragment of 1 bangle; RH in dip: 6.7 mm; heavy bangle; see also 1953b (rings)

TABLE 21:8 *The Bronze Anklets*

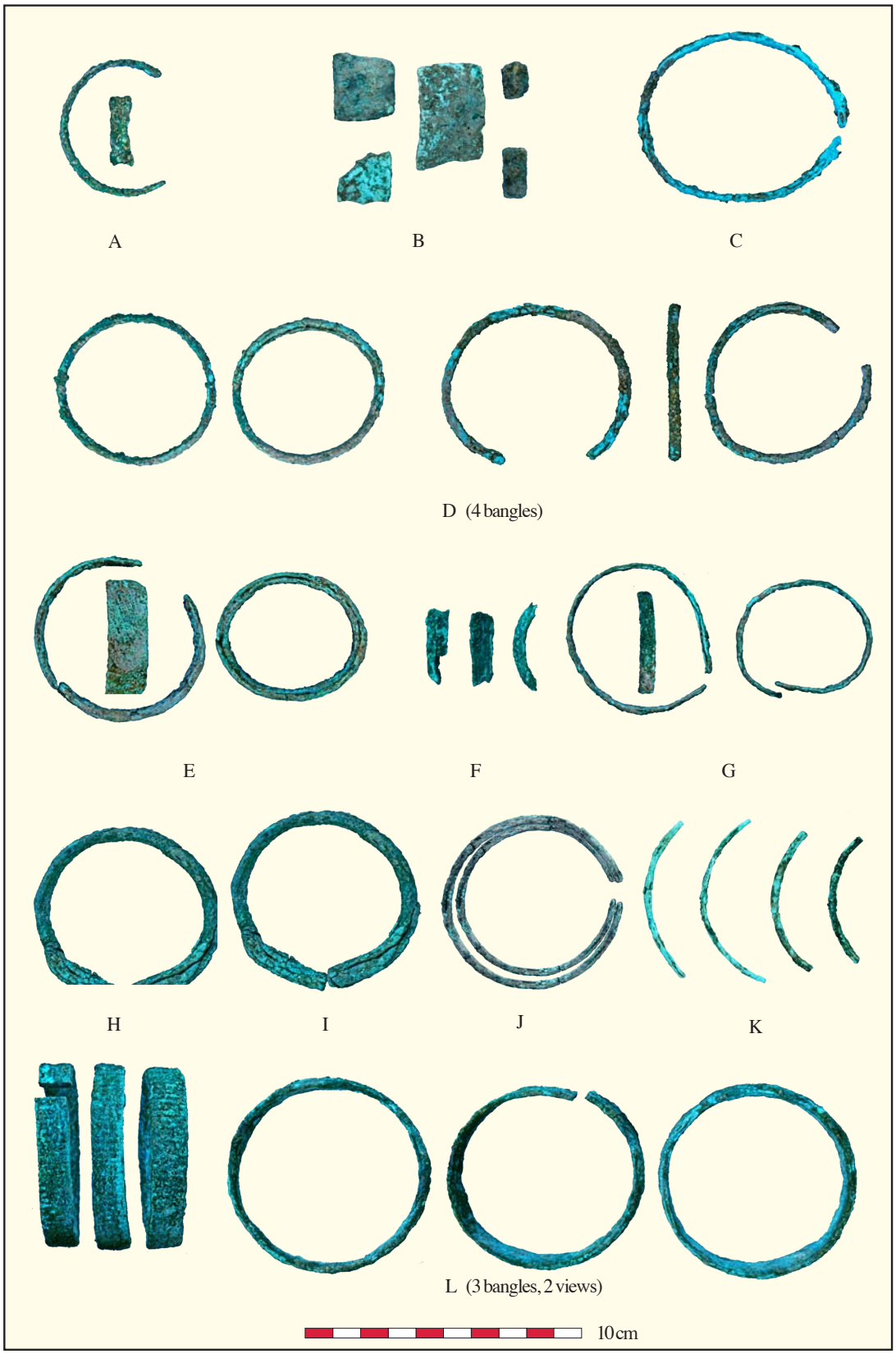
Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
159	B. 10	3.4	3.1	*c.* 45.0		10?	small fragment only; rt. leg
506	B. 25	3.0	2.9	*c.* 35		18	6 anklets; both feet?
		5.1	2.8	*c.* 36		11	
		6.2	5.1	*c.* 40	10/11		
		5.8	2.2	33.6x33.7	38.2x39.8	11	
		6.7	1.6	*c.* 55		24	
		8.3	1.6			24	
610	B. 39	22.7	4.0			11	fragment; left ankle

TABLE 21:8 *The Bronze Anklets* (cont.)

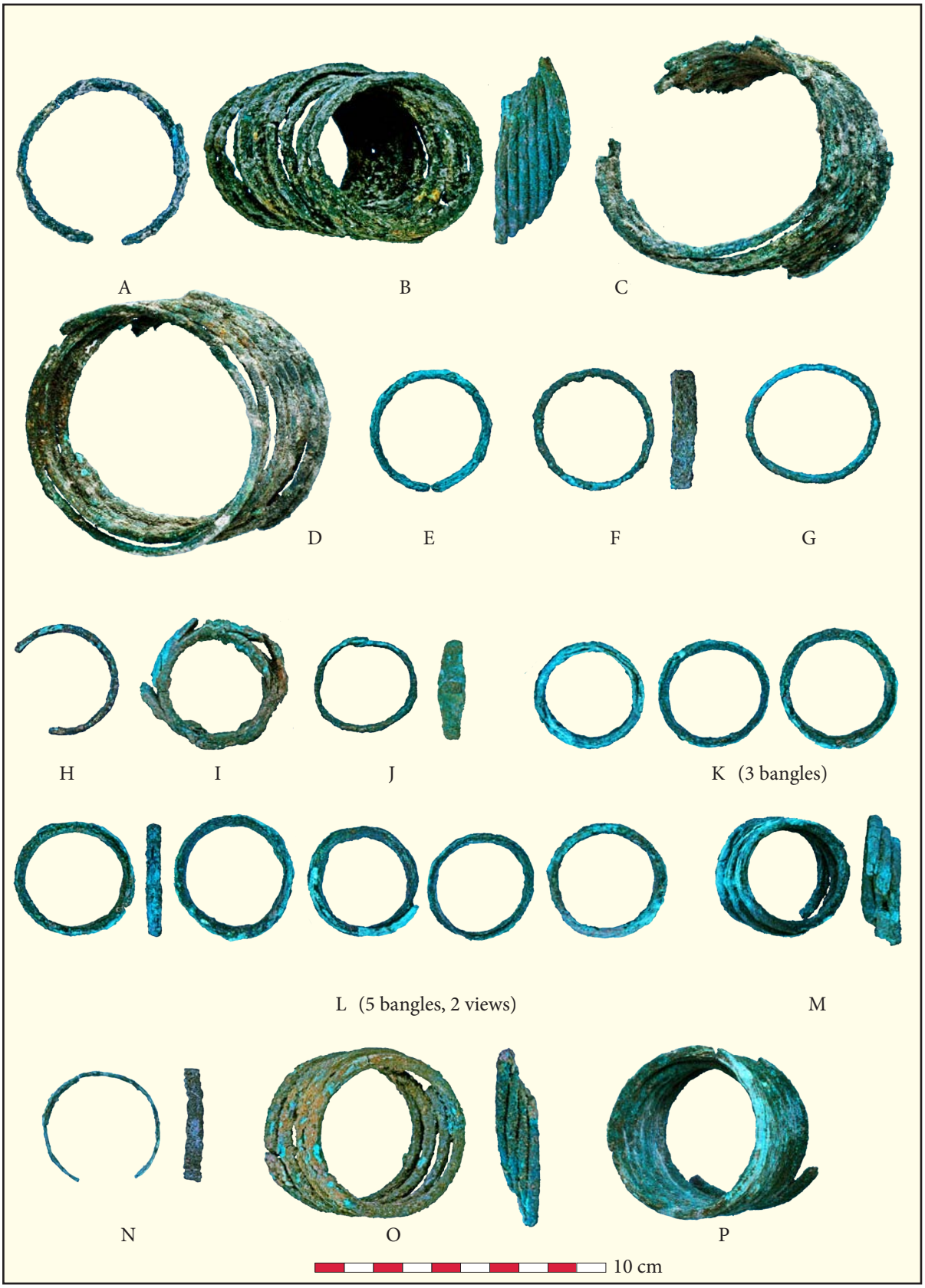
Cat.	Context	R,.H.	R.W.	I.D.	O.D.	Style	Notes
908	B. 62	5.0	4.8	57.0x68.0		10	fragments of at least 5 anklets; 2nd one is complete; all split rings; rt. ankle
		5.6	5.2	58.0x70.0		10	
		5.8	4.1	59.0x66.0		11	
		5.0	4.4	similar		11	
		5.2	4.4	similar		11	
909	B. 62	5.4	4.6	63.5x57.4	71.0x67.7	10	5 anklets, 4 remaining in a stack;
		5.3	4.2	64.0x59.0	74.0x68.4	10	dimensions given for 1st and 4th in
		6.3	5.1	similar to above		10	stack and for loose anklet (last set of dimensions); left leg
930	B. 63	5.8	2.9	34.8x42.7	40.2x48.9	11	stack of 3 anklets; complete; left
		5.9	3.6	38.3x38.6	44.8x47.9	11	ankle
		6.0	3.0	33.0x36.9	41.5x44.0	11	
931	B. 63	6.4	3.2	33.6x37.1	40.5x43.4	11	stack of 3 anklets; complete; rt.
		5.8	3.8	35.1x37.9	41.9x45.4	11	ankle
934	B. 63	6.5	3.9	28.9x30.8	37.7x38.6	11?	complete; maybe bimetallic; located left of left ankl
1152	B. 79	7.3	2.8	36.0x36.4	43.5x44.0	24	3 anklets from left leg; scalloped
		8.3	2.1	43.5x44.0	48.2x49.8	24	edges not very well defined;
		8.1	2.9	40.0x42.0		24	relatively thick metal
1153	B. 79	7.9	4.0	39.5x40.6	47.7x49.2	11	2 anklets, one complete (1st);
		8.0	2.3			11	maybe split rings; rt. ankle
1158	B. 81	7.3	1.8	36.5x39.5		11	1 circlet; left ankle
1159	B. 81	4.3-5.3	1.3	*c.* 36.0		24	prob. split ring; lightweight; right leg
1160	B. 77	6.6-8.6	1.4	*c.* 45.0		24	fragment; band starts narrow and becomes wide (dimensions given for widest part); left leg
1161	B. 77	7.9	1.7	39.6x41.1	43.0x44.5	24	at least three anklets, 1 complete
		7.5-8.5	1.6			24	(1st set of dimensions given); from
		7.1-8.8	2.1			24	area of body
1208	B. 79	6.5	1.2	*c.* 40.0		24	fragment
1210	B. 92	6.4-8.4	1.9	*c.* 50.0		24	scalloped; split ring; which ankle?; fibres attached to one fragment
1228	B. 91	5.4	5.0	*c.* 45.0			15 fragments, at least one complete
1611	B. 115	3.5	4.1	39.1x40.6		7	2 anklets; left ankle
		3.4	3.6	41.6x42.0		7	
1662	B. 80	4.4	4.3	37.8x39.7	48.7x50.5	15	9 anklets; rt. ankle; all virtually
		5.1	3.8	*c.* 38x*c.* 42		15	identical; split rings
		4.9	4.1	34.3x37.0	44.2x45.2	15	
		4.8	4.4	36.2x40.7	45.3x49.8	21	
		5.0	4.0	39.6x40.7	48.5x49.4		
		4.8	3.9	40.0x41.0		21	
		5.1	4.0	*c.* 39		15	
		4.7	4.2	*c.* 41x*c.* 35		15	
		4.4	4.2			15	
1663	B. 80	5.0	4.1	35.6x40.0	*c.* 44x*c.* 48	10/11	3 anklets; left ankle; 1st one listed
		4.9	3.7	*c.* 45		10/11	is split ring
		4.9	3.8			15	
1744	B. 120	1.9	4.8	32.1x32.1	41.5x41.7	9	3 complete anklets + frags. of 1 more, left foot, split rings
		2.1	3.9	28.1x28.2	35.7x36.8	9	
		2.3	4.0	*c.* 38.9			



21:3 Bronze bangles. A. cat. 1646 style 15/18, B. cat. 1656 style 22, C. cat. 15 Burial 1 - style 10, D. cat. 81 E. cat. 88 Burial 4 - style 22, F. cat. 137, G. cat. 138 Burial 14 style 9, H. cat. 267 Burial 30, I. cat. 472, J. cat. 472a Burial 20 style 7/8: K. cat. 326a Burial 27 style 11, L. cat. 481 Burial 27 (2 views)



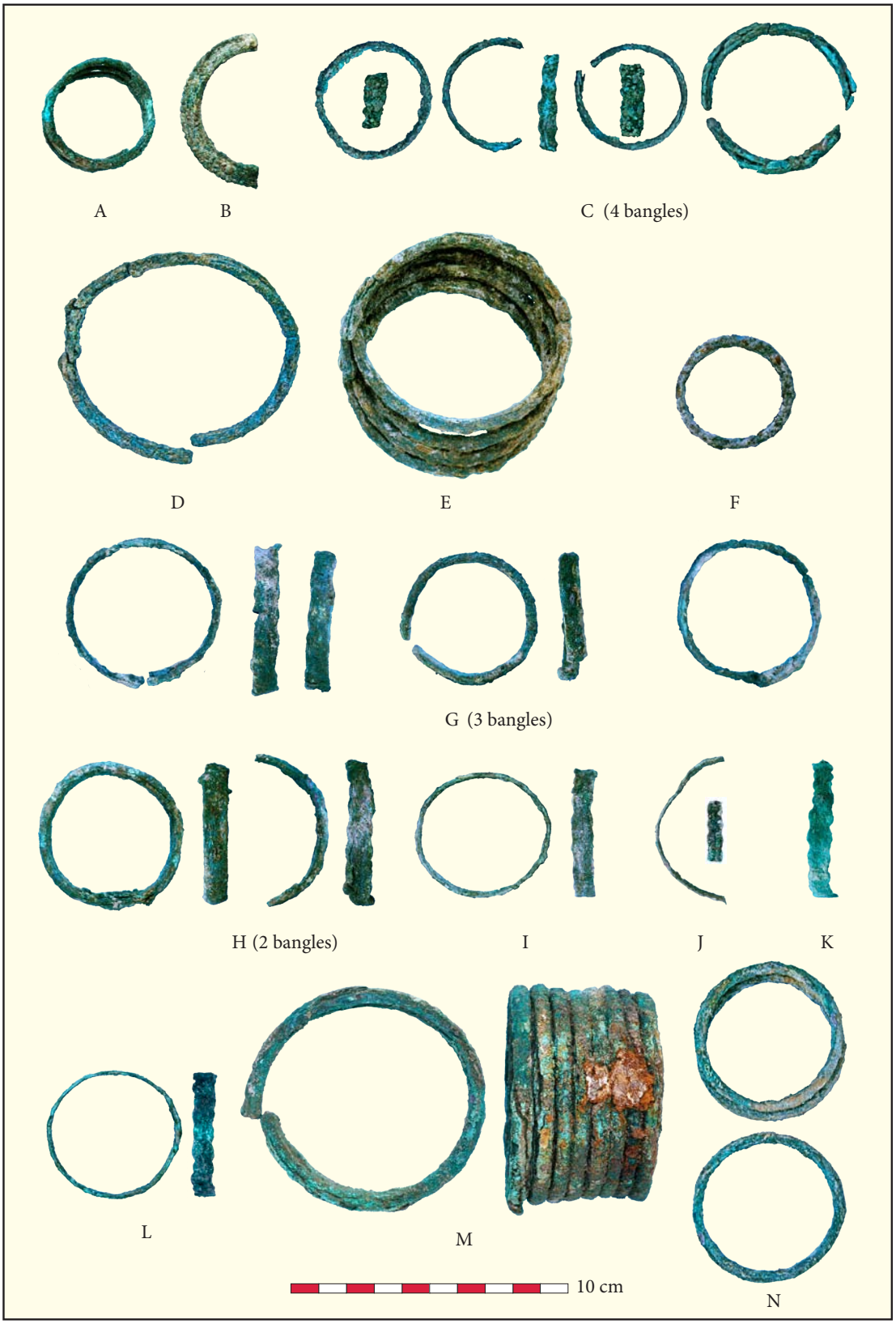
21:4 Bronze bangles. A. cat. 1657 Burial 31, style 24, B. cat. 467 Burial 32, C. cat. 560 Burial 33, style 11, D. cat. 581Burial 36, style 11, E. cat. 600 Burial 40, style 25, F. cat. 552 Burial 46, style 25, G. cat. 650 Burial 48, style 11/15, H. cat. 874 Burial 59, style 23, I. cat. 879 Burial 59, style 23, J. cat. 897 Burial 61, style 10, K. cat. 689 Burial 49, style 15, L. cat. 696 Burial 49, style 11)



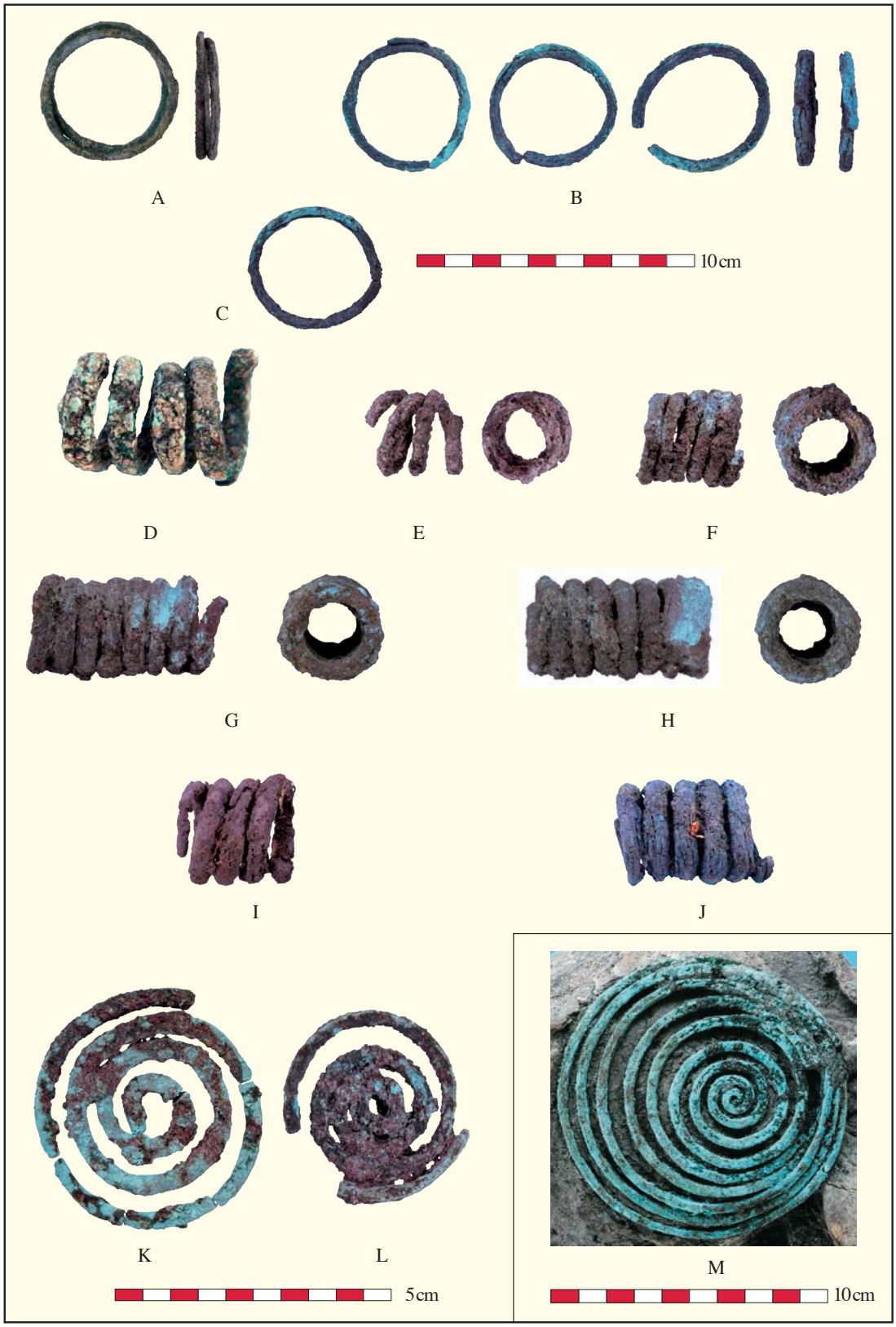
21:5 Bronze bangles. A. cat. 912 Burial 62 style 15, B. cat. 913 Burial 62, style 10, C. cat. 993 Burial 69, style 8, D. cat. 1602 Burial 69, style 10, E. cat. 1943 Burial 77, style 24, F. cat. 1147 Burial 79, style 11, G. cat. 1148 Burial 79, style 24, H. cat. 1149 Burial 79, style18, I. cat. 1150 Burial 79, style 11, J. cat. 1151 Burial 79, style 11, K. cat. 1664 Burial 80, style 11 & 15, L. cat. 1664 (continued), M. cat. 1665 Burial 80, style 10 & 15, N. cat. 1216 Burial 82, style 24, O. cat. 1222 Burial 82, style 15, P. cat. 1223 Burial 82, style 18)



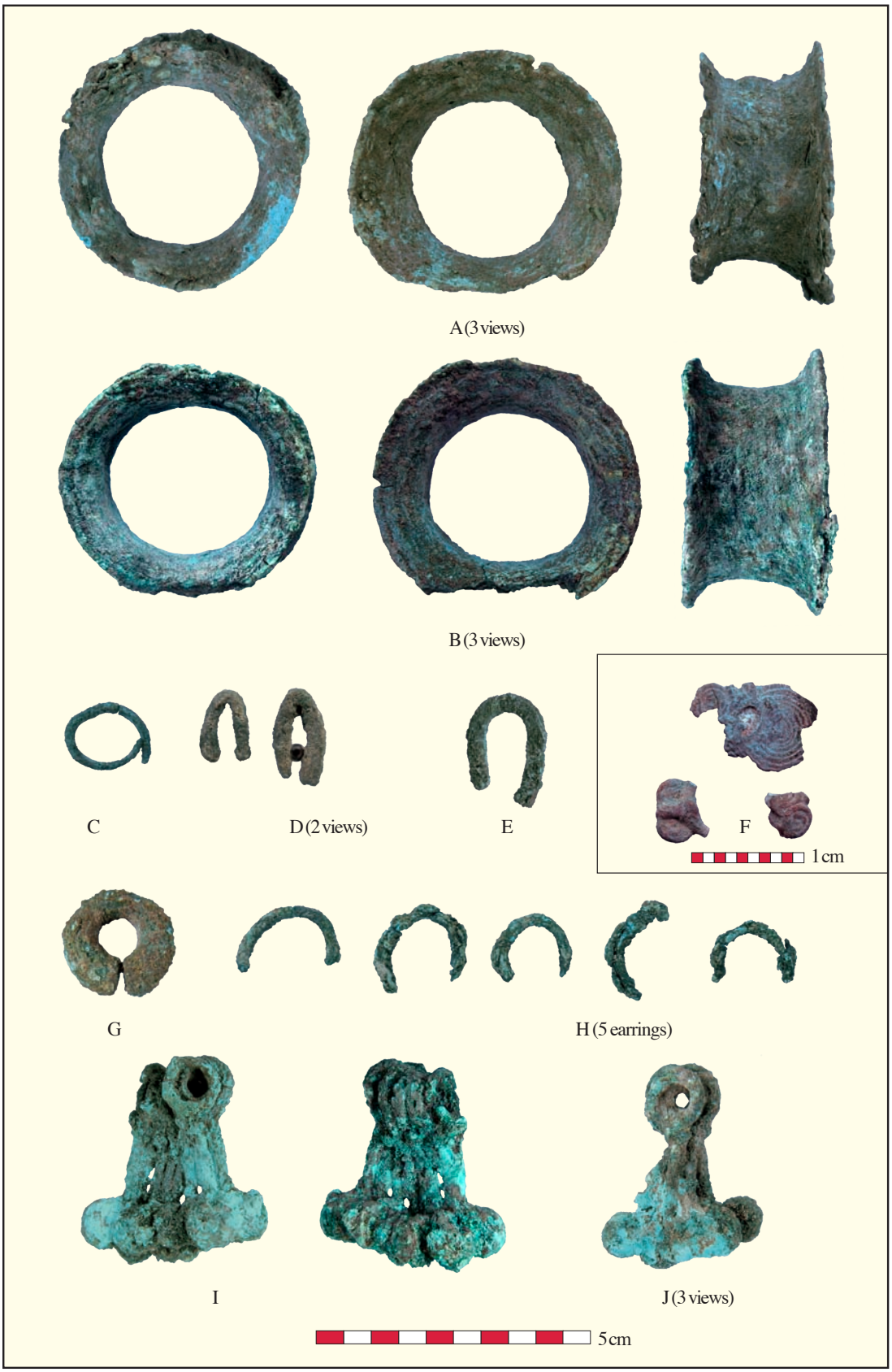
21:6 Bronze bangles. A. cat. 1227 Burial 91, style 24, B. cat. 1336 Burial 86, style 24, C. cat. 1356 Burial 98, style 18, D. cat. 1360 Burial 98, style 18, E. cat. 1682 Burial 99, style 11, F. cat. 1683 Burial 99, styles 4,7 & 11, G. cat. 1703 Burial 99, style 24, H. cat. 1469 Burial 102, style 11, I. cat. 1472 Burial 102, style 11, J. cat. 1471 Burial 109, style 5, K. cat. 1539 Burial 113, style 8/10, L. cat. 1707 Burial 113, styles 8 & 23, M. cat. 1598 Burial 115, styles 7,10,11 & 15, N. cat. 1609 Burial 115, styles 7,10,11 & 15, O. cat. 1689 Burial 118, style 10



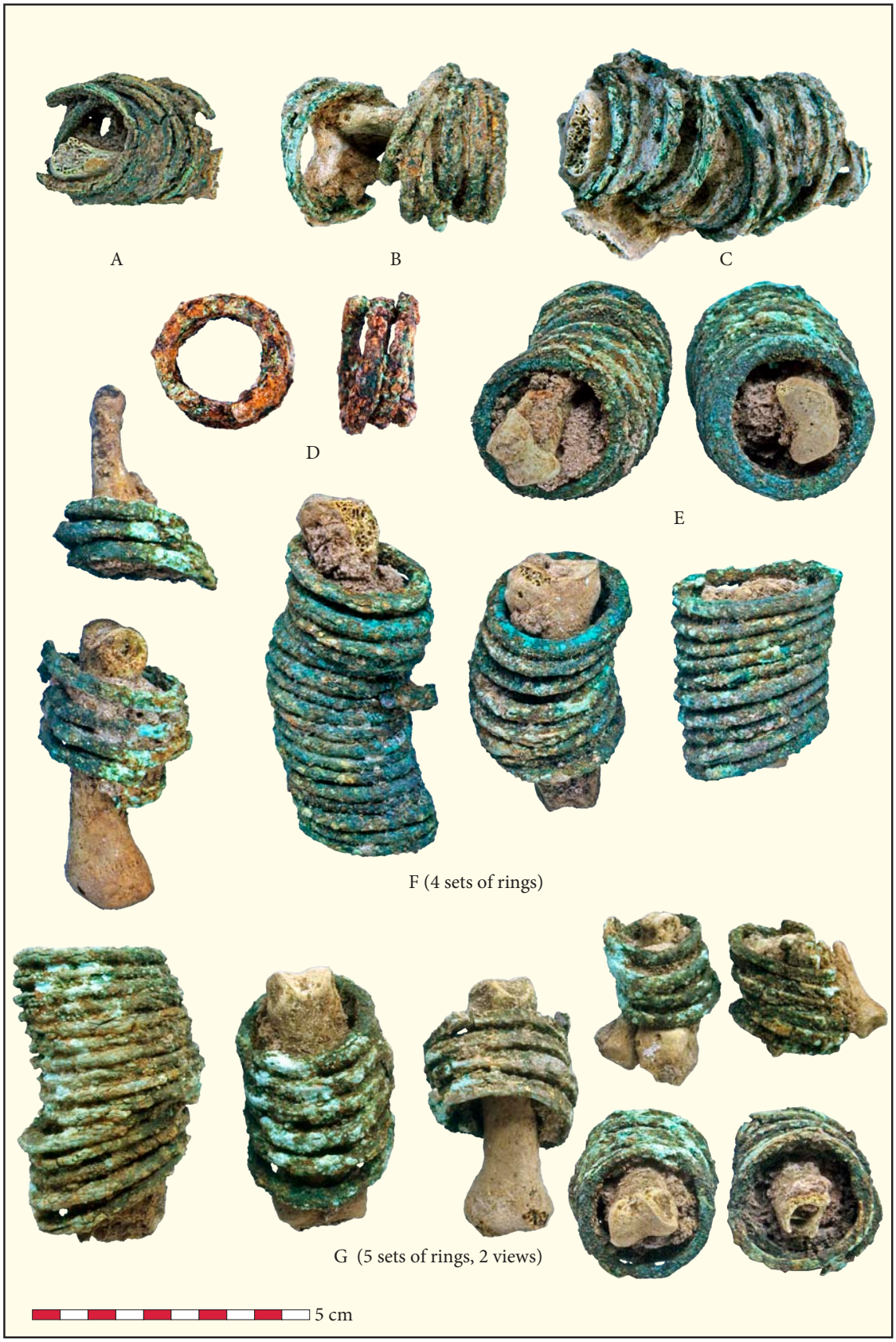
21:7 Bronze bangles and bronze anklets. Bangles: A. cat. 1740 Burial 120, style 13, B. cat. 1743 Burial 120, style 6). Anklets: C. cat. 506 Burial 25, style 10,11 & 24, D. cat. 908 Burial 62, style 10, E. cat. 909 Burial 62, style 10, F. cat. 934 Burial 63, style 11, G. cat. 1152 Burial 79, style 24, H. cat. 1153 Burial 79, style 11, I. cat. 1158 Burial 81, style 11, J. cat. 1159 Burial 81, style 24, K. cat. 1160 Burial 77, style 24, L. cat. 1161 Burial 77, style 24, M. cat. 1537 Burial 113, style 15, N. cat. 1610 Burial 115, style 7/8)



21:8 Bronze anklets, bronze and bimetallic spiral earrings and flat spiral ear ornaments. Anklets: A. cat. 1611 Burial 115, style 7, B. cat. 1662 Burial 80, C. cat. 1663 Burial 80). Spiral earrings: D. cat. 86, Burial 1, E. cat. 916, Burial 62, F. cat. 1482, Burial 78, G. cat. 1727, Burial 113, H. cat. 1728, Burial 113. Bimetallic earrings: I. cat. 291, Burial 14, J. cat. 292, Burial 14. Flat spirals: K. cat. 577, Burial 30, L. cat. 584, Burial 35, M. cat. 626, Burial 39



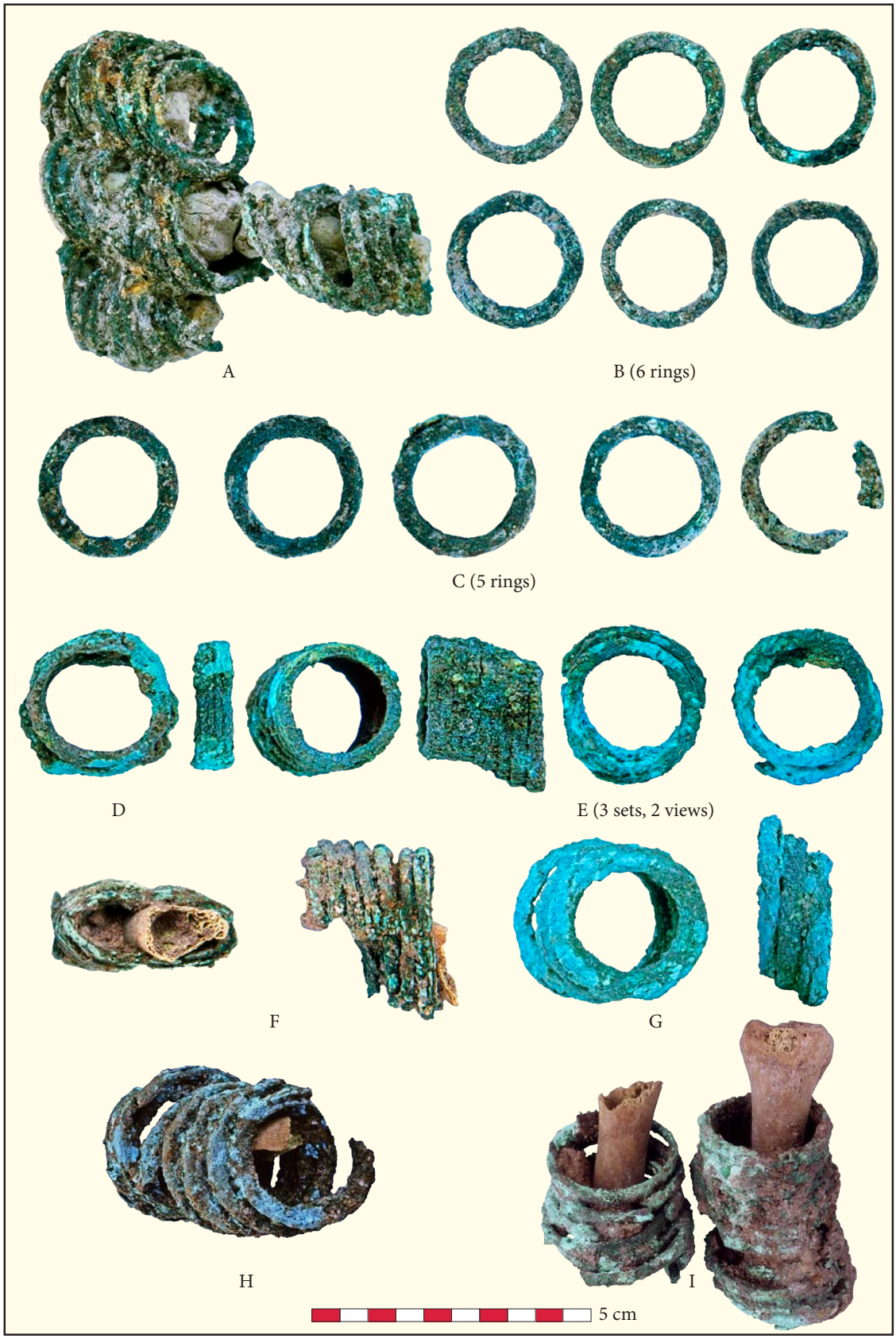
21:9 Bronze ear spools and earrings. A. cat. 1044,Burial 69 B. cat. 1045, Burial 69 C. cat. 102 D. cat. 188, Burial 9 E. cat. 1273 F. cat. 1353, Burial 98 G. cat. 1408, Burial 98 H. cat. 986, Burial 62 I. cat. 1701, Burial 99 J. cat. 1702, Burial 99



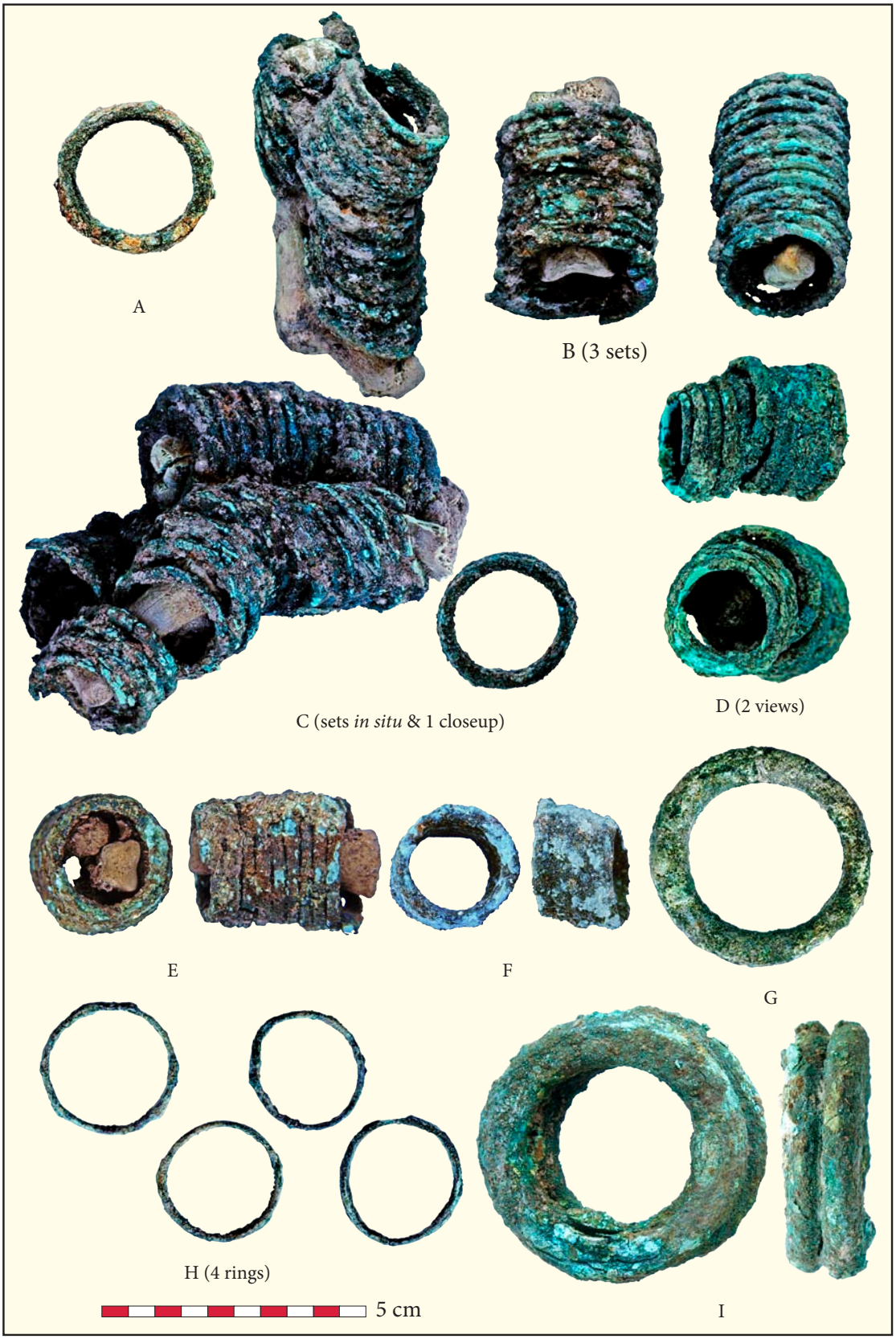
21:10 Bronze finger rings. A. cat. 75, Burial 1 B. cat. 77, Burial 1 C. cat. 90, Burial 1 D. cat. 94, E. cat. 214, Burial 14 (end view) F. cat. 214, Burial 14 (side view) G. cat. 215, Burial 14



21:11 Bronze finger rings. A. cat. 237, Burial 4 (3 rings) B. cat. 415, Burial 53 C. cat. 473, Burial 30 D. cat. 583, Burial 35 E. cat. 585, Burial 35 F. cat. 591, Burial 36 G. cat. 593, Burial 37 H. cat. 609, Burial 39 I. cat. 700, Burial 53 J. cat. 721, Burial 53



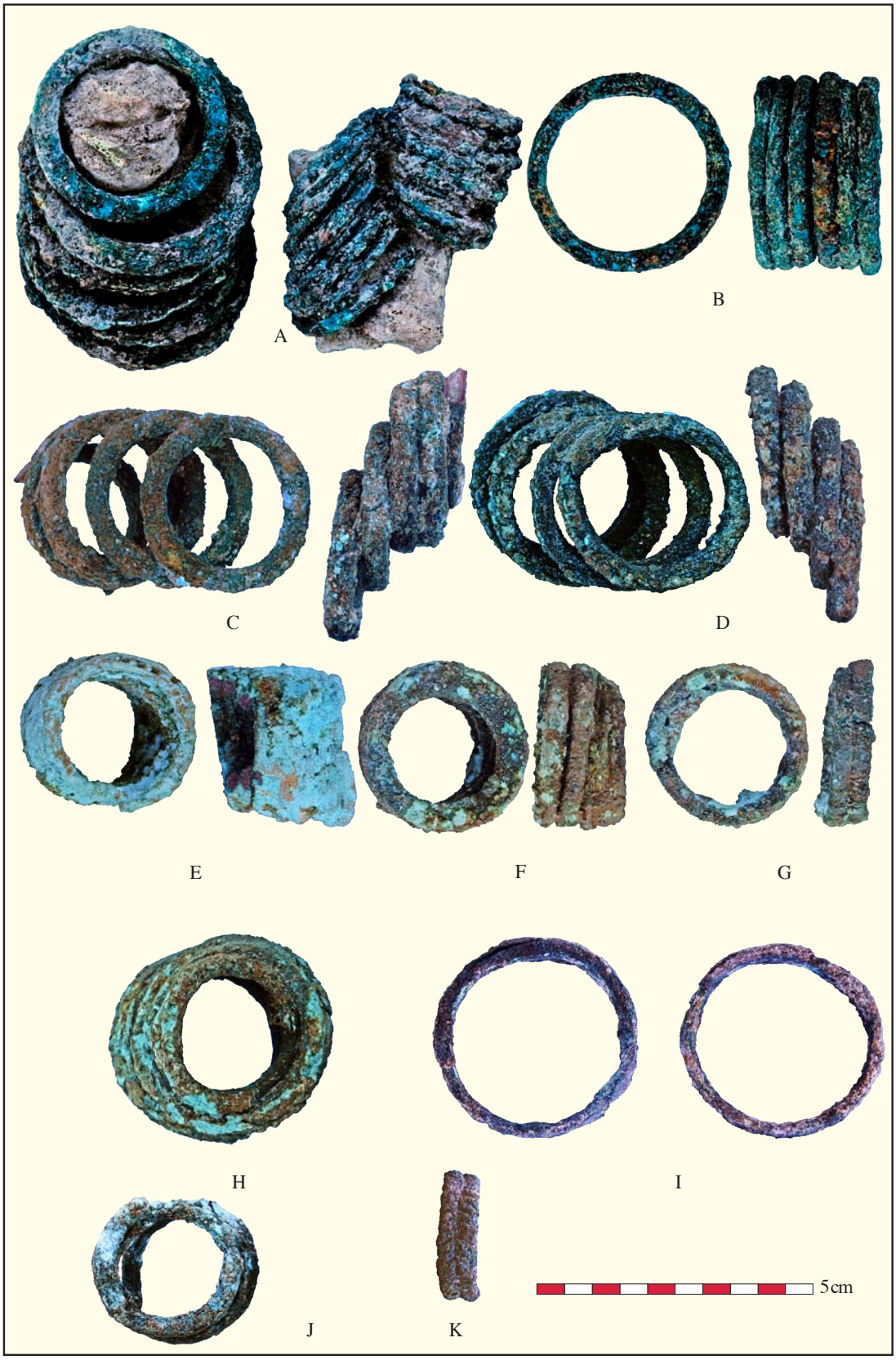
21:12 Bronze finger rings. A. cat. 910, Burial 62 B. cat. 1080, Burial 73 C. cat. 1081, Burial 73 D. cat. 1097, Burial 76 E. cat. 1098, Burial 76 F. cat. 1359, Burial 98 G. cat. 1426, Burial 94 H. cat. 1516, Burial 96 I. cat. 1538, Burial 113



21:13 Bronze finger and toe rings. Finger rings: A. cat. 1594, Burial 96 B. cat. 1603, Burial 69 C. cat. 1604, Burial 69 D. cat. 1659, Burial 31 E. cat. 1660, Burial 31 F. cat. 1690, Burial 118. Toe rings: G. cat. 160, Burial 12 H. cat. 165, Burial 12 I. cat. 210, Burial 14



21:14 Bronze toe rings. A. cat.699, Burial 53 B. cat. 545, Burial 47 C. cat. 717, Burial 54 D. cat. 1082, Burial 73 E. cat. 1166, Burial 87 F. cat. 1529, Burial 105 (large toe) G. cat. 1529, Burial 105 (smaller toe) H. cat. 1540 & 1541, Burial 113 I. cat. 1530, Burial 105 (large toe) J. cat. 1530, Burial 105 (smaller toe)



21:15 Bronze toe rings and an unidentified ring. A. cat. 1605, burial 69 B. cat. 1606, burial 69 C.– G. cat. 1691 burial 118 (5 sets) H. & I. cat. 1734, burial 82 J. cat. 1773, burial 122 K. cat. 1453

RH: 2.7 mm, RW: 2.8 mm, ID: 16.5 mm, OD: 22.2 mm.

Cat. 986, B. 62 is a set of six small U-shaped, or split ring, earrings from the left side of the cranium. They are very corroded but seem consistent is size and form. Three are described here. 1) RH: 3.1 mm, RW: 2.9 mm, ID: 9.0 mm, OD: 16.0 mm; 2) RH: 2.7 mm, RW: 2.1 mm, ID: 8.8 mm, OD: 14.7 mm; 3) RH: 2.4 mm, RW: 2.4 mm, ID: 7.8 mm, OD: 13.0 mm.

Cat. 988, B. 62 is made up of many fragmentary remains of what may be a simple split ring earring. RH: 3.1 mm, RW: 1.5 mm, ID: *c.* 20 mm, simple rectangular cross-section.

Cat. 1015, B. 71 is another simple split ring earring making a perfect pair for cat. 984 (above). RH: 2.9 mm, RW: 3.0 mm, ID: 17.2 mm, OD: 22.9 mm.

Cat. 1099, B. 76 is a ring described on the basis of location as a left earring. In other respects it is identical to the scalloped bangles common in the site, though with a small inner diameter. RH: 8.1 mm, RH in dip: 6.0 mm, RW: 2.5 mm, ID: *c.* 35 mm.

Cat. 1224, B. 82 is a fragment of bronze described, when excavated, as an earring, presumably on the basis of location. It is a strip of bronze with scalloped edges identical to the style 24 bangles. If it is indeed an earring then this is a secondary use.

Cat. 1273, C2, 4:8 feature 1 is a U-shaped strip of bronze with a rectangular cross-section. This is a relatively common form. RH: 2.8 mm, RW: 3.7 mm, overall width: 14.7 mm, overall length: 20.0 mm.

Cat. 1331, B. 86 is a one third fragment of a ring described as an earring when excavated. RH: 1.3 mm, RW: 0.8 mm, ID: *c.* 20 mm

Cat. 1353, B. 98 is the partial remains of at least three earring units similar to cats. 1701 and 1702 (below). Only the conjoined discs from the bottom of the unit remain. The decoration is the same with a raised central knob and rim on each dis*c.* Width (disc pair): 13.6 mm, height (disc): 8.9 mm, thickness: 1.7 mm.

Cat. 1375, B. 98 is a one quarter fragment of bronze described as a ring when excavated. Located at the neck, it has a sloping rectangular cross-section so that the diameter is significantly larger at one end than the other. RH: 6.5 mm, RW: 4.6 mm, thickness of bronze: 2.1 mm, ID *c.* 25 mm.

Cat. 1395, B. 98 is the fragmentary remains of a set of six U-shaped earrings. They appear to be identical though in very poor condition. Diameter of wire: 2.1 mm x 2.5 mm, length: *c.* 11.5 mm.

Cat. 1408, B. 98 is a complete bronze artefact that, while it was located near the left hand, and was described as an earring when excavated, can only be an earring. It is a heavy split ring with a generally D-shaped cross-section that becomes larger near the ends. It is a form that is common, in many materials throughout prehistoric Thailand. RH (opposite split): 5.2 mm, RW (opposite split): 4.8 mm, RH (adjacent to split): 7.6 mm, RW (adjacent to split): 7.4 mm, ID: 7.0 mm, OD: 19.5 mm x 20.5 mm.

Cat. 1521, B. 96 is a simple bronze ring which, by virtue of its location at the left ear, is designated as an earring. It is not a split ring so its use must remain debatable. Circular cross-section. RH: 2.9 mm, RW: 2.6 mm, ID: 16.6x17.4 mm, OD: 22.3x22.9 mm.

Cat. 1562, B. 96 is a short, narrow, bronze spiral. It resembles a belt clasp but the 'wire' is heavier and the inner diameter is smaller. Described when excavated as a right earring. ID: 2.8 mm, OD: 9.2 mm x 9.8 mm, length: 17.4 mm.

Cat. 1613, B. 115 is described as an earring from the left ear of this individual. It appears to be a simple ring but is not complete. RH: 2.5 mm, RW: 1.4 mm, ID: *c.* 19 mm.

Cat. 1701, B.99 matches cat. 1702 (see description below). It is located on the left side of the head. It is made up of eight units of identical form to cat. 1702. Overall length: 36.5 mm, ID (eyelet): 5.9 mm, OD (eyelet): 11.2 mm, diameter (rod): 2.2 mm.

Cat. 1702, B. 99 is an ear ornament made up of eight units located on the right side of the head. Each unit comprises a bronze rod, formed into a circular eyelet at one end, and with two conjoining discs at the opposite end. The discs lie in the same plane as the eyelet and each is moulded so that a small knob rises in the centre, is circled by a depression, and the outside edge is again raised. This set is better preserved than cat. 1701 (above) and provides a guide to the detail of that matching set. All the units are corroded together and lie parallel. This suggests that the set was hung by a cord threaded through the eyelet and then through the ear. Overall length: 37.4 mm, ID (eyelet): 6.4 mm, OD (eyelet): 10.7 mm, diameter (rod): 2.1 mm, diameter (disc) 9.6 mm.

Cat. 1764a, B. 122 is a half fragment of a bronze ring. It is probably a split ring and therefore an earring. RH: 3.6 mm, RW: 3.3 mm, ID: *c.* 20 mm. See also cat. 1764b (bangles).

Bronze finger rings

These are probably the most numerous ornaments considered in this report, with multiple rings on the fingers of each hand not uncommon. The vast majority are very simple rings with a band-like form. The most common departure is when the effect of multiple rings is produced by coiling a single length of bronze wire into a long spiral. Three rings stand out (cat 237, B. 4) because of a signet-like decoration. On one is a spiral motif and on another a diamond motif is used.

Bronze toe rings

Many toe rings are similar in form to the finger rings discussed above. However, as the big toe is so much larger than either the other toes or, the fingers, rings for the big toe are noticeably larger and, usually, heavier. Once again, sets of rings are not uncommon and spiral forms, imitating multiple individual rings, are also present.

Unidentified bronze rings

Many small rings; toe rings, finger rings and possibly earrings, are found loose in the substrate or in the general area of a burial and so cannot be assigned a particular use. Often these are fragments only.

Bronze bells

There appear to be two main forms of bell at this site. The most common is spherical with a slit at the bottom and an eyelet attached to the top. A pea is enclosed inside the sphere. There is some variation in size and level of decoration but they are all essentially very similar. Cat. 587 has the clearest decoration remaining. One face has broken away but the other has a spiral beginning in the centre of the face that uncoils to cover the whole half of the bell. The small cap is a spiral or concentric circles, and the eyelet is also in the form of a spiral or stacked wheels.

Cat. 331 represents a different type of bell which is long and cone shaped. It is significantly larger than the spherical examples and presumably had a clapper inside but no trace remains. The main body of bell is up to 5.6 mm thick. It is interesting that the eyelet attached to the top and the thicker, textured, cap around the upper third of the bell are similar to the decorative elements common on the spherical bells. The projecting eyelet is decorated with a spiral or stacked-wheel cast pattern and the cap has many parallel incised horizontal lines running around it.

Other bronze artefacts

Cat. 1427, A3, 4:1 is a possible bangle fragment with a D-shaped cross-section. RH: 3.5 mm, RW: 3.8 mm.

Cat. 380, A1, 4:11 is a small fragment of bronze, curved in two planes and with a rim along the one original edge. Length (rim): 9.8 mm, thickness: 2.2 mm, thickness (rim): 3.5 mm.

Cat. 383, B2, 4:4 is a long, narrow pendant with an eyelet at the top and with the diameter becoming slightly larger towards the bottom. Length: 33.3 mm, diameter (base): 6.8 mm x 7.4 mm, eyelet diameter: 7.6 mm, eyelet thickness: 3.4 mm, perforation: 2.0 mm.

Cat. 469, A2, 4:10 is a small fragment of bronze that is half of a small catch or hinge. Although not exactly the same dimensions it is of a form that would complement cat. 573 (below) or a similar artifact. It is the end of a simple band with an eyelet projecting vertically from the centre of the end. Width: 8.6 mm, thickness: 3.5 mm.

Cat. 573, B1, 4:10 at first sight appeared to be a fragment of a simple bangle. However, cleaning revealed that it was a finely worked catch or hinge. A curved band, one end has been divided in three with the central portion removed and the two outer strips rolled back on themselves, on the outside of the curve, to form two parallel eyelets. Width: 7.7 mm, thickness: 3.2 mm, length: 22.5 mm, diameter of eyelet: 5.1 mm, perforation: 1.6 mm.

Cat. 653, B2, L4:8 is a circular tab made up of bronze wire coiled into a tight spiral. It is not apparent whether or not this was part of a larger artefact. Maximum diameter: 11.6 mm, R.H. of wire (thickness of tab): 1.7 mm, R.W. of wire: 2.1 mm.

Cat. 732, B2, 4:11 fea.6 is a band or tube of bronze. It is long relative to its diameter. The thin wall is curved on its inner surface so that it is thicker mid-way along its length than at the ends. Only fragments are present. R.H./length: 23.2 mm, max. R.W. : 3.2 mm, I.D.: *c.* 20 mm

Cat. 766, B2, L4:1 is a fragment of bronze that may be from a bangle or a pot. It is curved as if from a pot and the remaining edge appears to form a rounded projecting rim. R.H.: 12.8 mm, R.W.: 6.6 mm, thickness: *c.* 3.0 mm, rim height: 3.6 mm, rim width: 4.4 mm.

Cat. 1130b, B. 86 is a fragment of bronze that may be part of a bangle or a pot. It has a comma shaped cross-section and curves longitudinally. RH: 16 mm, RW: 5.1 mm.

Cat. 1202, C1, 4:6 is a fragment of bronze rod with a triangular cross-section. Possibly a fragment of bangle or ring. RH: 2.8 mm, RW: 3.2 mm.

Cat. 1265, C2, 4:8 F.1 is a linear tab of bronze with a notch near one end. Length: 65.4 mm, width: 12.7 mm, thickness: 6.3 mm.

Cat. 1298, X1, 2:4 is an elongated pendulum shaped bronze fragment. It has a sub-circular cross-section and may be a point. Diameter (near thicker end): 4.0 mm x 4.8 mm, length: 31 mm.

Cat. 1553, C2, 5:2 is a regular, wedge-shaped, bronze block broken at one end. It may be a bronze axe or adze or may be a plug for creating a socket when casting an iron axe. It has a generally oval cross-section with sharper edges along the sides and down the middle of one face. Length: 30.0 mm, width: 28.0 mm, thickness: 13.6 mm.

Cat. 1592, C1, 4:13 is a curved fragment of bronze sheet with a deep rectangular notch cut in one edge. It is broken along the edge furtherest from the notch. Length: 29.2 mm, width: 23.8 mm, thickness: 2.1 mm, width of notch: 5.9 mm.

Cat. 1677, A2/A3, 5:1 is a very straight fragment of bronze rod with a D-shaped cross-section. RH: 4.0 mm, RW: 3.0 mm.

Cat. 1736, B2/B3, 4:15 is a fragment of bronze rod that may be a straightened bangle fragment. RH: 4.1 mm, RW: 2.8 mm, length: 23.9 mm.

Cat. 1738, B1/C1, 4:12 is a long hollow point with a circular cross-section. Length: 43.5 mm, diameter (large end): 11.6 mm x 11.9 mm, ID (large end): 6.0 mm.

Cat. 1843, B3 4:11 is the head of a rounded bronze arrowhead or chisel similar to examples found at Nong Nor and Non Pa Wai but the socket (if it was present) broken off. Length: 34.6 mm, width: 31.6 mm, thickness: 3.4 mm.

Bronze fragments

TABLE 21:9 *Spiral Earrings*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Length	Notes
86	B.1	4.7	4.3	15.5x12.0	*c.* 26.0	*c.* 30.1	rt. ear; heavy wire
94	B.1	3.4	3.6	14.7x14.1	*c.* 23.6	13.6	left ear; lots of iron rust associated - maybe clad in iron?
291	B.14	3.7	3.7	19.8x21.8			purple metal; gold foil present between spirals - originally clad whole wire ?; right ear
292	B. 14	4.4	5.0	11.8	20.7	28.8	same description as cat. 291; noticibly thicker wire; left ear
501	B. 25	3.2	2.2	18.8x24.0			1.5 turns only
505	B. 25	3.3	2.4	17.0x22.5			fragments of spiral ring; same artefact as 501 (above)?
916	B. 62	2.4	2.3	*c.* 16	19.8		1 earring; both ends broken off this loosely wound spiral; *c.* 2.25 turns
1482	B. 78			10.5x10.9	21.7	23.1	6 turns
1727	B. 113		3.3	10.9x19.3	38.0		at least 7 turns
1728	B. 113	4.2	3.9	18.5x19.2	34.5		rt. ear; 7.5 turns; very thick bronze
2001b	B. 81	3.4	2.6	7.2 19.0x19.0		7.4	2 small, & short, spirals; 1st may be
		3.2	2.8	7.6 14.0x14.0		6.3	complete (*c.* 1.75 turns); 2nd broken; see also 2001a (bangle)

Bronze is often found in small fragments or as unidentifiable lumps or other shapes. Some of these may be artefacts with a particular use while many are probably discarded manufacturing by-products.

Bimetallic rings

Although common, it is difficult to reconstruct the manner in which bimetallic rings were worn. Made with a core of bronze and iron cladding these peculiar artefacts often occur in pairs located near the shoulder, though it is not unusual for them to be found elsewhere. They are too small for bangles, too large for finger or toe rings and are not split in order to be worn as earrings. The simplest explanation is that they were used as some type of fastening device for clothing. It is important to note that I do not know if all these artefacts do indeed have a core of bronze. However, they are similar enough in size and form to be grouped together. Often, even on complete examples, the bronze shows through the corroded iron.

IRON, LEAD, GOLD AND SILVER ARTEFACTS

Two finds of iron bangles and a single find of iron necklets (torcs) have been made. These are particularly interesting as, generally in this site, iron has been used for tools and weapons while bronze has been used for jewellery.

Cat. 872, B3 3:6 resembles two bimetallic rings in a stack but with a solid bottom across one end. I have not been able to determine if the 'bottom' is original or a product of corrosion of the iron 'rings'. Length: 28.7 mm, diameter: 44.8 mm x 47.3 mm. If these are indeed rings the ring furtherest from the 'bottom' measures - RH: 9.0 mm, RW: 8.1 mm.

Cat. 1392, X1, 3:8 feature 1 is a heavy iron ring with a roughly circular cross-section. The level of corrosion makes it difficult to determine features but it is most likely a split ring earring with the radial dimensions larger adjacent to the split than elsewhere. Corrosion has also inflated the dimensions recorded here. RH: 13.7 mm, RW: 12.5 mm, ID: 6.4 mm, OD: 24.4 mm x 24.9 mm.

Cat. 1718, B. 108 is a single iron tor*c.* It is heavily corroded so it is impossible to tell if it was decorated or not. It is very close to a perfect circle in shape and there is no sign of decoration at the ends. RH: 10.8 mm, RW: 11.4 mm, ID: 91 x 97 mm, OD: 122 x 125 mm.

Cat. 1719, B. 108 is the heavily corroded remains of either two separate iron bangles or a single larger artefact. The former is more likely; the artefacts were worn on the left wrist. Bangle 1 - RH: 19.2 mm, RW: 8.3 mm, ID: *c.* 50 mm, style 15. Bangle 2 - RH: 13.3 mm, RW: 5.3 mm, ID: *c.* 50 mm, style 15.

Cat. 1720, B. 108, located on the right arm, is a pair of iron bangles complementing those found on the left arm (cat. 1719). These are split rings. Bangle 1 - RH: 12.6 mm, RW: 4.0 mm, ID: *c.* 60 mm, style 11/15. Bangle 2 - RH: 12.8 mm, RW: 4.4 mm, ID: *c.* 60 mm, style 15.

Lead

Cat. 852, C3 3:1 is a single lead pellet with a diameter of 16.8 mm.

Silver

Cat. 832, C1, 2:3 is a three quarter fragment of a simple silver ring. It has a carination running around the centre of the outside edge. RH: 3.0 mm, RW: 2.1 mm, ID: 16.3 mm.

Cat. 942, B. 59 is a small silver U-shaped earring. RH:

3.5 mm, RW: 3.3 mm, length: 13.9 mm, width: 10.5 mm, ID (width): 4.0 mm.

Cat. 1541, B. 113 is a silver toe ring associated in a stack with four bronze toe rings (see above). RH: 2.3 mm, RW: 1.7 mm, ID: 17 mm, OD: 20 mm.

Cat. 1706, B. 113 is a simple silver finger ring associated in a stack with at least four bronze rings. RH: 3.9 mm, RW: 2.4 mm, ID: 15.8x16.5 mm, OD: 20.9x21.7 mm.

Gold

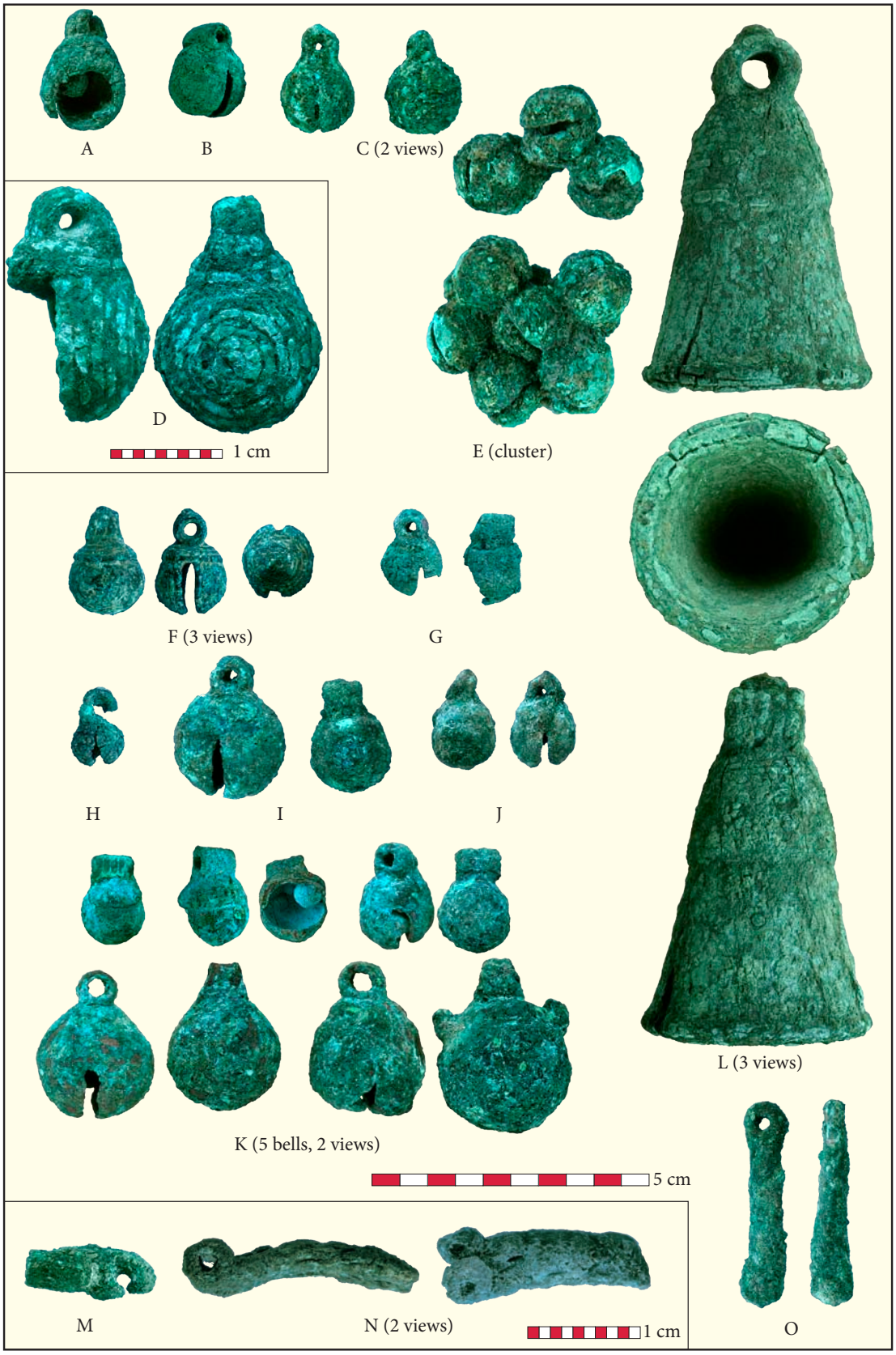
There have been two finds of gold beads. While the two finds are distinct, form and size are remarkably consistent within each set. One set of beads are spherical and the other bi-pyramidal in shape. In both cases the beads were made by encasing a fired clay core within thin sheet gold.

Cat. 965, B. 68 is a necklace of 39 gold beads. Each bead has a roughly circular cross-section but is flattened at the ends and was made by wrapping gold foil or sheet around a clay core. This gold may be alloyed with silver, or some other metal, as it is not as yellow as cat. 1710 (below) or the gold wrapping around the silver spiral earrings (cat.'s 291 and 292 above). The beads are similar in size and shape except for one larger bead on which the free edge of the gold wrapping is obvious. Bead 1) length: 2.8 mm, diameter: 4.1x4.3 mm, perforation: 2.3 mm; bead 2) length: 3.1 mm, diameter: 4.4x4.5 mm, perforation: 2.3 mm; bead 3) length: 3.1 mm, diameter: 4.2x4.4 mm, perforation: 2.0 mm; bead 4) length: 2.9 mm, diameter: 4.5x4.6 mm, perforation: 2.3 mm: bead 5) length: 3.1 mm, diameter: 4.7x4.9 mm, perforation: 2.3 mm; bead 6) (larger bead): length: 5.0 mm, diameter: 6.4x6.9 mm, perforation: 4.1 mm.

Cat. 1710, B. 113 is a necklace of 64 virtually identical gold beads. Each is a bi-pyramid with flattened apices through which the bead is pierced. These beads are also made by wrapping gold foil or sheet around a clay core. The gold is particularly yellow, perhaps indicating few impurities. Bead 1) length: 3.5 mm, width 1: 4.0 mm, width 2: 4.0 mm, width of apex: 1.4 mm, perforation diameter: 0.4 mm; bead 2) length: 3.3 mm, width 1: 3.8 mm, width 2: 3.8 mm, width of apex: 2.1 mm, perforation diameter: 0.4 mm.

CONCLUSION

As noted in the introduction this is not a complete report on the personal ornaments of Noen-U-Loke. Quite apart from the fact that other workers are responsible for the glass and semi-precious stone ornaments, what is reported here is very much work in progress and no hypotheses, conclusions or data should be quoted or used elsewhere. With this important caveat in mind, I hope that I have been able to convey an impression of the variety of personal ornaments recovered from this site and their potential value as tools with which to inquire into the development and nature of trade, technology and social structure of the Iron Age in Northeast Thailand.



21:16 Bronze bells and other bronze artefacts. Bells: A. cat. 176 B. cat. 288 C. cat. 716, Burial 54 D. cat. 587 E. cat. 716, Burial 54 (cluster) F. cat. 851 G. cat. 935 H. cat. 1170 I. cat. 1480, Burial 96 J. cat. 1755, Burial 120 K. cat. 1758, Burial 124 L. cat. 331 Bronze hinges/catches: M. cat. 469 N. cat. 573 Bronze pendant: O. cat. 383



21:17 Bronze, iron and lead artefacts. Bronze: A. cat. 653, B. cat. 1122, C. cat. 1592, D. cat. 1738, E. cat. ?? Bimetallic rings: F. cat. 95, G. cat. 186, H. cat. 982, I. cat. 1392 Lead: J. cat. 852 Silver: K. cat. 942 Bimetallic rings: L. cat. 91, M. cat. 93 Iron bangles: N. cat. 1719, O. cat. 1720 Iron torc: P. cat. 1718

TABLE 21:10 *Bronze Finger Rings*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
?	B. 1	2.5	1.2				fragment of 1 ring; rt. hand
?	B. 59	3.5	1.7	*c.* 18		11	fragments of at least 3 rings; variation in RH in one fragment between: 3.1-4.2mm
?	B. 104	2.7	1.4	*c.* 16		13	fragments of at least 1 spiral ring
?	B. 111	2.3-3.3	2.5-2.8	16.5		7-15	3/4 ring found under pot; interesting as illustrates variety of x-section around circumference
75	B. 1	2.4	1.4	16.4x19.4	19.9x23.4	11	7 rings in a stack; 5th finger; which hand?
76	B. 1	2.6	1.9	18.3x19.8	21.1x23.2	11	10 rings in two stacks of 5 each; 2nd and 3rd fingers; which hand?
77	B. 1	2.8	1.9	18.2x19.7 21	20.9x23.3	11	7 rings in a stack; 4th finger, lft. hand; all similar size
78	B. 1	2.4	1.8	*c.* 20.0		15	1/2 only; rt. hand
89	B. 1	2.5	1.7	*c.* 25.0		?	fragments of at least two rings, right hand
		3.0	1.5			?	
90	B. 1	3.0	1.9	18.1x18.8	21.5x23.4	11	20 complete rings in a stack; 4th finger, rt. hand, all similar dimensions
92	B. 1?	2.7	1.6	*c.* 20.0		11?	fragments of at least 2 rings; rt. thumb
		3.3	1.7	*c.* 25.0		11?	
157	B. 10	2.1	2.0	15.2x16.0	19.6x20.7	18	at least 6 rings; 2 of form 18; at least 4 of form 11, right hand
		3.6	1.5			11	4 of form 11; rt. hand
158	B. 10	3.6	2.0	*c.* 20.0		11?	at least 3 rings; left hand
		3.5	2.0	*c.* 20.0		11?	
		3.4	1.8				
214a	B. 14	2.5	3.5	17.3x18.2	25.0x25.0	8	at least 17 rings; left hand, finger 1; grade in size from large to small
		2.8	3.8	16.0x16.4	23.6x23.9	8	grade in size from large to small
214b	B. 14	2.8	2.9	21.1x21.3	27.3x27.7	8	at least 9 rings; left hand, finger 2; grade in size from large to small
		2.9	3.5	18.7x19.1	25.9x26.6	8	grade in size from large to small
214c	B. 14	2.3	3.1	18.3x18.7	24.8x25.0	8	at least 8 rings; left hand, finger 3
		2.0	3.3	17.0x17.4	24.1x24.3	8	
214d	B. 14	3.0	2.2	18.8x19.3	23.8x25.5 13		at least 1 spiral; 2 fragments, 5 & 3 turns respectively; left hand
		3.0	1.8	17.1x19.8	23.0x24.0	13	
214e	B. 14	2.1	3.1	22.2x22.3	28.4x28.8	8	11 other rings disassociated from original stacks, left hand
215a	B. 14	2.8	3.6	18.1x18.2	25.3x25.7	8	stack of at least 15 rings; rt. hand,

TABLE 21:10 *Bronze finger rings* (cont.)

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
		2.8	3.0	20.8x21.8	27.8x29.3	8	finger 1; also at least 1 more ring loose
215b	B. 14	3.7	2.7	15.0x16.5	19.7x21.8 13	13	4 spiral rings; at least 4, 7, 4 & 4 turns respectively;
		3.6	2.2	19.2x21.6	24.9x26.5 13	13	rt. hand
		3.0	2.2	18.5x18.6	23.8x24.8	13	
		3.0	2.6	16.4x20.8	23.5x25.8		
237	B. 4	2.5	2.0	13.8x15.5	20.0x20.1	signet /18	diamond shaped signet with cast
		2.1	1.8			signet /18	circular signet with cast pattern of 2
		2.2	1.8			signet /18	circular signet; pattern not clear, maybe spirals again; sig. dia.:7.6 mm. All three rings on the same finger of the left hand
326b	B. 20	2.2	2.9	*c.* 20		7	at least 1 ring; see also 326a (bangles)
415??	B. 53	5.1	1.8	21.4x22.1	25.5x26.3	11	2 complete rings; rt. hand
		4.8	2.6	19.3x20.4	26.0x26.8 11		
473	B. 30	2.5	1.8	18.4x19.8	22.7x23.0		10 rings; left hand
583	B. 35	4.1	2.0	16.3x16.9 20.5x21.2			11 rings, 9 similar to the 1st given here, last 2 different
		8.0	3.5	18.1x18.6			
		6.2	3.2	14.8x15.1	21.2x22.0		
585	B. 35	4.1	2.3	17.2x20.2	23.1x25.3		5 rings; all similar dimensions
591	B. 36	8.0	2.6	15.0x15.3	20.3x21.1	11	3 complete rings; left hand
		9.7	2.9	14.0	19.0x21.0	11	
		8.2	2.0	15.1	20.3x20.6	11	
593	B. 37	10.5	2.9	16.0x16.5	21.8x22.0	11	4 wide rings; rt. hand
		9.2	2.2	16.8x17.5	21.7x23.2	11	
		10.3	1.9	15.8x16.0	20.6x21.0	11	
		9.1	2.7	14.3x14.4	19.0x19.2	11	
609	B. 39	3.3	2.6	14.6x16.3	19.4x21.0	11	4 rings; all similar dimensions; left
611	B. 39	4.0	2.4	*c.* 20			1 ring; rt. hand
700	B. 53	5.3	2.4	19.3x21.2	25.0x26.9	11	1 complete ring; fragments of 2 more; left hand
		4.8	1.8			11	
		4.3	2.4			11	
721	B. 53	5.0	1.6	18.5x19.6	22.3x23.8	11	4 rings in a stack; rt. hand
		5.2				11	
		4.6				11	
		4.8	1.7	20.2x21.5	24.1x25.4	11	
875	B. 59	2.8	1.2	*c.* 20		11	fragments of at least 3 rings; rt.hand
		3.4	1.0	*c.* 23		11	
		3.9	1.5	*c.* 18		11	

TABLE 21:10 *Bronze finger rings* (cont.)

Cat.		Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
896	B. 61	2.8	1.2	*c.* 19		15		fragments of 2 rings; rt. hand
		2.4	1.8	*c.* 20		15		
907	B. 59	3.4	1.4	*c.* 18				at least 4 rings; left hand
910a	B. 62	2.8	2.3	*c.* 23		11		at least 10 rings; left hand, finger 1
910b	B. 62	2.2	2.0	*c.* 19	*c* .23	15		at least 9 rings; left hand, finger 2
910c	B. 62	3.1	2.4	17.1x17.6	22.7x23.0	15		at least 6 rings; left hand, finger 3
		2.4	1.8	16.7x17.4	20.0x21.5	15		1st & 6th given here
910d	B. 62	2.4	2.0	*c.* 18		11/15		at least 3 rings; left hand, finger 4
910e	B. 62	3.2	2.7	16.0x17.0	21.1x22.9	15		at least 8 rings; left hand, finger 5
		2.8	2.1	*c.* 18		15		(may be part of another finger
911	B. 62	2.8	2.2	*c.* 23		11		at least 28 rings on 3 fingers (5, 13 &
		2.6	1.6	*c.* 19				10); rt. hand; difficult to get at to count
		3.4	2.2	*c.* 18				hand?
		2.6	1.9	*c.* 18		11		
1031d	B. 67	2.4	1.7	*c.* 15		11		1 ring fragments; see also 1031c
1080	B. 73	2.9	3.3	16.3x16.5	23.1x23.3	7		at least 9 rings, 6 complete; left
		2.5	3.3	15.5x16.6	23.0x23.2	7		hand;
		2.7	3.0	16.9x17.4	22.6x23.8	7		
		2.8	3.3	16.3x16.7	23.0x23.0	7		
		2.4	2.9	16.0x16.5	22.0x22.0	7/18		
		2.6	3.0	*c.* 16.5		3		
		2.6	3.0	*c.* 18		7		
		2.7	2.9	16.5x16.7	21.9x22.4	7		
1081	B. 73	2.5	3.5	17.2x17.5	24.0x24.2	4		at least 6 rings; rt. hand
		2.1	3.5	16.4x16.8	23.7x24.4	4/7		
		2.4	3.5	16.2x17.3	23.8x24.4	7		
		2.4	3.0	16.9x17.5	23.2x23.6	7		
		1.9	3.0	17.0x17.2	24.3x24.3	4/7		
		2.5	2.9	*c.* 17		7		
1097	B. 76	5.2	1.9	17.4x18.5	22.1x24.2	11		3 complete finger rings; rt. hand; at
		7.2	2.7	16.5x19.1	23.1x24.1	11		least 1 (prob. all) decorated with 3
		6.8	2.4	17.7x19.0	23.0x24.1	11		parallel incised lines around outside surface
1098	B. 76	2.0	1.8	16.2x16.3	20.8x21.0	15		at least 13 rings; left hand; stack of
		2.4	1.4	17.4x18.0	21.2x22.2	15		9 (1st & 2nd here = 1st & 9th in
		3.0	2.4	17.7x18.0	23.9x24.0	15		stack) even graduation in size from
		c. 4	*c.* 3	18.8x18.8	24.8x26.0	15		1-9; 2 more stacks of 2 each
		2.9	3.0	17.0x18.3	23.5x25.0	15/18		
		3.2	2.8	17.9x19.0	23.6x26.5	15		
1357	B. 98	3.1	3.0		22.6x24.6	13		3 spiral rings; left hand; no. of turns
		3.3	3.3		22.4x26.3	13		respectively: 5, 3 & 4

TABLE 21:10 *Bronze finger rings* (cont.)

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
		2.6	2.8		23.8x25.0	13	
		2.7	1.8			11	formation, flattened; rt. hand
		2.5	1.4	21.0x9.7		11	
1426	B. 94	4.0	1.8	*c.* 20		11	4 rings (3 complete and in stack -
		4.3	5.0	18.4x18.4	28.5x29.0	18	style 18); left hand
					26.0x27.0	?18	
		5.3	4.9	15.9x17.0	27.0x27.2	7/18	
1451	B. 104	2.8	1.6	14.8x18.6		13	at least 2 turns
1516a	B. 96	*c.* 4	*c.* 2	*c.* 19		11	at least 14 rings; 1st 3 in stack
		2.4	3.4	*c.* 18		7	similar to 1st measure. given here;
		2.3	3.3	*c.* 18		4/7	remaining 5 in stack and frag. rings
		2.5	3.4	*c.* 18		7/10	rep. by other measurements given;
							see also 1516b (bangle); at least 2 are split rings-earrings?
1538	B. 113	2.3	1.6	17.9x19.5	22.0x22.1	11/18	at least 25 rings - 1 stack of 7 (1st
		2.9	1.7	18.4x18.4	22.0x22.4	11	measure given), 1 stack of 11 (2nd measure), remainder = fragments; dimensions within stacks seem consistent; left hand
1594	B. 96	2.8	3.1	18.4x19.2	25.4x26.1	7	1 ring; under pelvis
1603a	B. 69	1.8	2.7	21.8x23.2	27.2x27.2	8	at least 16 rings; rt. hand, finger 1; all similar dimensions
1603b	B. 69	2.0	2.7	17.4x17.6	23.3x23.4	8	at least 14 rings; rt. hand, finger 2;
		2.5	2.0	17.8x18.0	21.6x22.0	18	all similar dimensions though most have circular cross-sections
1603c	B. 69	1.8	2.3	19.7x19.8	23.1x23.6	7	at least 5 rings & at least 1 spiral
		3.4	2.0	15.8x17.5	21.7x23.8	24	ring (7-9 turns); rt. hand, finger 3;
1603d	B. 69	2.3	2.3		23.5x24.0	18	at least 16 rings; rt. hand, finger 4;
		2.2	1.8	*c.* 18		18	
1604a	B. 69	3.1	2.0				
1604b	B. 69	2.1	2.3	16.5x17.2		10	at least 18 rings; left hand, finger 2
1604c	B. 69	1.9	2.8	17.9x18.0		8	
		3.0	3.3	19.2x19.5		7	
1604d	B. 69	3.3	2.2	*c.* 21		10	
1604e	B. 69	3.0	2.4	*c.* 20			
1659	B. 31	3.1	2.9	19.6x21.1	26.2x27.6	15/18	7 rings; rt. hand; single stack of 6
		2.3-2.7	2.5	15.5x16.4	20.9x21.8	13	simple rings (prox. end) & 1 spiral (distal end); spiral at least 5 turns, length: 14mm
1660	B. 31	2.4	2.4	19.6x19.6	24.4x25.1	13	1 very long spiral ring of at least 12 turns; left hand; length: 32.4mm
1690	B. 118	3.5	2.4	15.9x16.8	21.8x22.8	11	stack of 5 rings; rt. hand; all very
		3.8	2.6	15.9x16.4	20.6x21.6	11	similar in dimension
. 1705	B. 113	2.6	1.8	16.9x20.4	21.0x24.4	15	stack of 8 rings; rt. hand

TABLE 21:11 *Bronze toe rings*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
160	B. 12	4.5-6.2	4.7-7.6	24.6x25.6	36.8x37.2	?18	1 ring; located near rt. forearm?
165	B. 12	3.9	1.1	19.3x19.4	22.5x22.6	11	at least 5 rings; rt. foot
		3.5	1.9	16.7x17.6	20.0x21.0	11	
		3.1	1.4	15.8x17.6	19.8x20.6	11	
210	B. 14	6.4	8.7	27.2x28.0	45.2x46.0	15	2 rings; left foot
		7.3	8.6	27.2x27.8	44.0x44.3	15	
545	B. 47	3.2	3.2	27.4x27.7	34.4x35.0	18	1 ring; possibly a toe ring
698	B. 53	5.7	2.6	27.3x29.6	34.4x35.1	11	set of 3 toe rings; right foot; toe?
		5.8	2.3	26.5x28.5	34.3x34.5	11	
		6.8	2.1	27.7x28.7	35.0x36.0	11	
699	B. 53	6.0	2.8	26.5x27.8	34.5x35.0	11	set of 4 toe rings; big toe; left foot
		6.1	2.6	27.6x27.9	33.6x34.8	11	
		6.2	2.7	28.0x29.0	34.1x36.0	11	
		6.2	2.9	27.6x28.3	34.3x35.5	11	
717	B. 54			20.5x22.4	26.2	11	4 toe rings in a stack; dimensions
						11	taper from one end to the other;
						11	radial ht. of stack: 20.7 mm
				20.9x23.8	30.0	11	
				18.0x19.7	25.0x26.4	11	2 toe rings in a stack; radial ht. of
				19.6x20.5	25.4x27.2	11	stack: 10.9 mm
1082	B. 73	3.7	3.4	15.7x16.0	22.5x23.2	10	9 toe rings in a stack; rt. foot;
		4.4	3.0	18.3x18.5	24.5x24.8	10/15	measurements given for 1st and 9th; 2 larger rings in centre of stack (OD: 25.8x26.8mm); **iron clad**
1166	B. 87	3.6	3.2	23.3x23.5	30.5x30.5	10	stack of 3 rings; big toe, rt. foot
		3.0			29.5x30.0		
		2.7	2.8	23.8x24.6	31.0x31.7	15	
1456z	B. 105	2.2	2.2	*c.* 20		18	at least 8 rings; 1st 1/4 fragment,
		2.5	3.4	*c.* 20		18	next 2 complete, remainder all
		3.4	3.1	*c.* 18		18	fragments similar to last given
		3.3	2.1			15	here; see also 1456y (bangles)
1529a	B. 105	5.5	6.6	27.3x27.5	39.0x39.3	7	stack of 3 rings; rt. foot, toe 1
			5.7	39.2x40.2			
		5.0	6.5	28.4x28.9	40.8x40.9	8	
1529b	B. 105	8.2	2.2	15.8x16.8	21.1x21.3	11	5 rings (4 in stack); rt. foot, toe 2
		2.5	2.5	17.8x18.0		7	
		2.6	3.4	17.4x19.0	25.8x26.3	7	
		3.2	3.4			4	
		3.3	4.1	*c.* 17		8	
1529c	B. 105	3.1	3.7	18.0x18.5	25.7x27.1	7	stack of 3 rings; rt. foot, may also
		3.4	3.4	25.1x25.2		7	be from toe 2
		2.8	3.2	18.5x18.6	25.0x25.5	7	
1530a	B. 105	5.7	6.0	26.6x27.4	39.6x39.7	7	stack of 3 rings; left foot, toe 1;
		6.3			40.1x40.5		distal to proximal given
		6.7	6.4	27.0x27.6	40.5x41.1	10	
1530b	B. 105	2.5	3.7	16.5x17.3	23.7x24.8	9	stack of 7 rings; left foot, toe 2; #'s 1
		2.6	2.7	*c.* 18	23.6x24.8	8	(distal) & 7 (prox.) given
1530c	B. 105	2.2	2.8	17.6x17.7	22.7x23.7	7	stack of 15 rings; left foot, toe 3; #'s
		2.3			25.6x25.6		1 (distal), 12, 14 & 15 (prox.) given;
		3.0	3.4		26.6x27.8		possible fibre cladding lining inner
		8.8	2.3	17.7x17.9	21.9x22.5	11	surface of stack

TABLE 21:11 *Bronze toe rings (cont.)*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
1540	B. 113	2.6	1.6	16.0x19.6	19.5x22.5	15	5 rings in stack along with 1541 (below); 4 similar in dimension, last 1 before silver ring larger- RH: 3.0
1605a	B. 69	4.9	5.1	26.8x30.2	37.8x40.9	8	6 rings; rt. foot, toe 1; 5 similar to
		3.2	3.9	21.6x22.4	31.5x31.6	7	the 1st given here & 1 smaller on end (2nd measure)
1605b	B. 69	2.3	2.4	17.9x22.1	23.1x26.2	15	at least 12 rings (10 in stack); rt.
		3.0	4.0	*c.* 21		7	foot, toe 2; 1st 2 given here form
		2.4	2.5	17.6x17.8	22.3x24.3	15	stack; 2nd 2, loose
		2.2	2.1	19.0x19.4	24.3x24.3	15	
1605c	B. 69	2.5	2.0	16.3x18.4	20.8x22.2	15	stack of at least 8 rings; rt. foot, toe
		2.5	2.7	*c.* 18	*c.* 22	10	3; consistent dimensions
1606	B. 69	4.0	3.8	25.3x25.8	33.2x33.4	10	stack of 7 rings; left foot; all very
		4.2	3.8	26.0x26.4	34.4x34.6	10	similar; 2 may be bimetallic
		3.6	3.5	25.9x26.3	33.9x34.2	10/15	
1691a	B. 118	2.7	3.2	19.0x20.1	22.0x25.8	13	1 spiral ring; at least 14 turns;
		2.1	2.8	18.4x19.6	25.3x25.7	13	measurements from 2 positions along spiral
1691a	B. 118	3.6	3.1	20.7x22.7	27.5x29.0	10/18	stack of 2 rings
		3.5	3.5	19.0x19.6	26.8x27.8	18	
1691a	B. 118	4.5	5.7	18.3x18.4	28.7x28.9	7	at least 6 rings (2 complete);
		4.4	4.4		28.7x29.1	10	fragments are lighter wt. rings
		2.9	2.5	18.7x19.7		15	(poss. from 1 spiral, not simple rings?)
1691b	B. 118	4.9	4.3	20.2x21.3	29.2x29.9	10	9 rings (1st 2 in a stack, next 5 in a
		4.7	3.5	20.9x21.7	28.3x29.3	10/15	stack); which foot?
		4.7	4.1	21.9x22.0	30.4x30.5	11/15	
		5.2	4.1	21.9x?	30.0x30.7	11	
		4.6	4.4		29.8x30.4	11	
		4.8	4.3	22.3x22.4	30.2x31.6	10	
		4.6	3.7	*c.* 21		11	
		4.6	3.8	*c.* 22		11	
		3.9	3.6	*c.* 22		11	
1691c	B. 118	5.0	3.9	20.8x22.3	29.5x30.1	15	5 rings (4 in stack); all very similar
		4.8	3.7	22.2x22.3	30.4x30.6	15	
					30.5x30.5	15?	
					29.6x30.4	15?	
		4.5	3.9	21.8x24.5	29.5x32.2	15	
1693	B. 74	2.8	3.0	23.4x23.7	29.8x30.1	7	1 complete ring; left toe
1734	B. 82	10.8	6.7	26.3x27.0	38.7x40.2	3	3 toe rings; the first has a rounded
	9.3	*c.* 7.0			38.6x40.3	26	triangular x-section - less defined
		5.6	4.0	22.2x22.8		15	version of the 2nd, a band with a D-shaped projection around the outside edge; left foot
1735	B. 82	9.9	5.7	26.4x27.0	39.0x39.4	26	stack of 3 rings; rt. foot; width of
		10.0	6.5	24.9x26.6	38.6x39.6	26	raised decoration: *c.* 5 mm
		5.0	4.7	20.7x23.0		10	
1773	B. 122	3.8	3.5	17.0x17.5	24.8x25.0	13	1 spiral toe ring; 2.5 turns; which foot?

TABLE 21:12 *Unidentified bronze rings*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
?b	B. 62	1.8	1.7	*c.* 15			1 fragment; see also ?a (bangles); (2/70)
?	B. 77	1.9	1.8	*c.* 20		18	1/3 fragment
?000b	B. 105	2.4	3.4	*c.* 16		4	fragments of at least 1 ring; see also ?000a (bangles); (2/47)
?	B. 105	2.9	2.5	*c.* 20		10	1/4 fragment; split ring? (2/50)
?	B. 105	2.6	3.2	16.5x17.3	24.3x24.6	7	1 complete ring; + many frags. of bronze
?	B. 59	2.5	1.2			11	fragments of at least 2 rings; see
	2.9	1.2				11	other rings from this burial
?	B. 110	6.8	2.3	*c.* 25		11	single ring fragment
?	B. 111	3.2	4.4	16.1x17.4	25.3x26.1	7	complete ring; under pelvis
?	B. 113	2.7	1.5				very small fragment of 1 ring
?	B. 115	2.4	1.5	*c.* 20		11	fragments of 1 ring (2/56)
85b	A2, L3: sf.3	2.5	1.3	*c.* 25		11	fragment; finger ring ?; see also cat. 85a (bronze frags.)
157	B. 10	3.7	1.5	*c.* 25		11	several fragments; all similar dimensions; 1 finger ring ?
240	B. 13	1.4	1.8	*c.* 18		7/18	1 very fine ring
241	B. 13	1.3	1.8	*c.* 20		7	1 very fine ring; from flot.; makes a pair (earrings?) with cat. 240
247	B. 16	2.4	3.3	*c.* 30		8	fragment; from flot
256	B. 12	2.0	1.9	*c.* 15		11	fragment; finger ring ?
287	1.7	2.2	*c.* 22			8	1/3 fragment
310	B. 21	3.3	2.2			11	small fragments
325	B. 20	3.0	2.6	*c.* 25		11	1/3 fragment (spiral?)
347a		3.2	2.1	*c.* 25		11	fragment only; see also 347b (bronze fragments)
349		3.8	1.5	16.2x16.4	19.5x19.8	11	2 rings corroded togethe
		4.0	1.3	16.9x17.4	20.4x21.0	11	
386		3.0	2.9	*c.* 40		7/18	1/3 fragment
645	B2, L4:7	10.0	2.4	*c.* 20		11	fragment; very wide band; finger ring ?
691	B. 49	5.5	2.0	*c.* 20		11	1/3 fragment; finger ring ?; also fragment of bronze wire/bangle ?
692	B. 50	1.9	1.9	*c.* 15		18	fragment; finger ring ?
712b	B2, L4: 10	1.9	1.7	*c.* 22		11	fragment; see also cat. 712a (bronze fragments)
726	B2, L4: 10	6.6	1.8			11	fragments
779	B, L4: sf.6	1.8	5.0	*c.* 25		7	fragment; earring ?

TABLE 21:12 *Unidentified bronze rings* (cont.)

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
856	C2, 3:2	2.8	2.5	*c.* 10		11	small fragment of ring or earring
903	C3, 3:8	2.0	1.8	*c.* 18		15	1/2 fragment
968	C1, 3:7	4.1	1.7	*c.* 20		11	1/8 fragment
977	A3, 3:9 fea. 2	2.6	2.6	*c.* 17		18	1/2 fragment
983	B. 62	2.8	2.2	*c.* 18		10	3/4 fragment; rt. of pelvis
1012	B. 63	6.0	4.1	31.8x33.0	41.4x42.9	11	complete; not split ring
1022	B. 63	2.0	2.2	*c.* 20		18	fragments of at least 2 rings
		2.0	2.3	*c.* 18		15	
1031b	B. 67	2.4	*1.8*	c. 15		15	1/4 fragment; see also 1031a (bangle)
1048	C1, 3:13	2.5	2.2	*c.* 20		?15	1/2 fragment
1061	C1, 4:1	1.9	3.0	*c.* 20		7	1/2 fragment
1063	B. 69	2.3	2.4	*c.* 19			ring fragments; + frags. of 3 glass beads
1071	B. 73	2.0	2.1	*c.* 18		18	2-3 fragments from flot
1073b	B . 78	2.6	2.4	19.0x19.2	24.2x24.3	18	3 rings (1 complete); see also 1073a
		3.5	2.5	*c.* 18		11	(bangles)
	3.3	3.1	*c.* 16			7	
1079	B. 59	3.4	1.1			11	fragments of at least 2 rings
	2.5	1.2				11	
1130a	B. 86	2.9	2.5	19.5x20.4	25.2x26.0	18	1 complete ring; see also 1130b
1144	B3, 4:4	2.9	*2.8*	*c.* 23		15/18	1/2 fragment
1145	B3, 4:4	6.7	2.2	12.4x12.6	18.0x19.2	11/15	1 complete ring
1173	B. 74	3.7	3.2	*c.* 20		4/5	1/2 ring; from screening
1174	B. 73	2.5	3.2	16.3x16.4	23.1x23.4	7	complete ring and 1/3 fragment;
	2.2	2.9	*c.* 18			7	from screening
1187	B. 78	1.9	1.6			11	fragment; from grave cut
1202	C1, 4:6	3.6	2.8	*c.* 18		11	1/2 a bronze ring; maybe a split
1207	C3, 4.7	6.5	*1.9*	*c.* 12		11	1/2 fragment; this small ring is
1231	B.81	2.7	2.8	*c.* 20		18	3/4 fragment; very thin for this diameter
1232	C2, 4:7	10.4	*4.6*	*c.* 18		11	1/2 fragment; heavy ring
1241b	B. 84	2.0	2.0	*c.* 22		18	fragments of 2 rings; 2nd is very small & maybe a split ring; other bronze fragments, see also 1241a (bangle)
	1.6	1.6	*c.* 5			18	
1274b	3.0	2.3	*c.* 18			11/18	1/4 fragment; see also 1274a (bangles) & 1274c (bronze
1275	X1, 2:1	2.8	2.3	*c.* 18		15	1/3 fragment
1279	C1, 4:7	6.5	1.9	*c.* 20		11	very small fragment
1291	B. 85	1.8	2.4	*c.* 17		7	fragments of 2 rings

TABLE 21:12 *Unidentified bronze rings* (cont.)

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
		2.2	2.3	*c.* 15		18	
1363	B. 95	3.6	3.1	*c.* 18		15	fragments of 2 rings, 2nd may be a
		3.6	3.5	*c.* 17		15/18	split ring (2/10)
1363	B. 95	3.0	2.8	18.0x19.2	24.5x25.2	15	2 complete rings from flot (2/23)
		2.6	2.3	16.7x17.2	21.1x22.2	15	
1363a	C1/X1	2.2	1.8	*c.* 19		15/18	fragments of at least 4 rings; B. 95?;
	4:1/4:6	2.8	2.8	*c.* 17		18	see also 1363b (bangles)
		3.0	2.5	*c.* 18		11/18	
		2.7	4.0			8	
1409	C3, 9:10 fea. 1	2.6	2.3			18	1/3 fragment of very small ring
1416c	X1, L3: sf.13 fea. 21	2.0	2.8	17.5x17.8	23.4x23.8	8	at least 13 rings; 4 complete, the 4th is a split ring of small diameter - possibly an earring; otherwise 2 sizes with i.d.'s of *c.* 18 mm and *c.* 25 mm - finger rings and toe rings? see also, cat. 1416a & b (bangles & bell)
		3.0	3.4	18.9x19.1	16.2x16.7	7	
		2.5	3.9	18.5x18.7	25.4x26.4	8	
		3.5	3.3	8.7x10.0	15.8x16.2	18	
		2.7	3.0	*c.* 28		10	
		2.1	2.3	*c.* 18		18	
		2.2	2.5	*c.* 20		10	
		2.3	2.9	*c.* 18		8	
		2.5	3.2	*c.* 18		7	
		2.8	3.1	*c.* 18		7	
		6.2	3.0	*c.* 25		11	
		3.0	3.4	*c.* 28		8	
		3.0	1.5			8	
1433b	X1, L3:8	2.5	2.9	16.8x17.3	22.5x23.4	18	complete
	fea.1	3.1	3.8	17.4	19.8	18	3/4 fragment
		2.0	2.5				fragments of two rings; all together at least 4 rings; see also cat. 1433a (bronze bangles); loose bronze
		2.4	3.1				
1456b		2.6	3.6	16.2x16.4	22.3x23.2	7	at least 14 rings (4 complete); also variety of x-sections among fragments; found in grave cut; see 1456a (bangles) & a1456c (belt)
		2.4	2.6	16.5x16.9	22.5x22.5	7	
		2.8	3.2	16.8x17.0	23.4x24.7	7	
		2.6	3.6	14.9x16.6	23.0x23.8	7	

TABLE 21:12. *Unidentified bronze rings (cont.)*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
1468b	X1; 3:13	2.9	2.6	17.1x17.7	23.0x24.4	18	at least 8 rings (3 complete) located east of B. 105, along with scattered human bone & glass beads; see also 1468a (bangles)
		2.7	2.5	17.3x18.3	24.1x24.3	7	
		2.6	3.0	*c.* 20		7	
		2.9	3.2	*c.* 18		7	
		2.5	2.6	*c.* 18		18	
		1.9	2.0	*c.* 20		18	
		3.5	2.8	*c.* 22		11	
		2.3	2.8	16.3x17.5	22.6x23.8	7	
1470b	B. 102	3.0	3.0			18	1/3 fragment; see also cat. 1470a (bronze bangle) & cat. 1470b (bimetallic ring)
1481b	B. 96	2.8	2.6	18.2x18.6	23.4x24.2	18	3 rings (2 complete)
		2.8	3.6	16.1x16.8	23.2x23.6	7	
		2.8	3.7	*c.* 18		7	
1453	B3, 4:11 feat. 2/ C3, 4:10 feat. 1	6.6	2.3	*c.* 18			1/2 fragment; unique form- band decorated on outside edge as two opposing rope patterns
1490b		2.4	3.0	*c.* 20		7	small fragments of at least 5 rings; see also 1490a (bangles)
		2.9	2.9	*c.* 17		18	
		2.5	2.8	*c.* 20		8	
		2.0	1.9	*c.* 20		18	
		2.6	3.3	*c.* 20		7	
1503a		2.6	2.8	*c.* 20			at least 2 rings; see also, cat. 1503b (bronze fragments)
		1.6	2.4	*c.* 18			
1504b	B. 96	3.5	3.0	15.8x16.1	21.5x22.5	18	complete; fragments of at least 2 more rings, 3 all together; grave area; see also cat. 1504a (bangles)
		2.5	3.0	*c.* 18		18?	
		2.1	1.9	*c.* 20		18?	
1523b		2.9	1.4	*c.* 18			fragments of at least 4 rings; see also 1523a (bangles)
		2.8	1.8	*c.* 18			
1559	B. 105	2.3	3.2	26.4x27.4	32.8x33.5	4/5	1 large, thin, ring; complete; found under pot
1561	B. 111	3.2	3.6	19.4x21.2	27.1x27.8	7	2 rings (1 complete); rt. of skull
		2.4	3.1	*c.* 19		7	
1586	B. 105/ 111	3.5	3.9	16.4x16.8	24.2x25.3	7	3 rings (2 complete)
		4.2	4.8	*c.* 17		7/18	
		2.5	2.2	*c.* 20		15	
1598c	B. 115	2.3	1.3	*c.* 30		11	very small fragment

TABLE 21:12 *Unidentified bronze rings* (cont.)

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
1560	B. 111	3.1-3.5	3.3-4.6	18.7x19.4	28.0x28.0	7	single complete ring located near bronze belt
1921b	B. 95	3.3	3.0	17.0x17.5	23.3x23.9	10/18	at least 9 rings (1 complete); see also 1921a (bangles) & 1921c (bell)
	2.9	4.0	*c.* 20			7	
	2.8	2.8	*c.* 18			18	
	3.6	3.3	*c.* 18			15/18	
	3.8	2.7	*c.* 22			11	
	2.8	2.1	*c.* 20			7	
	2.7	3.4	*c.* 18			4.7	
	2.1	1.6	*c.* 20			11	
1938	B. 59	3.4	1.0				fragments only from flot 1/3 fragment
1944	B. 77	1.7	1.7	*c.* 20		18	
1945b	B. 80	1.2		*c* .20		11	1/3 fragment; see also 1945a (bangles)

TABLE 21:13. *Bronze bells*

Cat.	Context	R.H.	D.1	D.2	F.D.	Style	Notes
176		20.6	13.6		2.1	sphere	1 bell; more pendulous than others of this form; pea *in situ*
204		*c.* 12	7.3	7.4		sphere	fragmentary remains of 1 bell
288		15.8	13.1		1.8	sphere	1 bell; v. long perforation; pea in situ
308		16.4		11.1			1 bell; more pendulous than others of this form
331a	A2, 4:6	65.2	41.6		5.9x6.3	cone	unique bell form; may be pendant (no sign of clapper);
379		20.2		14.2	2.0x2.2	sphere	1 damaged bell; traces of decoration on eyelet remains
587		19.4		14.1	1.5	sphere	1 broken bell; very clear decoration
716	B. 54	17.8	13.4		2.7	sphere	21 bells; all of very similar
		18.5	13.0	12.3		sphere	dimensions; many still in clusters; left foot
809		15.8				sphere ?	1 bell
826					1.0	sphere ?	eyelet only at top of bell; spiral decoration
851	C3, 2:4	18.0	12.8		2.3	sphere	1 bell; well preserved; circular decorations cast on faces and about the cap; fibres present in perforation !
935	C1, 3:4	15.0	10.3			sphere	2 bells; 1 broken; similar in size
			11.3		2.1	sphere	
1170	B3, 4:7	12.2	8.6	7.5	2.0	sphere	1 very small bell

TABLE 21:13. *Bronze bells* (cont.)

Cat.	Context	R.H.	D.1	D.2	F.D.	Style	Notes
1213	B3, 4:7	>11.2	9.6			sphere	1 bell; perforation broken off
1416b	X1, L3: sf.13 fea. 21		19.5			sphere	relatively large bell with bottom broken off; pea is preserved- dia.: 5.1 mm; see also, cat. 1416a & c (bangles & bronze rings)
1480	B. 96	24.4	18.8	23.0	2.0	sphere	2 bells; grave fill; 2nd shows detail
		18.9	13.7	14.0	2.0	sphere	of moulded perforation
1655		21.2	14.1		1.7	sphere	1 broken bell; clear cap (acorn like)
1695	B2/3, 4:1	>21.3			1.9	sphere	1 broken bell
1755	B. 120	16.2	11.1	10.5	0.7	sphere	1 bell
1758	B. 124	29.7	22.7		3.6	sphere	21 bells; 2 large (1st 2), rest similar
		26.0	20.0		2.3	sphere	to 2nd 2 given here; 1st has 2 horns
		18.6	14.2	13.0	1.0	sphere	near the top; traces of circular or
		15.8	12.5	11.0	1.2	sphere	spiral decoration on faces of larger bells at least.
1921c	B 95	7.0				sphere	fragment of one small bell; see also 1921a (bangles) & 1921b (rings)

TABLE 21:14 *Bronze fragments*

Cat.	Context	M.D.	Notes
?	B. 59		
85a	A2, L2: sf.3	17.0	linear, with roughly square x-section, other similar fragments present
294		7.6	lump
347		45.0	bronze rod, dia.:3.2x3,9 mm
376	B1 A, 2:1	7.0	rounded lump
410		9.0	corroded brone fr.
424	B. 28	3.0	
432	B2, L4: sf.12fea.1	17.6	linear, with rectangular x-section to form a ridge along its length: 7.3x3.,3 mm
460		20.7	bronze lump
528		15.5	wire-like, dia.: 2.7 mm
564		15.0	
571		18.6	fragment with plano-convex cross section
578		11.9	
668a	B2, L4:9	23.0	linear with oval x-section: 3.8x4.4 mm; other similar fragments present; see also cat. 668b (bangle frag.)
682b	B. 52	28.0	irregular globular tab of bronze
705	B. 50	6.1	flattened ovoid bronze lump
710	A1, L6:7	50.3	linear with roughly circular x-section: 6.9x6.3 mm; casting spillage?
712a	B2, L4:10	20.0	ovoid tab of bronze; other fragments of bronze waste; see also cat. 712b (bronze rings)

TABLE 21:14 *Bronze fragments* (cont.)

Cat.	Context	M.D.	Notes
734	B2, L4:12	8.4	ovoid bronze lump
738	B2, L4:13	46.2	linear with rectangular x-section: 5.7x2.3 mm; bangle frag. ?
		10.3	irregular bronze lump
		11.3	irregular bronze lump
743	B. 25a	25.2	irregularly shaped tab of bronze; thickness: 5.1 mm
745	B. 25a		powdery fragments of corroded bronze; maybe 2 bags with this cat. no. ?
746	B2, L6:1	35.3	irregular linear rod; roughly circular x-section: 4.1x5.2 mm
		10.2	irregular lump of bronze; 2nd fragment in cat. 746
751	B2, L6:3	10.0	unrecognizable fragments; 2 bags with this cat. #
795	A1/B, L3:7	10.3	originally spherical ?; now broken
853	C1, 3:2 fea. 1	3.8	
865	B3, 3:4	10.5	
1018	C3, 3:13	16.2	
1026	C1, 3:9 fea. 1	9.6	egg shaped ball
1035		12.0	fragment of thin bronze sheeting
1088	C1, 4:2	11.7	
1116	B. 78	8.0	
1122		12.6	bronze pellet
1146	B3, 4:4	24.3	
1178	C3, 4:6	12.3	rod
1182	C1, 4:5	1.5	
1188	A3, 4:6	12.0	
1211	C3, 4:7	26.5	
1214	B3, 4:2	6.1	
1217	C3, 4:7	29.6	
1218	B. 95	8.9	rod
1238		9.0	lump
1250	B. 95	12.5	wire
1252	B3, 4:8	23.8	
1259	C3, 4;8	6.6	
1274c		28.0	tabular fragment; curvilinear edge where not broken; width: 25mm, thickness: 5mm; see also 1274a (bangles) & 1274b (rings)
1280	C3, 4:8 fea. 1	22.0	
1333	C1, 4:8	11.0	
1366	B3, 4:10	29.4	
1408	Sq.?, L2:6	19.4	linear with rectangular x-section: 6.9x4.6 mm; bangle ?
1427	A3, 4:15	12.0	
1461	C3, 4:10 fea. 1	6.5	
1467	B. 106	9.0	
1497		22.2	hollow bronze lump (tube?) closed at one end; diameter: 12.2mmx12.4mm, ID: 6.2mm
1500		38.7	perhaps spillage from casting?
1503b	B. 105	44.0	linear with circular x-section; 4.6x5.0 mm; bangle ?/ nail ?; see also cat. 1503a (bronze rings)
1584	B. 111	30.5	large lump under pelvis

TABLE 21:15 *Bimetallic rings*

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
91	B. 1	7.1	8.0	23.2x24.7	41.9x43.8		pair of rings corroded together;
		6.0	7.9	25.5x26.7	41.6x42.7		prox. left femur
93	B. 1	8.6	7.5	26.2x27.0	43.2x45.2		pair of rings corroded together;
		7.4	6.1	28.2x28.4	41x41.9		right shoulder
95	B. 2	7.6	6.0	28.0x28.0	42.0x42.0	15/18	1 complete; found at lip of pot
112	B. 7	8.1	9.1	24.5x26.3	41.4x41.6	15/18	1 complete
186	B. 5	5.5	6.7	24.7x25.3	43.4x43.8		
190	B. 9	7.3	7.2	20.6x21.6	41.8x45.8		1 complete; skull area
232	B. 13	9.8	5.6	28.7x29.2	42.4x43.2	11	1 complete ring; sloping cross-sec
233	B. 13	7.5	4.4	26.5x30.4	36.4x38.4	11	1 complete ring; bangle like cross-section
235	B. 13	7.9	5.6	28.6x29.2	40.0x41.8	11	1 complete ring
290	B. 14	9.4	8.5	34.3	48.4		pair of rings corroded together;
		10.1	7.0	34.1	48.6		perpendicular orientation; matting
799	A2/B2, L3:8	6.3	7.4	*c.* 30.0		1/3	fragment
850	B. 57	7.6	6.6	25.0x26.3	39.8x41.0	10/11	1 complete
867	C2, 3:4	9.4	9.6	23.1x23.6	41.0x42.0	18	
873	B. 59	5.5	6.3	24.1x25.3	40.0x41.1	7/11	pubic area; 1 complete ring
885	?	7.5	7.3	26.0x26.5	41.5x43.8	10	1 complete ring
890	B. 62	7.5	7.1	30.1x30.2	45.0x45.6	18	1 complete; neck area
927	B. 63	7.4	7.1	23.8x26.0	40.0x40.8	11/15	2 complete rings
		7.3	7.2	24.5x25.0	40.8x44.5	15	
962	B. 68	7.2	7.4	23.8x25.9	41.6x43.0	7	1 complete ring
967	C1, 3:7	12.5	14	14.0x16.0	43.2x48.8	7/18	1 complete ring; much corrosion
982	B. 62	10.2	9.4	20.8x23.1	43.0x43.8	10/18	2 bimetallic rings in pair
		8.8	9.8	17.0x18.0	40.0x43.8	10/18	
985	B. 71	7.7	4.8	28.0x31.7	39.7x42.7	11	1 complete
996	C2, 3:12						1/3 fragment
997	A3, 3:6	10.6	10.5	*c.* 25		15	1/2 fragment; heavily corroded
1013	B. 63	7.2	6.1	29.9x31.5	44.5x45.3	15	1 complete ring; under pot cat. 925
1016	C2, 3:13 fea. 1	8.7	5.7	*c.* 30		11	fragments of 1 ring
1049	C1, 3:13	8.5	4.8	*c.* 35		11	1/3 fragment
1083	B. 70	7.8	4.5	34.4x36.2	45.6x45.8	11	set of 3 complete rings
		7.2	5.0	35.8x36.0	46.0x46.4	11	
		10.1	5.8	32.2x34.2	45.4x45.8	11	

TABLE 21:15 *Bimetallic rings* (cont.)

Cat.	Context	R.H.	R.W.	I.D.	O.D.	Style	Notes
1287	B. 85	9.7	5.6	27.9x31.8	40.2x46.7	11	3 complete rings; rt. arm; fibre
		9.8	5.8	29.8x32.6	44.0x46.5	11	impressions (< 0.4 mm dia.) on
		10.5	4.5	34.8x41.4	44.4x50.4	11	middle ring
1288	B. 85	10.9	4.2	33.9x35.9	43.6x49.3	11	4 complete rings from left arm
		9.0	5.6	33.6x36.0	44.6x46.7	11	region; last 2 in a stack;
		8.2	5.4	28.5x30.0	42.0x42.6	11	fibre/fabric pseudomorphs on all
		7.2	6.0	29.2x30.0	42.3x43.6	11	
1289	B. 85	8.9	6.3	33.8x35.8	46.0x48.0	11	1 complete; neck area; asso*c.* with a dark brown glass bead
1470c	B. 102	6.7	6.6	26.1x29.1	44.1x46.1	18	complete; regular circular x-section (most others more D-shaped); see also cat. 1470a (bronze bangle) & cat. 1470b (bronze ring)
1597	A2/A3, 3:5	8.2	7.8	c .25		11/18	fragments of 1 ring
1608	B. 69	7.7	7.6	28.2x28.8	42.2x45.4	15	1 complete ring; over upper left femur; split ring
1614	B. 115	7.2	7.0	29.5x30.3	43.0x43.8	18	1 complete
1625	B2/C2, 3:10 fea. 1	8.3	6.5	27.2x29.9	41.2x42.2	15	1 complete ring
1647	B. 69	8.5	6.4	29.8x31.0	44.0x44.4	11	1 complete; under rt. chin
1653	B. 104	7.8	7.9	23.6x25.7	40.6x42.3	10/15	1 complete ring; neck area
1750	B. 113	8.1	8.1	24.6x25.6	42.1x42.8	7/11	1 complete ring; under skull; much fabric impression
1620	B2/C2, 3:7	8.7	7.6	*c.* 35		15	1/3 fragment
1034	C1, 3:10	8.7	5.8	*c.* 30		11	fragments of 1 ring
1797	X1, 3:13 fea. 2	6.0	5.5	25.0x25.8	37.3x37.6	15	1 complete ring

XXII. THE IRON AND BIMETALLIC ARTEFACTS

R. CONNELLY

A wide spectrum of iron artefacts was recovered at Noen U-Loke from both mortuary and non-mortuary con texts (Table 22:1). The aim of this research was to examine the distribution of iron and bimetallic artefacts from both contexts to gain insight into socio-economic aspects of iron use. There were three main areas of research: the first iron artefacts, the distribution of iron among burials, and iron as a reflection of the economy. To gain results, the artefacts were firstly classified according to function and form, with each type described below.

DESCRIPTION OF TYPES

Knives

A knife is a cutting tool usually with one blade that is fixed in a handle. They can be used for cutting a variety of materials, from chopping through bone and for scraping plant material. The following types are all found at Noen U-Loke. Based on morphology, it is probable that they were used for different purposes, but this is currently impossible to prove as corrosion has obliterated the cutting edges of the tools.

1a Ridged knife with straight top (Fig. 21.1)

This type is tanged with diagnostic ridges along both the top and side surfaces. The top ridge is offset from the tang by around 2 cm; the side ridge extends the entire width of the knife. Another diagnostic feature is a hole is pierced in the upper right corner, inset from the confluence of the two ridges. This type of knife was probably used in a chopping motion as the side ridge would have prevented a slicing motion.

Dimensions:
Length (including tang): 121 - 138 mm
Maximum width range: 48 - 62 mm
Thickness of blade below top ridge: 2.9 mm
Thickness of blade at cutting edge: 1.0 - 1.4 mm
Thickness of top ridge: 2.8 - 5.4 mm
Depth of top ridge: 3.6 - 4.2 mm
Length of tang: 10.4 mm
Width of tang: 8 mm

1b Unridged curve-bladed knife (Fig. 22.2)

These are tanged and generally small. The blade curves up away from the tang. The cross section is thicker than in type 1a.

Dimensions:
Length: 57 - 107 mm
Maximum width: 12 - 22 mm
Thickness at top of blade: - 9.3 mm
Thickness at cutting edge: 2.1 - 4.2 mm
Length of tang*: 37.6 mm
Width of tang*: 10.6
* The tang survives on only one specimen.

TABLE 22:1 *Distribution of iron and bimetallic artefacts between mortuary and non-mortuary contexts (including slag)*

Context	N iron artefacts	N bimetallic artefacts	Total
Burial	53	50	103
Non burial	178	15	193
Total	231	65	296

1c Machete (Fig. 22:2)

The machete is tanged with an ellipsoid cross section. The cutting blade is on the lower edge of the artefact. The upper edge of the artefact curves up toward a point.

Dimensions:
Length: 122.75 mm
Width at tang: 8.98 mm
Thickness at tang: 6.93 mm
Width at end: 34.21 mm
Thickness of cutting surface: 2.37 mm

1d Long narrow bladed knife (Fig. 22:2)

This is a tanged knife. The blade is long and narrow and gradually widens away from the tang. It is a fragile knife and would not be able to withstand vigorous cutting nor chopping. The tang has a circular cross section which flattens out to the blade.

Dimensions:
Length: 235.4 mm
Width at tang end: 5.1 mm
Thickness at tang end: 3.5 mm
Width at end of blade: 22.8 mm
Thickness at end of blade: 4.8 mm

1e Knife fragment

These are fragments of knives that cannot be positively assigned to any of the above categories.

AGRICULTURAL TOOLS

The function in this type was determined by comparing modern tools available in the markets in Phimai to the prehistoric types. Little has changed over the two millennia: the prehistoric sickles from Noen U-Loke are remarkably

similar to those used today. The only difference is that the tang is replaced by a metal handle in the modern tools. Similarly, hoes and spades have changed little: both have split sockets to accommodate wooden handles, and the blade is of a similar shape. Digging sticks were less easy to identify. Modern iron digging sticks are scoop-shaped and are usually fashioned out of a flat rectangular piece of metal that has been curled at one end to create a split socket. Some similarities between modern and ancient types still exist, however. Both are socketed and the silhouette remains the same: both gently flare out from the socket to the flat blade.

2a Sickles (Fig. 22:3)

These are tanged and with a curved blade. The tang is normally circular in cross section and flattens out around the cutting surface to the tip. The size varies greatly.

Dimensions:
Length: 53 - 335 mm
Width at curve: 24.0 - 30.7 mm
Thickness at curve: 2.0 - 6.0 mm
Width at tang: 3.2 - 12.6 mm
Thickness at tang: 2.9 - 10.7 mm

2b Hoes (Fig. 22:3)

These are large robust socketed tools. The socket is typically about 90 mm long and is sometimes split to allow the socket to grip the handle more effectively. The blade flares out from the socket to form an oval, and it is the oval blade that differentiates this type from the digging sticks.

Dimensions:
Length: 120 - 167 mm
Length of socket: 62 - 96 mm
Interior diameter of socket: 17.5 - 28.7 mm
Exterior diameter of socket: 30.2 - 38.2 mm
Width of blade: 40.4 - 80.4 mm

2c Digging sticks with straight-edged blade (Fig. 22:3)

The socket of this type tapers to a flat blade. These digging sticks probably had a wooden handle as wood remains were found in the socket. This type varies in size, but are generally robust tools.

Dimensions:
Length range: 75.60 - 130.74 mm
Interior socket diameter: 18.32 - 31.37 mm
Exterior socket diameter: 29.4 - 47.5 mm
Width of blade: 26.77 - 42.6 mm

2d Winged spade (Fig. 22:4)

This is a socketed tool that is very robust. The socket is asymmetric and split, which would give the user more lift. The wings flare up from the blade to form a lunate silhouette.

Dimensions:
Length: 139.6 mm
Maximum width: 184.4 mm
Length of socket: 85.8 mm
Length of blade from end of wings: 182.1 mm
Thickness of blade at end: 5.5 mm

JEWELLERY AND PERSONAL ORNAMENTS

The function of this class was perhaps the easiest to determine. As most specimens were recovered from mortuary contexts, the position on the body was the best indicator to the purpose of the artefact. If the artefact was found encircling the wrist, it was a bangle; if the artefact encircled the neck, it was a torc. The function of bimetallic rings was more difficult to determine. They are not found encircling the wrists, fingers, toes, or neck of the body. They are usually found in pairs in the neck/shoulder region or in the waist or groin region. It is thought that these artefacts were used to fasten clothing or a shroud.

3a Bangles (Fig. 22:5)

These are usually found in burial contexts on the wrists of the body. They are flat in cross section and are often in sets of two.

Dimensions
Exterior diameter: 64.6 - 66.5 mm
Interior diameter: 55.6 - 56.9 mm
Width: 10.1 - 15.0 mm
Thickness: 3.1 - 8.7 mm

3b Torc (Fig. 22:5)

Only one specimen was found. The torc is circular and with a break in the front to put the item on. The ends overlap each other to make a smooth continuous appearance. The cross section is circular.

Dimensions
Exterior diameter: 118.4 mm
Interior diameter: 95.4 mm
Width: 12.4 mm
Thickness: 11.5 mm

3c Bimetallic rings (Fig. 22:6)

Many bimetallic rings were found in mortuary contexts. These are a green colour with a rusty orange hue. From the broken ones it appears that iron is wrapped around a bronze core, this would be confirmed by metallurgical analysis. Some are flat in cross section but most are ovoid or circular.

Dimensions:
Exterior diameter: 36.6 - 50.0 mm
Interior diameter: 11.5 - 43.9 mm
Width: 3.6 - 12.8 mm
Thickness: 5.4 - 10.5 mm

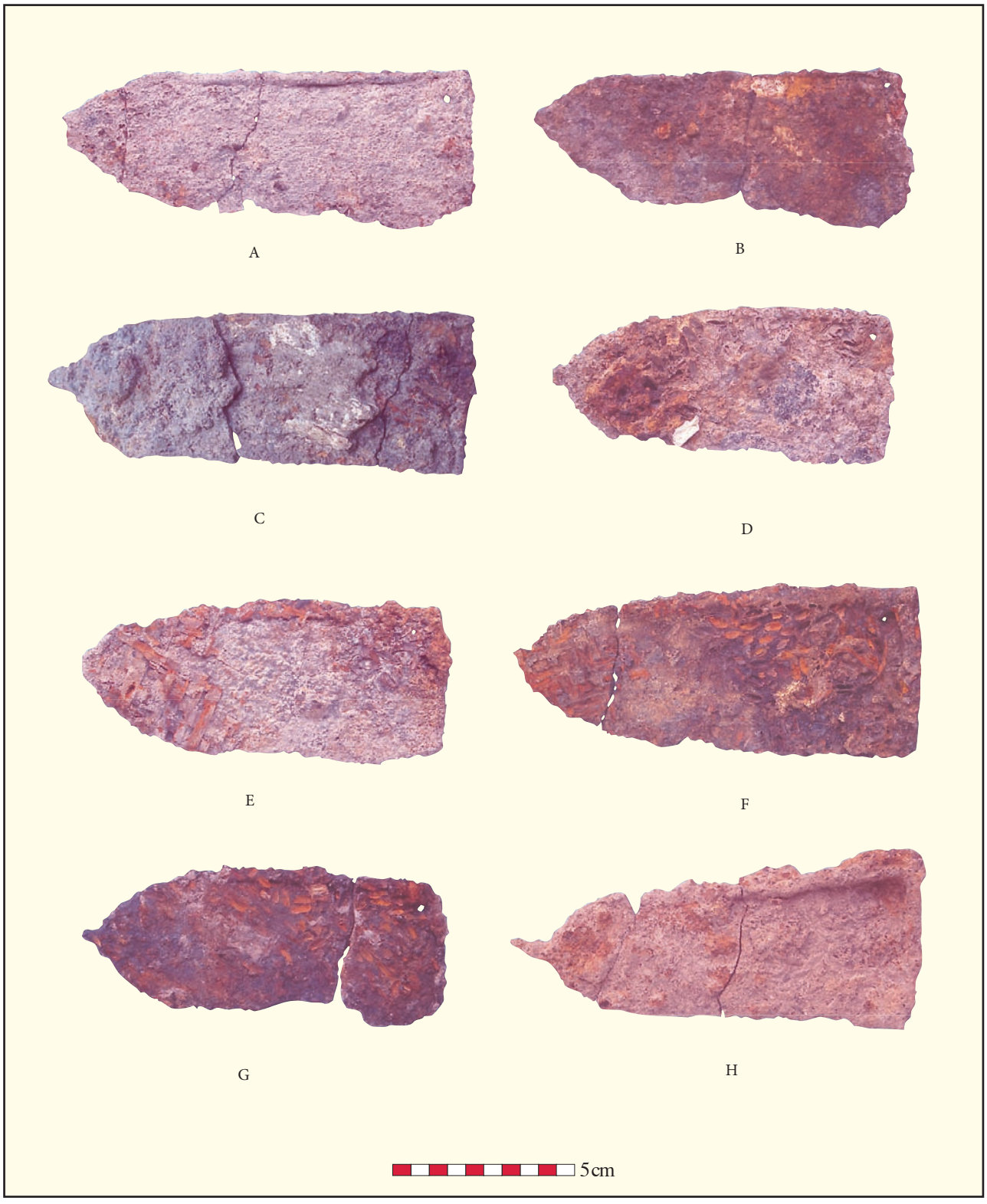


FIG. 22:1 Type 1a knives from Noen U-Loke. A. cat 1010, Burial 72; B. cat. 1079, Burial 73; C. cat. 888, Burial 59; D. cat. 914,Burial 62; E. cat. 994, Burial 69; F. cat. 1286, Burial 85; G. cat. 1454, Burial 105; H. cat. 134, Burial 4

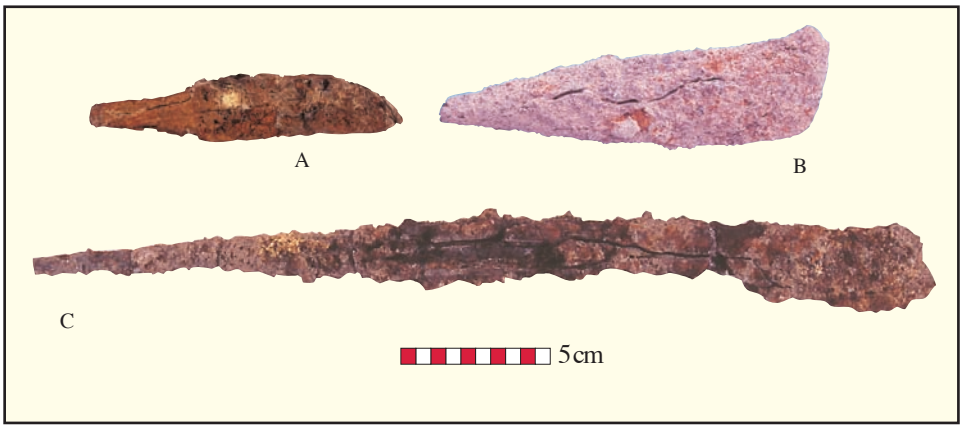


FIG. 22:2 Knives from Noen U-Loke. A. cat. 898 unridged curve-bladed knive (1b), Layer 3:7 Feature 1; B. cat. 969 machete (1c), Layer 3:12; C. cat. 161 long narrow tanged knife (1d), Burial 16

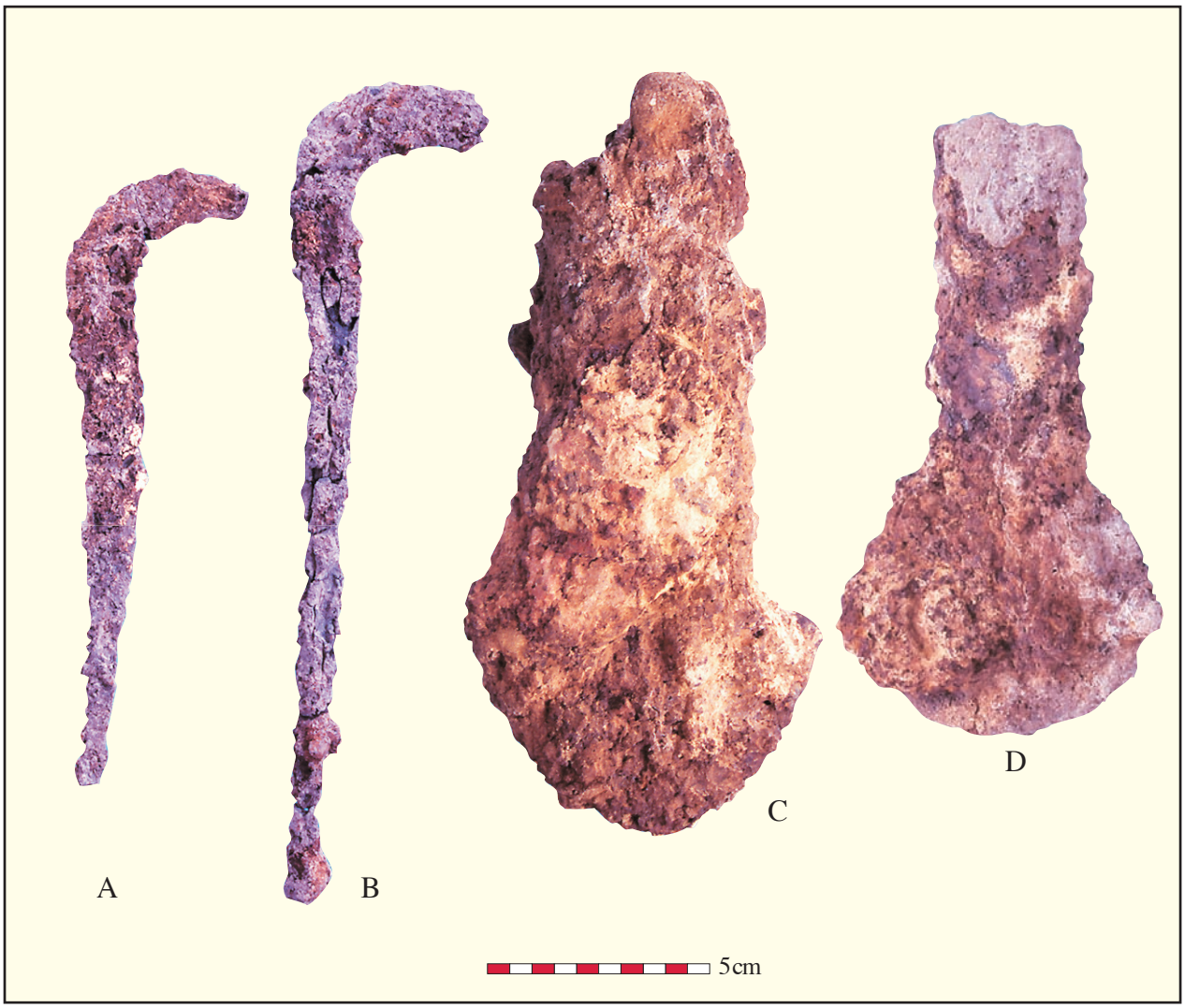


FIG. 22:3 Agricultural implements from Noen U-Loke. A. sickle cat. 147 (2a), Burial 4; B. sickle cat. 153 (2a), Burial 10; C. hoe cat. 1293 (2c), Layer 4:9; D. cat. 524 hoe (2c), Layer 4:7

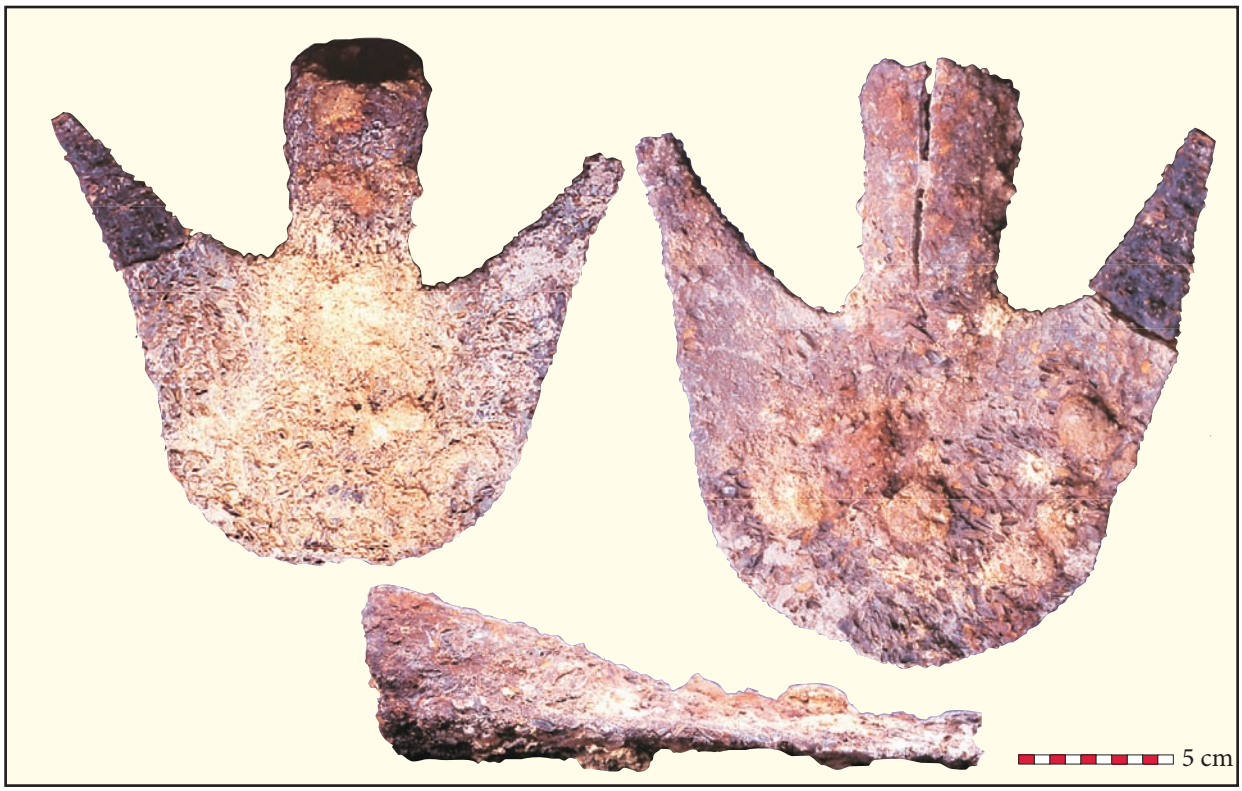


FIG. 22:4 Socketed spade, cat. 1269, (2d), burial 86

POINTS

This class could alternatively be called weapons. The distinguishing feature is that all taper to a sharpened point. The function was relatively easy to determine: most are similar in appearance to modern examples. In several cases pseudomorphs of wood appear on the artefact indicating the artefact was attached to a shaft or handle.

4a Tanged and barbed arrowhead (Fig. 22:7)

The barb flares out from the termination of the tang which was fastened on to a shaft.

Dimensions:
Length: 100.4 mm
Length of tang: 41.6 mm
Maximum width: 13.6 mm
Maximum thickness: 5.8 mm
Width at termination: 8.1 mm
Thickness at termination: 3.9 mm

4b Tanged point with no barbs (Fig. 22:8)

The points are tanged with no barbs, instead the blade curves around in a leaf-shape. These were probably arrowheads and were fastened on to a shaft.

Dimensions:
Length: 62.6 mm - 93.2 mm
Length of tang: No tangs survive intact.
Maximum width: 11.9 - 22.1 mm
Thickness at maximum: 3.0 - 7.7 mm
Width at termination: 1.1 - 4.5 mm
Thickness at termination: 0.9 - 4.8 mm

4c Tanged ovoid spear

The tang has a circular cross section flattening out into a flat blade. The blade tapers at both sides suggesting that it has two cutting surfaces. The edges do not taper to a point, rather they curve to a rounded tip.

Dimensions:
Length: 146.5 mm
Length of tang: 24.2 mm
Maximum width: 49.8 mm
Thickness at maximum: 2.3 mm
Width at tip: 11.7 mm
Thickness at tip: 3.0 mm

4f Socketed point (Fig. 22:7)

Socketed at the end and tapers to a point. These points are cone shaped and appear to be manufactured by rolling a flat piece of iron into a cone. Wood remains are found in the socket, indicating that these artefacts were attached to a wooden shaft.

Dimensions:
Length: 39.5 - 91.9 mm
Exterior diameter: 10.0 - 19.1 mm
Interior diameter: 5.8 - 15.0 mm
Width at tip: 4.0 - 10.4 mm

Thickness at tip: 1.8 - 7.6 mm

4g Socketed ridged square-based spear (Fig. 22:8)

This is a large spear that has a ridge running along the length of the blade which becomes the socket. The ridge narrows toward the tip. This was probably used as a thrusting spear as it is too heavy to be aerodynamically efficient. Slight raised edges along the blade indicate that it probably is not a sword, and were designed to increase strength upon impact.

Dimensions:
Length: 449.1 mm
Length of socket: 86.1 mm
Exterior diameter of socket: 15.8 mm
Interior diameter of socket: 12.0 mm
Maximum width of blade: 73.5 mm
Thickness of blade at maximum: 2.6 mm
Width at termination: 6.9 mm
Thickness at termination: 3.7 mm

4i Socketed spear unridged (Fig. 22:8)

This is smaller than the above type and without the characteristic ridge along the middle. The socket tapers to a flattened blade. It appears that the blade was manufactured by rolling a flat piece of iron into a socket then hammering the point flat to fashion a blade.

Dimensions:
Length: 155.6 mm
Length of socket: 75.3 mm
Exterior diameter of socket: 17.2 mm
Interior diameter of socket: 11.3 mm
Maximum width of blade: 31.7 mm
Thickness at maximum: 6.5 mm
Width at termination: 13.0 mm
Thickness at termination: 3.44 mm

4k Flat cross-sectioned triangular point (Fig. 22:7)

These points have no obvious tang or socket and were apparently attached by a notch at the end of the shaft. The diagnostic features are the flat cross section and the triangular shape. These are small in size and cross-section.

Dimensions:
Length: 30.8 - 81.2 mm
Maximum width: 12.5 - 21.8 mm
Thickness at maximum: 1.3 - 5.6 mm
Width at termination: 2.0 - 7.9 mm
Thickness at termination: 1.3 - 3.7 mm

4l Small circular cross-sectioned point (Fig. 22:7)

This point has no obvious tang and it is quite possible that the shaft joined on directly to the end of the point. These are all small in size and have a continuous circular cross section that tapers to a point.

Dimensions:
Length: 25.2 - 49.5 mm
Maximum width: 3.6 - 7.4 mm
Thickness at maximum: 2.8 - 4.9 mm
Width at termination: 2.0 - 4.8 mm
Thickness at termination: 1.3 - 5.5 mm

4m Large circular cross-sectioned point (Fig. 22:7)

The distinguishing factor between type 4l and 4m is that the 4l is consistently small in diameter and in length whereas 4m is large in diameter and length.

Dimensions:
Length: 63.6 - 179.3 mm

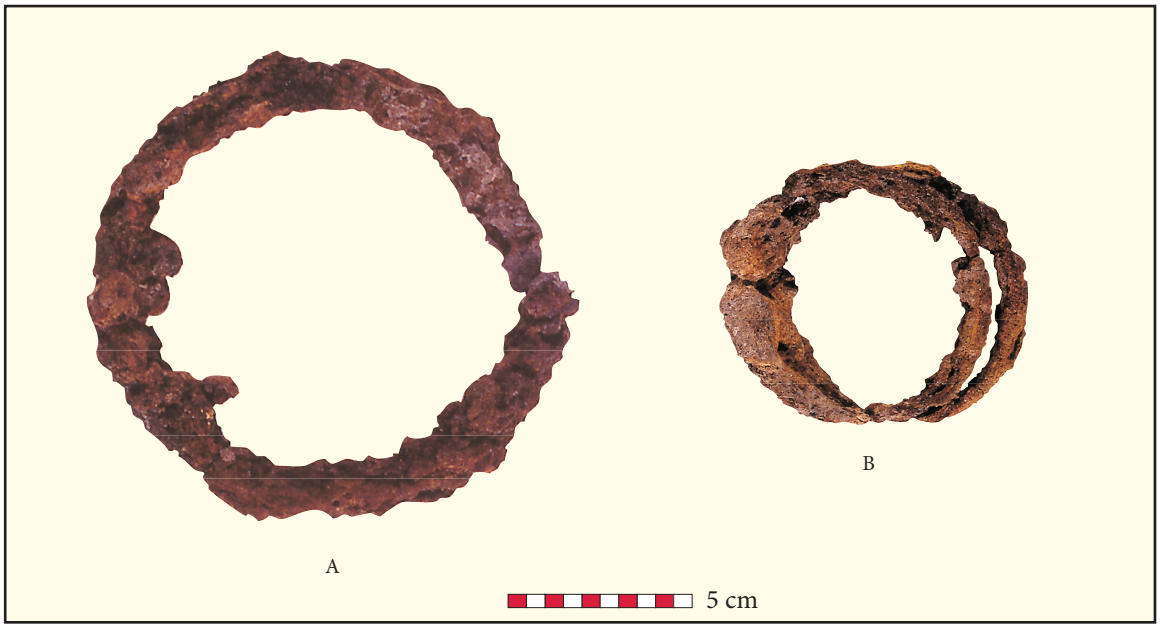


FIG. 22:5 Iron jewellery from Noen U-Loke. A. cat. 1718 torc (3b), Burial 108; B. cat. 1720 bangles (3a), Burial 108

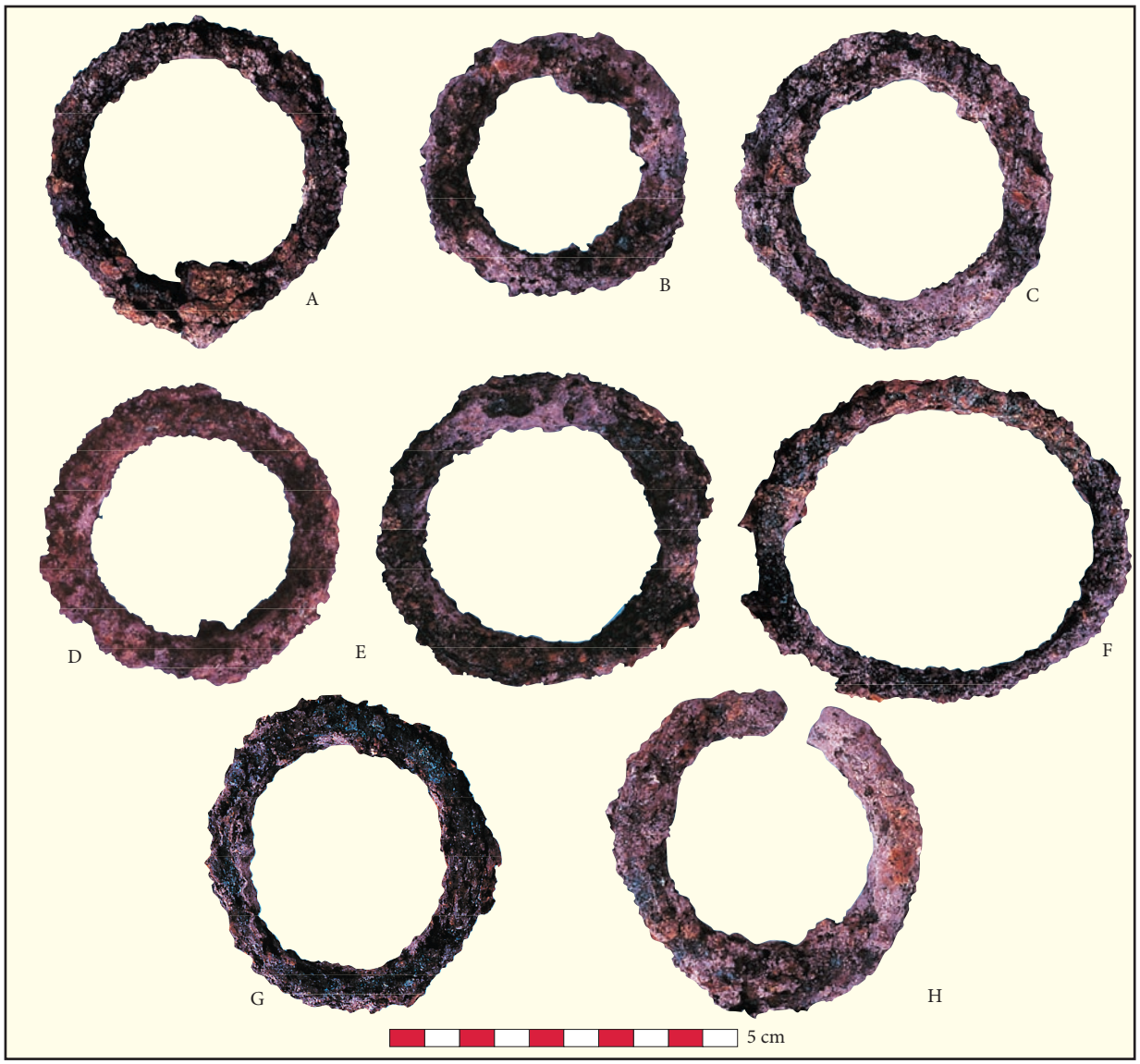


FIG. 22:6 Bimetallic rings (3c) from Noen U-Loke. A. cat. 1013, Burial 63; B. cat. 873, Burial 59; C. cat. 890, Burial 62; D. cat. 232 Burial 13; E. cat. 1287a, Burial 85; F. cat. 1287b, Burial 85; G. cat. 1287c, Burial 85; H. cat. 1608. Burial 69

Maximum width: 8.7 - 14.1 mm
Thickness at maximum: 6.7 - 13.3 mm
Width at termination: 2.0 - 9.1 mm
Thickness at termination: 1.1 - 8.4 mm

4n Square point tapering to a circular tip

The square butt end tapers to a circular tip. Pseudomorphs of wood on the surface indicate that a wooden handle or shaft was attached to the rectangular end.

Dimensions:
Length: 109.1 139.5 mm
Maximum width: 16.8 - 19.6 mm
Thickness at maximum: 6.9 - 9.9 mm
Width at termination: 5.1 - 5.9 mm
Thickness at termination: 4.4 - 5.0 mm

4p Point fragment

These have enough diagnostic characteristics to be classified as a point, but are too fragmentary to be classified further.

Unidentified function

The function of artefacts in this section was impossible to ascertain. There are no modern counterparts and there are no written records or illustrations that suggest a function.

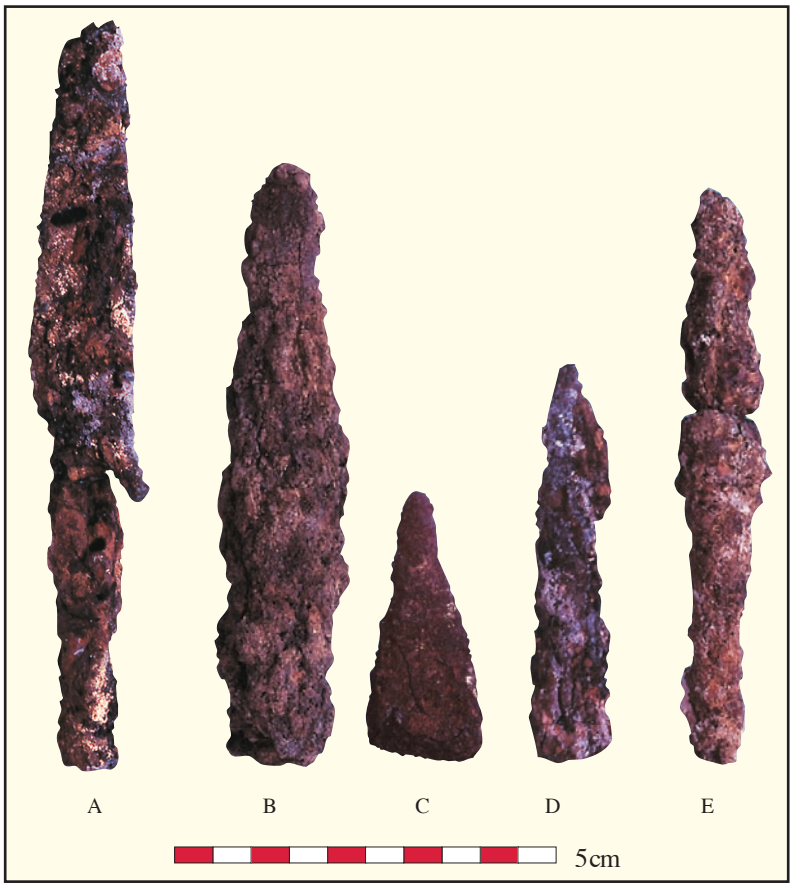


FIG. 22:7 Small points from Noen U-Loke. A. cat. 1814 tanged and barbed arrowhead (4a), Layer 3:9; B. cat. 669 socketed point (4f), Layer 4:10; C. cat 1800 flat cross-sectioned triangular point (4k), Layer 3:4; D. cat 1817 small circular cross-sectioned point (4l), Layer 3:9 Feature 1; E. cat. 1674 large circular cross-sectioned point (4m), Burial 69

6b Bifurcated artefact (Fig. 22:9)

These artefacts bifurcate out from a point with the two ends twisted around to cross over each other. The metal is very thin. The function of these artefacts is not clear.

Dimensions:
Length: 114.0 - 133.1 mm
Maximum width: 29.5 - 34.5 mm
Thickness of metal: 1.7 - 2.0 mm

UNIDENTIFIED FRAGMENTS

7a Unidentified fragment
These have no diagnostic characteristics and therefore cannot be put into any of the above categories. These are fragmentary in condition.

THE FIRST IRON

Two hypotheses were tested in this section. The first, proposed by Piggott and Marder (1984), suggested that iron went through a transitional bimetallic phase between the Bronze and Iron Ages, using the bimetallic spearheads recovered from Ban Chiang as evidence. To test this hypothesis the distribution of bimetallic artefacts at Noen U-Loke was analysed. If the bimetallic artefacts appear early in the sequence before the first iron artefacts, it would provide support for this hypothesis. If bimetallic artefacts appear later in the sequence after the appearance of the first iron, it would reject this hypothesis.

The first bimetallic artefacts occur long after the introduction of iron at Noen U-Loke. The first iron from non-mortuary contexts comes from in Layer 6, where two fragments were recovered (Table 22:3). Bimetallic artefacts from mortuary contexts only appear in Layer 4 where 15 were found. These results provide evidence to reject the hypothesis for a transitional Bimetallic Phase between the Bronze and Iron Ages postulated by Piggott and Marder (1984).

Clearly another explanation to explain the early iron is required. Snodgrass (1980) has suggested that iron went through a period of ornamental use. He developed a framework for the introduction of iron as part of a hypothesis to explain the spread of iron in Europe and the Near East. He believes that iron in Eurasia went through three phases of use during from introduction to widespread use as utilitarian items (Snodgrass 1980:336). When iron first appeared (Stage 1) it was a prestige item, found mainly in tombs, often embellished with precious metals and stones. It was used for ornamental and ritual items, such as rings and daggers, but these had no practical role, being not strong enough for everyday use. Stage 2 saw the onset of iron being used for utilitarian items, but these are still less numerous than their bronze counterparts. Iron gradually disappeared as a material used for prestigious ritual items. In Stage 3, iron tools were more abundant than their bronze counterparts, but bronze was not necessarily supplanted.

Stage 1 is distinguished from Stages 2 and 3 by the absence of working iron, described as "iron used to make the functional parts of the real cutting and piercing implements that form the basis of early technology" (Snodgrass 1980:336). Another way to distinguish between these stages is the presence of intentional carburisation, quenching, and tempering. If an artefact has these qualities, it is likely that it was made for utilitarian purposes. Stages 2 and 3 differ in the ratio of bronze and stone to iron artefacts: in Stage 2 the ratio of bronze/stone practical tools will be more abundant than iron; in Stage 3, this pattern is re-

TABLE 22:2 *Distribution of bimetallic and iron artefacts at Noen U-Loke*

Burial no.	Mortuary Phase	Sex	Age	Count iron artefacts	Count bimetallic artefacts	Comment
1	5	M	MA	-	4	
2	5	-	I	1	4	1 knife
3	5	-	I	-	-	only humerus and radius present
4	5	-	YA	2	-	1 knife, 1 sickle
5	5	M?	YA	2	1	1 spearhead, 1 sickle
6	5	-	I	-	-	
7	5	-	I	-	1	only humerus present
8	5	-	YA	2	-	1 knife, 1 sickle
9	5	-	I	2	4	1 knife, 1 sickle
10	5	F	OA	2	-	1 knife, 1 sickle
11	5	-	I	-	-	
12	5	F	OA	2	-	1 knife, 1 sickle
13	4D	-	I	1	3	possible iron spear
14	4D	M	OA	1	2	1 knife
15	4D	-	A	-	-	
16	4D	F	YA	1	-	1 point
17	4	-	I	-	-	
18	4	-	I	-	-	
19	4	-	I	-	-	
20	4D	-	A	-	-	
21	4D	-	A	-	-	
22	3B	-	I	-	-	
23	4	-	-	-	-	
24	3A	-	I	-	-	
25	4B	-	C	-	-	
26	2	M	MA	-	-	
27	2	M	OA	2	-	1 hoe, 1 socketed spear
28	3B	-	I	-	-	
29	3B	-	C	-	-	
30	3B	F	YA	-	-	
31	4B	-	C	-	-	
32	3B	M	A	-	-	only the cranium survives
33	3B	M	YA	-	-	
34	3B	-	I	-	-	
35	3B	F	MA	-	-	
36	3A	F	YA	-	-	
37	3A	F	OA	-	-	
38	3A	-	I	-	-	
39	3B	M	YA	-	-	
40	3B	F	YA	-	-	
I: infant, C: child, YA: young adult, MA: mid adult, OA: old adult						

Burial no.	MP	Sex	Age	Count iron artefacts	Count bimetallic artefacts	Comment
41	3A	-	C	-	-	
42	3A	M	OA	-	-	
43	4	-	I	-	-	
44	3A	M	Y	-	-	
45	3B	M?	YA	-	-	
46	4B	-	I	2	-	1 knife, one indeterminate item
47	4B	-	A	-	-	
48	3B	F	YA	-	-	
49	3B	F	MA	-	-	
50	3B	M?	YA	-	-	
51	-	-	-	-	-	loose maxilla in a layer 6 pit
52	3B	F	OA	-	-	
53	3B	-	A	-	-	
54	3B	-	A	-	-	only foot bones present
55	3B	-	A	-	-	only foot bones present
56	5	-	I	-	-	
57:1	5	-	A	1	1	1 knife, few and scattered bones
57:2	5	-	12-15y	-	-	few and scattered bones
58	5	-	I	1	-	1 sickle
59	5	-	MA	2	1	1 knife, 1 sickle
60	5	M	YA	-	-	-
61	5	M	YA	1	-	Socketed iron arrowhead lodged in spine
62	4C	F	MA	1	3	1 knife
63	4C	-	I	-	2	
64	5	F	A	-	-	Only the foot bones present
65	5	M?	A	1		1 iron knife blade
66	5	M	MA	-	-	-
67	5	-	YA	-	-	-
68	5	M?	YA	-	1	
69	4C	M	YA	2	4	1 knife, 1 point/arrowhead
70	5	-	C	-	3	bundled secondary child burial
71	5	-	I	1	1	1 knife
72	5	-	-	1	-	1 knife, very fragmentary burial
73	5	-	MA	1	-	1 knife
74	4C	M	YA	-	1	
75	4C	-	YA	1	-	1 knife
76	4B	-	A	1	-	1 knife
77	4B	-	I	-	-	
78	4A	-	MA	-	-	
79	4B	-	I	-	-	
80	4A	-	I	-	-	

Burial no.	MP	Sex	Age	Count iron artefacts	Count bimetallic artefacts	Comment
81	4B	-	I	-	-	
82	4C	F	MA	-	-	
83	4B	-	-	-	-	no bones recovered
84	4B	M?	A	-	-	scattered bones
85	4C	-	I	1	8	1 knife
86	4C	M	YA	2	-	1 knife, 1 spade
87	4C	-	A	-	-	foot bones only
88	4C	-	I	-	-	
89	4C	-	I	-	-	
90	4C	-	I	-	-	
91	4C	-	I	-	-	
92	4B	-	I	-	-	
93	4B	-	I	-	-	
94	4A	M	OA	-	-	only skull and upper body present
95	4A	-	A	1	-	1 hoe or axe
96	4A	-	A	2	-	2 knives
97	4	-	C	-	-	
98	4B	M	A	1	-	1 knife
99	4B	F	OA			
100	4C	-	I	-	-	
101	4	-	A	-	-	foot bones only
102	5	-	I	-	1	
103	4B	-	I	-	-	
104	4A	F	YA	-	1	
105	4A	M	A	3	1	2 knives, one point
106	2	-	I	-	-	
107	2	M	YA	-	-	
108	2	F	OA	5	-	4 bangles, 1 torc
109	4A	-	-	-	-	disturbed
110	4A	F	OA	-	-	
111	4A	M?	YA	-	-	
112	4A	-	I	-	-	
113	4A	F	YA	1	1	1 knife
114	2	F	MA	-	-	
115	5	-	I	-	1	
116	5	-	I	2	1	1 knife, one iron object
117	4B	-	I	-	-	
118	4C	-	A	2	-	2 pendants
119	4B	-	I	-	-	
120	4B	-	I	-	-	

Burial no.	MP	Sex	Age	Count iron artefacts	Count bimetallic artefacts	Comment
121	4A	-	I	-	-	
122	4A	-	I	-	-	
123	4B	-	I	-	-	
124	4A	-	A	-	-	only foot bones present
125	1	-	-	-	-	probably late Bronze Age
126	4B	-	I	-	-	

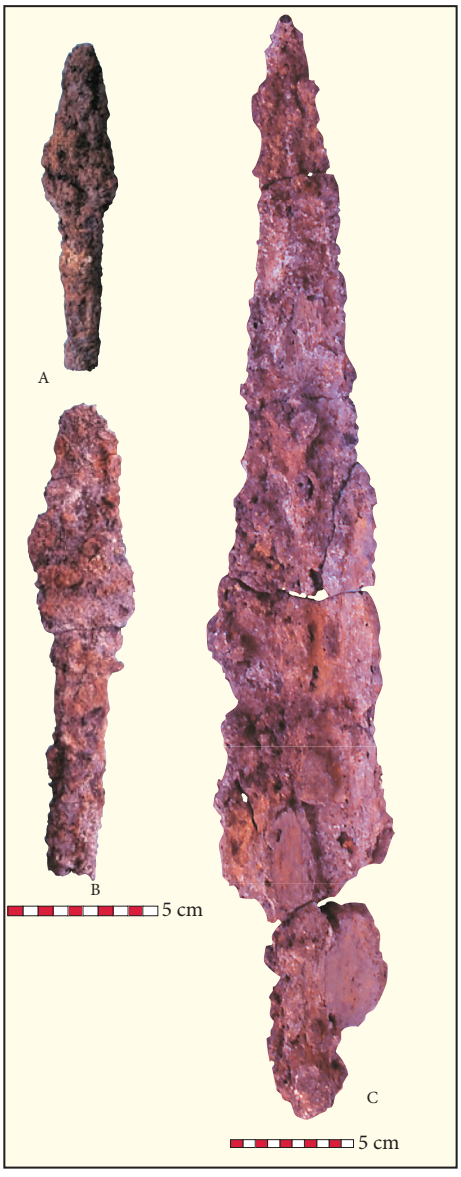


FIG. 22:8. Spearpoints from Noen U-Loke. A. cat. 1131 tanged point, no barbs (4b), Layer 4:3, Feature 3; B. cat. 1807 socketed spearhead (4i), Layer 4:1 Feature 2 C. cat. 640 socketed square-based spear with central ridge (4g), Burial 27

versed. In this research, Snodgrass' (1980) framework is tested against the data from Noen U-Loke.

To test for Stage 1 of Snodgrass's (1980) framework for the introduction of iron, the frequency and types of early iron were examined. The first iron at Noen U-Loke is rare: only two iron artefacts were found in non-mortuary contexts in Layer 6, both in fragmentary condition (Table 22:3). Also recovered were five jewellery items from mortuary contexts (Burial 108). In Layer 5, five artefacts including fragments were encountered from non-mortuary contexts, with only one artefact located in a burial. From Layer 4 onwards, iron became much more abundant, with the number of types and artefacts increasing in both mortuary and non-mortuary contexts.

Iron jewellery appears only in Layer 6 at Noen U-Loke

TABLE 22:3 *Distribution of mortuary and non-mortuary iron by layer at Noen U-Loke*

Layer	6	5	4	3	2	Total
Mortuary iron	5	1	18	24	6	53
Non Mortuary iron	2	5	58	104	9	178

where it is restricted to mortuary contexts and rare, forming only 2.3% of the iron sample. Iron jewellery does not co-occur with utilitarian iron which appears in Layer 5 in low numbers, then increases over time (Table 22:4). The first iron tools include a knife (1b), and two points (4g and 4m), all from Layer 5. This number grows in Layer 4 and 3 to 41 and 93 artefacts respectively. From these results it appears that iron went through a phase of ornamental use (Stage 1).

Snodgrass (1980) prescribes that the difference between Stages 2 and 3 is the ratio of utilitarian iron to bronze artefacts. The only utilitarian bronzes found were two spearheads (cats. 488a and b) recovered from Burial 27 in Layer 5:2. Stone tools comprised ten adzes, one axe head, and one flake, recovered from Layers 6:4 through 2:1. These tools co-occur with utilitarian iron but are not abundant. Stone tools are more plentiful than utilitarian iron only in Layer 6 (Table 21.5). Bronze utilitarian artefacts are never more plentiful than iron artefacts.

These results suggest that iron at Noen U-Loke did not go through Stage 2 of Snodgrass' (1980) framework as

bronze and stone utilitarian tools never outnumber their iron counterparts (Table 22:5). The evidence suggests that Stage 2 did not occur, with iron proceeding directly from Stage 1 of the framework to Stage 3. Ornamental iron artefacts do not co-occur with utilitarian iron, forming a clear distinction between the two. This suggests a change from the ornamental use of iron at Noen U-Loke to its widespread use as the utilitarian metal of choice.

Before fully embracing this revised framework, however, one must consider the factor of site deposition. There is little evidence for intensive occupation at Layer 6 of Noen U-Loke. Primary deposits consist of a few pits, while the rest of the sediment appears to be redeposited from lower Layer 4. This means that if the site was used only as a burial-ground for people living in another part of the site, or another area altogether, it is unlikely that they would bring and dump utilitarian iron artefacts at the site.

To gain support for this theory, trends at other sites intensively occupied during the transition from bronze to iron must be studied. Sites such as Nil Kham Haeng, Ban Chiang, Ban Na Di, occupied during this critical period, have yielded early iron artefacts. Gorman and Charoenwongsa (1976:23) and Stech Wheeler and Maddin (1976:46) have suggested that bimetallic spearheads recovered from Ban Chiang were probably of ceremonial function, basing their arguments on the fact that the spearheads were rare: only three being recovered, all from mortuary contexts dating to the transitional period between the Bronze and Iron Ages. Other examples of early iron at Ban Chiang include four bangles from the same phase as the bimetallic spearheads recovered from the wrists of a child burial (Burial 26) (White 1982:80). More evidence to support this hypothesis has since come to light. Early iron from Nil Kham Haeng has also been discovered in burials, with a number of iron bangles found adorning the wrist of an adult, and another adult found buried with one iron bracelet, which is securely dated to 700 - 500 B.C. (Natapintu 1991:156). At Ban Na Di the first iron artefacts are neck rings, bracelets, and a spear, and are recovered from mortuary contexts. These artefacts are found at the beginning of Mortuary Phase 2, and date to around 400 - 200 B.C. There is then a shift away from ornamental use to utilitarian iron. The above evidence suggests that there was a period where iron was used primarily for ornamental artefacts. The quantitative analysis of the Noen U-Loke iron suggests that iron did go through a period of ornamental use before being supplanted by utilitarian tools.

IRON IN MORTUARY CONTEXTS

The cemetery of Noen U-Loke offers a unique opportunity to explore the social dimensions of iron. At Noen U-Loke iron first appears in mortuary contexts, and it subsequently becomes a popular grave good (Table 22:6). Several types are restricted to mortuary contexts. Artefacts in this group are all rare and limited to single burials. Types found only in non-mortuary contexts are more abundant, and tend to be smaller types of artefact, such as points and fragments. Artefacts found in both contexts include the ridged knife (1a) which is more abundant in burials than non-mortuary contexts. Sickles (2a), hoes (2b), and bimetallic rings are more common in burials. Conversely, knife fragments are far more abundant in non-mortuary contexts (30) than from burials (4).

These results show that the people of Noen U-Loke used mostly large iron artefacts as mortuary offerings. The few fragments found in burials have probably come from the grave fill. The large number of bimetallic rings (3c) and ridged knives (1a) indicate that these played an important part in the ritual of death to the local people. All examples of these two types found in non-mortuary contexts are broken and have probably come from disturbed burials. Non-mortuary artefacts tend to be smaller and include more fragments that those from mortuary contexts. These results show that iron objects played an important role in mortuary ritual at Noen U-Loke.

Distribution of iron by sex

TABLE 22:4 *The distribution of iron, bronze, and stone tools in mortuary and non-mortuary contexts at Noen U-Loke*

Layer	6	5	4	3	2
Iron jewellery - mortuary	5	0	0	0	0
Iron jewellery - non-mortuary	0	0	0	0	0
Utilitarian iron tools - mortuary	0	1	11	20	6
Utilitarian iron tools - non- mortuary	0	2	30	73	5
Utilitarian bronze tools - mortuary	0	2	0	0	0
Utilitarian bronze tools - non-mortuary	0	0	0	0	0
Stone tools - mortuary	0	0	0	0	0
Stone tools - non-mortuary	5	2	2	1	1

TABLE 22:5 *Bronze and utilitarian iron, stone tool ratios in mortuary and non-mortuary contexts*

Layer	6	5	4	3	2
Utilitarian iron : bronze - mortuary	0:0	1:2	10:0	22:0	5:0
Utilitarian iron : stone - mortuary	5:0	3:2	41:2	93:1	10:1
Utilitarian iron : bronze - non-mortuary	0:0	2:0	30:0	73:0	5:0
Utilitarian iron : stone - non-mortuary	5:0	3:2	41:2	93:1	10:1

Sex was able to be determined for only a small proportion of the burials (25.1%), and only these shall be used in this analysis. Nineteen females and sixteen males were positively identified, with individuals of both sexes interred with iron and bimetallic artefacts (Table 21.7). Type 1a knives were found with both male and female graves, as were agricultural implements (Table 22:8). One sickle was found in a female grave, and one winged spade from a male grave. Four male and four female burials contained bimetallic rings. Points are rare in mortuary contexts, three are found in males graves and one in female. There appears to be no restriction in the distribution of iron or bimetallic artefacts according to sex: there are no types found exclusively with either sex in statistically significant numbers.

There is not enough evidence to infer divisions of labour on the basis of the distribution of iron tools at Noen U-Loke. It is possible to generally say, however, that iron is not restricted in distribution by sex. That is neither sex are buried with all of the iron artefacts.

Distribution of iron over age groups

To analyse the distribution over age, the burials are grouped into five broad age groups (Table 22:9). It was decided to use broad groupings for two main reasons. Firstly, the sample of burials for which the age was positively determined was relatively low. If the sample was divided into more groupings, the sample would have been thinly spread, making results less meaningful. Secondly, the determination of age is sometimes less than straight forward, particularly in older individuals. In some cases, age estimates can span several years. Using broad groupings can ensure that these individuals are assigned into the correct age group.

Most age groups are buried with iron artefacts, with the only exception being children (Tables 22:10-11). This may be due to the small sample size (n=8). Six iron artefacts were found with infants (<3 years), four of these being of type 1a. One knife fragment and a sickle constitute the other two. Eight child burials (3-15 years) were identified, none containing iron artefacts. Nine of the 26 young adult burials (15-30 years) have iron. These include: six type 1a knives, three sickles (type 2a), one digging stick (type 2c), one socketed spade (2d), and a variety of points (4b, 4c, 4l, and 4m). Individuals from this age group are interred with the widest variety of artefacts. Iron grave goods from mid adult (30-40 years) graves include type 1a knives, and one point (4g). Eleven old adults (40+ years) are identified. Grave goods include type 1a knives, knife fragments (1f), one sickle (2a), four iron bangles (3a), one torc (3b), and one iron fragment (7a). Bimetallic artefacts are found with most age groups (Tables 22:10 and 11). Old adults are

TABLE 22:6 *Provenance of iron and bimetallic finds at Noen U-Loke*

Type	A	B	N
1a Ridged knife with straight top	22	6	28
1b Unridged curve-bladed knife	-	4	4
1c Machete	-	1	1
1d Long narrow-bladed knife	1	-	1
1e Knife fragment	4	30	34
2a Sickle	8	3	11
2b Hoe	2	3	5
2c Digging stick with straight-edged blade	-	4	4
2d Winged spade	4	-	1
3a Bangles	4	-	4
3b Torc	1	-	1
3c Bimetallic rings	50	15	65
4a Tanged and barbed arrowhead	1	1	2
4b Tanged point with no barbs	1	7	8
4c Tanged ovoid spear	1	-	1
4f Socketed point	-	15	15
4g Socketed, ridged square-based spear	1	-	1
4i Socketed spear no ridge	-	1	1
4k Flat cross-sectioned triangular point	-	8	8
4l Small circular cross-sectioned point	1	17	18
4m Large circular cross-sectioned point	1	35	36
4n Square point tapering to a circular tip	-	5	5
4p Point fragment	-	3	3
6b Bifurcated pendant	2	-	2
7a Unidentified fragment	2	35	37
Total	103	193	296

A Mortuary contexts, B non-mortuary contexts, N Total

TABLE 22:7 *The number of male and female burials containing iron and bimetallic artefacts (nb many burials are incomplete)*

	Male	Female
n burials	25	20
n burials with iron	9	6
n burials with bimetallic artefacts	6	3

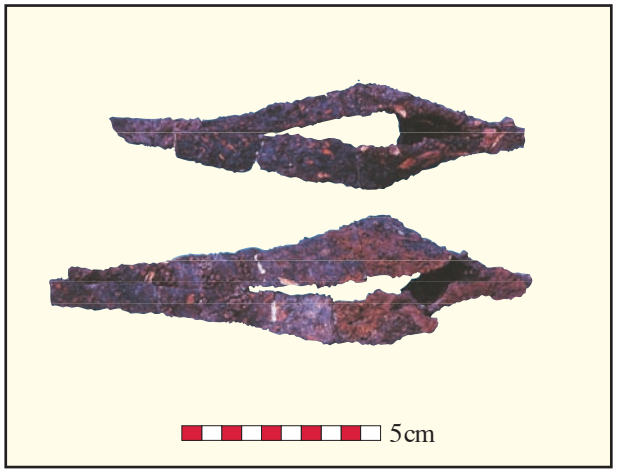


FIG. 22:9 Bifurcated artefact (6b), Burial 118, cat.1686

the only part of the population were not buried with this type of artefact, which may be due to the small sample size (n=11).

There appears to be no age restriction on knives, individuals from all age groups other than children being buried with this type of artefact. Similarly there appears to be little or no restriction of distribution in agricultural implements, which are found with both infants and young adults. Points are restricted to young and mid adults, although the number of points recovered from burials is low.

TABLE 22:8 *Distribution of iron and bimetallic artefacts by type over sex*

Type	Male	Female
Knife	7	4
Sickle	1	2
Winged spade	1	-
Bangles	-	4
Torc	-	1
Bimetallic rings	14	5
Spear	2	-
Arrowhead	1	-
Point	1	1
Hoe	1	-
Spade	1	-
Total	29	17

TABLE 22:9 *Description of age groups*

Group	Age range
Infants	>3 years
Children	3 - 15 years
Young adults	15 - 30 years
Mid adults	30 - 40 years
Old adults	40+ years

The sample of burials is too small to provide information on the division of labour by age. By taking a more general view, however these results provide some interesting information. A total of 26 burials of young adults were encountered, 16 of which contained iron and bimetallic artefacts. This is a significant result as it is most likely that this group were involved in a wide variety of economic activities, ranging from agriculture to hunting or warfare. The fact that infants were also interred with utilitarian iron artefacts suggest two possibilities: Firstly, that relatives interred them with artefacts considered representative of their own lives, or secondly, that these artefacts played an important role in the death ritual. The lack of iron interred with children may be explained by the small sample size.

TABLE 22:10 *The number of burials with iron and bimetallic artefacts over age group*

	Infant	Child	Young adult	Mid adult	Old adult
Number of burials	46	7	23	12	9
Number of burials containing iron	7	0	8	4	4

Distribution of iron and bimetallic artefacts over burial clusters

The division of burials into cluster groups is based primarily on the location of a burial in relation to others. The excavators have divided the burials in Mortuary Phases 3, 4, and 5 into cluster groups. In Mortuary Phase 3, two clusters of burials are found (MP3a and MP3b). Mortuary Phase 4 consists of four clusters (MP4a - 4d). In Mortuary Phase 5, there is no apparent cluster, but one large group. Burials that are do not occur in cluster groups are discounted. The distribution of types and classes of tools was recorded for each burial cluster.

Only burials from Mortuary Phases 3, 4, and 5 were included in this analysis as they were the only ones that

TABLE 22:11 *Distribution of types over age groups*

Type	Infant	Child	Young adult	Mid adult	Old adult
Knife	6	-	5	4	2
Sickle	2	-	3	1	2
Winged spade	-	-	1	-	-
Bangles	-	-	-	-	4
Torc	-	-	-	-	1
Bimetallic rings	25	3	9	10	-
Point	-	-	1	-	-
Spear	1	-	-	-	1
Arrowhead	-	-	1	-	-
Hoe	-	-	-	-	1
Unidentified fragment	1	-	-	-	1
Total	35	3	20	15	12

formed clear cluster groups or in the case of the final phase, a large group. Seventy-four of the 127 burials recovered at Noen U-Loke are clustered into six groups and are labelled according to mortuary phase and cluster. Burials in Mortuary Phase 3 clusters a and b contain no iron or bimetallic material (Table 22:12). Iron from clustered burials first appears in Mortuary Phase 4, but not all burials from this phase iron. Cluster MP4b did not contain iron or bimetallic artefacts, whilst all other clusters from MP4 had both (Tables 22:13).

Clusters 4a, 4b, 4c, and MP5 all contain ridged knives (1a). Other types of iron artefacts appearing in clusters are rare, only one of each type are found. Bimetallic artefacts, however, are more abundant. Bimetallic rings (3c) are found in Mortuary Phases 4 and 5. They are most abundant in Mortuary Phase 4c where 18 were found. (Table 22:13). Not all of the burials in this cluster contained this type, however.

There is little information to suggest division of labour through the clustering of burials, nor to suggest that iron and bimetallic artefacts are useful tools to differentiate differences in mortuary ritual between clusters. There is one interesting trend, however: the lack of iron artefacts in clusters 3a and 3b. It may be that at this juncture, iron though present and well established at the site, played a lesser role in the ritual of death.

TABLE 22:12 *The number of burials with iron and bimetallic artefacts over cluster groups*

Mortuary phase	3A	3B	4A	4B	4C	4D	5
Number of burials	7	18	14	20	15	6	30
burials with iron	0	0	4	3	6	3	16

TABLE 22:13 *Distribution of iron and bimetallic artefacts over cluster groups*

Type	3A	3B	4A	4B	4C	4D	5
Knife	-	-	1	3	5	1	13
Sickle	-	-	-	-	-	-	8
Hoe	-	-	1	-	-	-	-
Spade	-	-	-	-	1	-	-
Bimetallic rings	-	-	3	-	18	5	24
Point	-	-	1	-	1	1	-
Spearhead	-	-	-	-	-	1	1
Arrowhead	-	-	-	-	-	-	1
Pendant	-	-	-	-	2	-	-
Total	0	0	6	3	27	8	47

XXIII. THE REMAINS OF WATTLE AND DAUB STRUCTURES

J.N. CHETWIN

During the course of the excavation, several concentrations of red, burnt daub were encountered. Some were clearly burnt floors, thin and flat, with artefactual and faunal material still on the surfaces. Most were concentrations of burnt clay with no apparent form. James Chetwin took part in the excavation as a supervisor of square C1 in the second season, and has undertaken the following analysis of a sample of this material. His study has revealed the impressions of wood, particularly bamboo, within the some of the clay samples. These suggest a construction technique in which a framework of bamboo with wooden cross-ties was coated in clay. Further examination reveals the thickness of these putative walls.

INTRODUCTION

This chapter will explain the analytical steps taken to illuminate the techniques of building wattle and daub structures at Noen U-Loke. The first step taken will be to build a working classification system to enable the wattle and daub fragments to be placed into categories for easy analysis.

The technology of construction of daub is then described, and theoretical considerations are matched against the material from Noen U-Loke. The construction of wattles is then considered, with special reference to the use of bamboo. This next task will be to explain the variation in our excavated material. Quantification of this variation is possible, and can be used to examine the likelihood of the presence of cognitive models behind the process of construction at Noen U-Loke.

Variation in construction materials will also be examined as will the interpretations of previous authors who have commented on these remains (Indrawooth *et al.* 1991, Nitta 1991). Lastly, the processes that have contributed to the preservation of these remains must be assessed. The literature suggests that such preservation is highly selective and is strongly associated with factors of destruction in prehistory (McIntosh 1974, Bankoff and Winter 1979, Shaffer 1984). These factors, when viewed in a combination appreciative of each other, are expected to provide much useful information on wattle and daub structures at Noen U-Loke.

As the term 'wattle and daub' will be central to the following analysis it is necessary first to define these terms. The wattle refers to the timber framework onto which the daub was applied. Reconstruction of the wattle will be addressed in a later section. Daub is made up of clayey sediment mixed with various additives (Shaffer 1984, Dammers and Joergensen 1996). These additives may be either non-plastic inclusions such as rice straw chaff, or additives of a chemical nature. Inclusions of both types have important effects on the physical and chemical properties of the daub (Dammers and Joergensen 1996).

Classification is at the heart of organisation. Dunnell (1971:44) restricts its meaning to the ideational practice of the "creation of units of meaning by stipulating redundancies (classes)". Thus, it refers to an arbitrary, qualitative, and purely organisational system (Dunnell 1971). The basis of this system involves the description of attributes to denote fields in the system. The following system has been devised to enable the wattle and daub remains to be easily categorised and discussed without exhaustive reference to individual fragments. The scheme follows the system that Dunnell (1971) refers to as a paradigmatic classification. Thus, it revolves around the intersection of variables. The forms of these variables are arranged as the axes on a two-dimensional plane, thus the classification is referred to as a two-dimensional paradigm (Table 23:1). The variables are explicitly defined below as an introduction to the terminology that will be used. It should be noted, however, that while Dunnell (1971:71) notes that dimensions (defined as a set of attributes or variables) are mutually exclusive, different attributes on the same axis of the paradigm can occur on the same object. This is the simplest way to achieve an easily understood classification of a fragment of wattle and daub with several individual features. This slight modification to the paradigmatic classificatory pattern will be made clear by the use of examples below. At this point, classificatory terminology must be explicitly defined. The following terms will be used, and the definitions below have been developed for the ease of use of those terms.

A fragment of wattle and daub is defined as a singular piece of daub that is clearly incomplete and/or broken from a whole original structure. Fragments are labelled as a combination of two letters and a number, ie. 'WD ##'. The letters 'WD' are an arbitrary designation. Complete information on each fragment (and other excavated material) can be found in table 23:3.

An Impression is the cast of a single botanical structure that extends across the entire fragment on its same plane. Thus, casts of straw chaff are not classed as impressions. This was designed so that impressions are deemed to refer

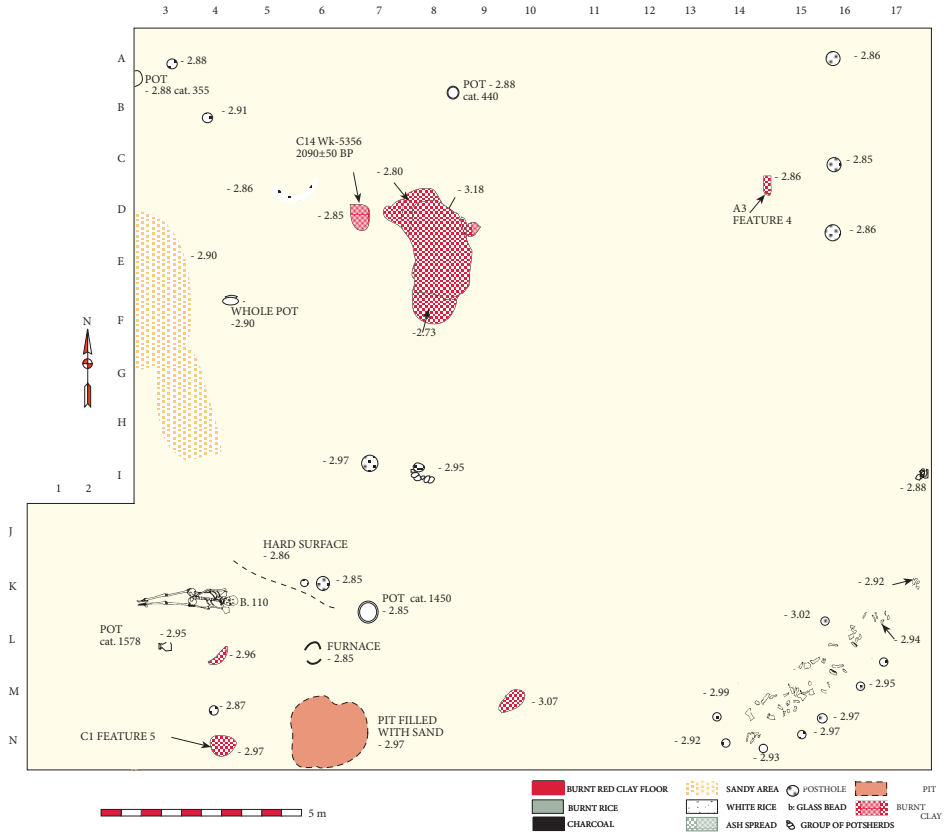


FIG. 23:1 Layer 4:9, showing the location of A3 feature 4, sample WD 32 and of samples from C1 feature 5. There was much evidence for daub structures in this context, particularly in A1-2

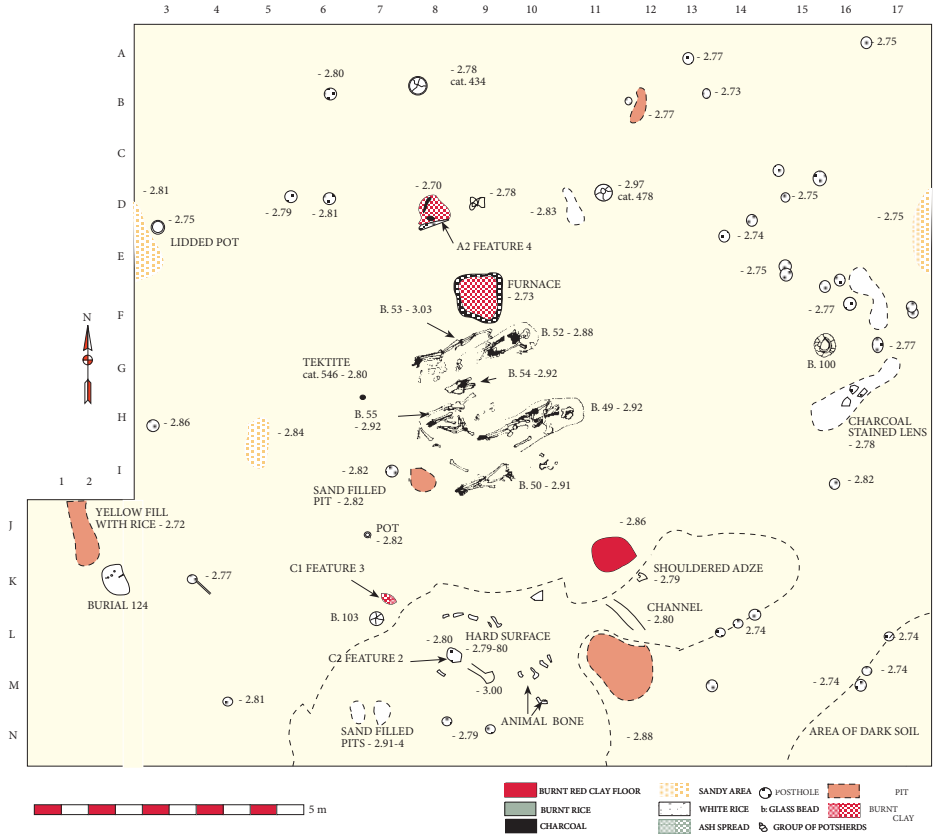


FIG. 23:2 Layer 4:8, showing the location of the daub samples. This layer revealed many structural remains and evidence of domestic activity

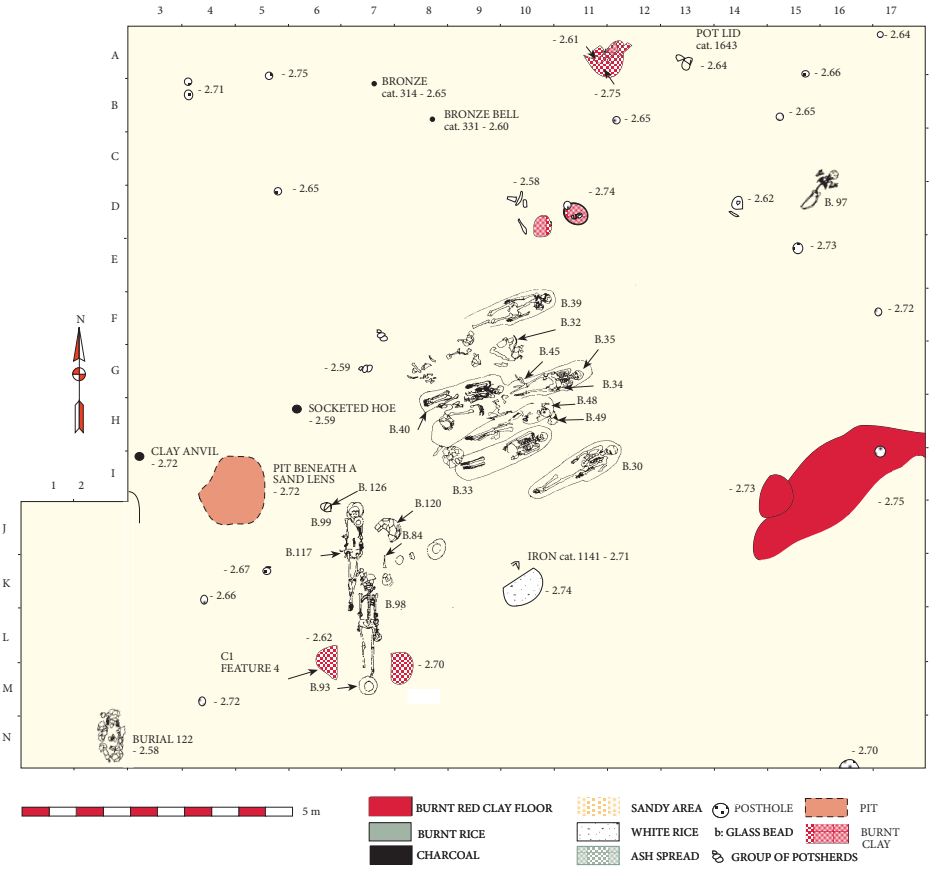


FIG. 23:3 Layer 4:7, showing the location of sample WD 76-7 and 89-93 (C1 feature 4). This concentration of daub was severed with the interment of burial 98. It was one of several examples of construction activity in this layer

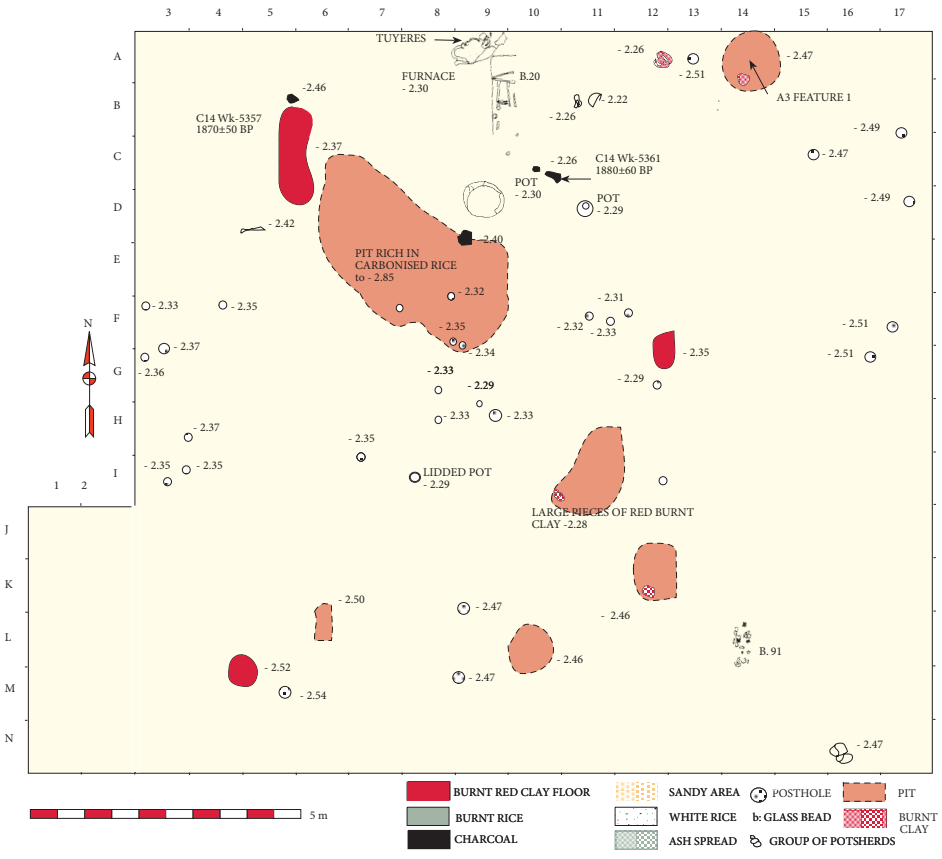


FIG. 23:4 Layer 4:5, showing the location of the daub sample WD 52 from a pit (feature 1) in A3. There were numerous examples of occupation activity in this layer

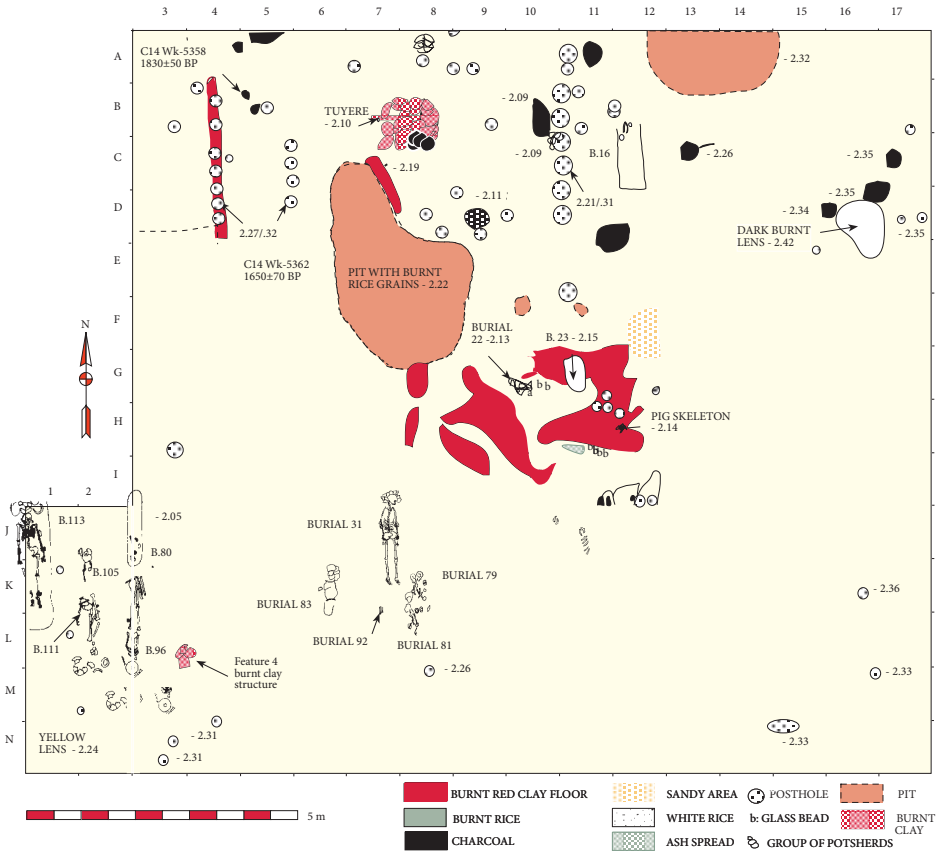


FIG. 23:5 The location of C1 4:3 feature 4. It is notable that this layer has much evidence for constructions in the form of clay floors, as well as furnaces, burning lenses and charcoal concentrations

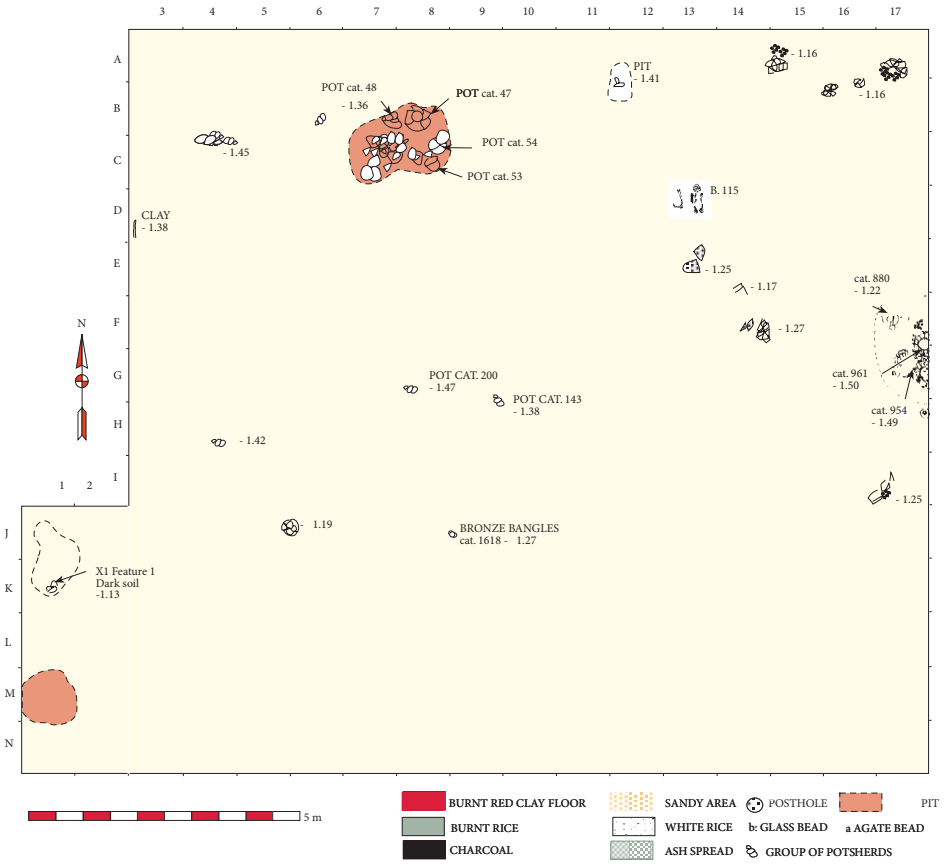


FIG. 23:6 Layer 3:6, showing the location of feature 1, WD 37-48, in square X1



FIG. 23:7 WD 5, C1 4:3 feature 4, to show the impressions of bamboo wattles and straw temper. Length 14.3 cm

primarily to casts of structural materials, originally part of the wattle. Impressions have been divided into several categories for the purpose of this study.

Concave Bamboo Impressions are those where the cast of the bamboo structure is concave. WD 5, pictured in figure 23:7, is a good example.

Convex Bamboo Impressions are those that preserve a convex semi-circular cast. It will be argued in a later section that these impressions are formed by the plastering of daub onto the inside of a longitudinally split bamboo shaft. This has important connotations for construction behaviour.

Flatwood Impressions are defined as timber impressions formed as casts of wood cut on a flat plane.

Roundwood Impressions are those formed as casts of timbers that are not bamboo, but are circular in cross-section. WD 48 is the only example from Noen U-Loke. It is also possible for a fragment of daub to have no impressions at all.

Fragments are referred to as having a face if one entire side of their structure features a consistent curvature combined with a smooth texture. Faces can be described in the following ways:

Flat Faces are those with a face that follows the same plane. It is often observed that flat faces often run parallel to impressions, where both are found on the same fragment.

Concave Faces feature a concave curvature. Their interpretation is difficult, although it is considered possible that processes of destruction could have influenced the shape of the face.

Convex Faces feature a convex curvature. They are not uncommon in the sample, but their interpretation is fraught with difficulty. They will be considered in detail in a later section.

Both faces and impressions are subject to distortion. The assignment of this identification is entirely subjective and based on observations in the laboratory. It is deemed to be appropriate when a given fragment has the basis of a given feature (ie face or impression) but the feature appears incomplete or damaged in some way.

With the terminology now clearly defined, it is now possible to consider the classification system that has been devised for use with the wattle and daub remains from Noen U-Loke. The paradigm is based around the intersection of two axes. One notes the face (or lack thereof) on the fragment. It should be noted that, because of the definition given above (whereby a face covers one side of the fragment), it is not possible for a fragment to possess multiple values on this axis. The potential values on this dimension are Flat (F), Concave (C), Convex (V), and No Face (N). The second axis revolves round the identification of impressions. It is possible for a given fragment to possess multiple noncontradictory values in this field. This merely denotes the presence of multiple impressions on the fragment. The possible values are Concave Bamboo (1), Convex Bamboo (2), Flatwood (3), Roundwood (4), and No Impressions (5). The intersection of these variables in this two dimensional scheme provides a descriptive classification of any given fragment of daub. Table 23:1 provides a graphical representation of the paradigm. When citing the classificatory identification of a given daub fragment, I have chosen to use the following format:

Face Value/Impression Value /Impression Value

Thus WD 5 is identified as an F/1/1, noting the presence of a flat face and two concave bamboo impressions.The aim of this classification is to enable the organisation of the sample into classes based on diagnostic features repre-

Table 23:1 *Paradigmatic Classificatory System*

Faces					
Flat (*F*)					
Concave (*C*)					
Convex (*V*)					
No Face (*N*)					
	Impressions				
	Convex	Concave	Flatwood Bamboo	Roundwood Bamboo	None
	(*1*)	(*2*)	(*3*)	(*4*)	(*5*)

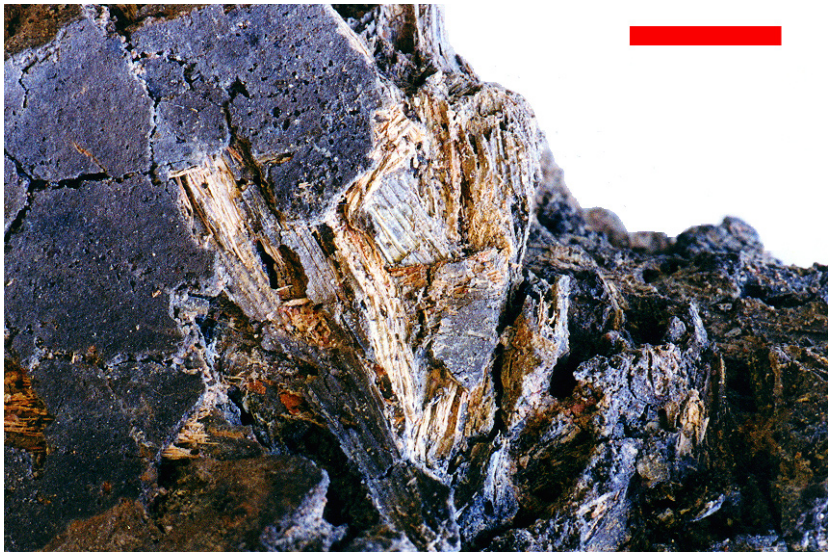


FIG. 23:8 Close-up of WD 17, C1 4:3 feature 4, showing large amounts of rice straw chaff in the daub. Scale 5 mm

sentative of specific technologies of construction.

The complete classification of all the daub fragments collected in the 1998 field season can be found in table 23:3.

In the archaeological record, we find presereved daub as sediment, while the materials used for wattling leave casts in the daub material. The wattle and daub fragments recovered from Noen U-Loke show certain common features visible across the entire sample. The inclusion of straw chaff is one such feature. The presence of this material is clearly illustrated in figure 23:8 a close-up of WD 17. The straw chaff has been identified as rice straw. Rice remains are very common at Noen U-Loke, especially exemplified by the discovery of floors covered in carbonised rice grains and the 'rice-bed' burials. Many publications (Moore 1988, Higham 1989, 1996a, 1996b) have commented on the ubiquity of rice in the prehistoric economy of Southeast Asia. It certainly appears that rice straw chaff was a major feature of building practices.

Another common feature of the daub remains at Noen U-Loke is the extreme variation in colour. This will be examined more fully, as it is apparent that the colour of baked clay remains is correlated with the combustion temperature (Dammers and Joergensen 1996). It is mentioned at this early stage to appraise the reader of this variation before the analysis of construction techniques begins. The colours visible on the daub fragments have been classified by the Munsell © System.

TECHNIQUES OF WATTLE CONSTRUCTION

The raising of a wattle involves the construction of a timber framework upon which the daub is spread. The timber framework must be lashed together (McIntosh 1974) in order to give the daub something to adhere to. Peterson (in McConnell 1992) divided the wattle structures preserved by casts in the daub sample from La Muculufa into 'ranges' based on size. Thus she was able to demonstrate the different uses of various materials. This type of analysis has been frustrated in the Noen U-Loke material because of the ubiquity of rice straw temper in the fabric. Peterson found it possible to measure all the plant casts in the fabric. Such a task is clearly not a productive use of time when one is confronted with the casts of hundreds of rice straws in any given fragment. The material excavated at Noen U-Loke can be easily assessed by construction material as there is an easy distinction between fragments bearing bamboo impressions and those without.

Bamboo appears to have been an important construction material at Noen U-Loke. Of a total 99 fragments, 38 bear the impressions of bamboo structures. The most clear evidence for the way in which bamboo was used can be seen in figures 23:9-10, which show WD 4, an F/1/1 fragment.

The figures above show clearly that bamboo was a major component of structural technology. The bamboo impressions of F/1 and F/1/1 types are noted to run parallel to the flat face. This indicates that the bamboo was a structural support and thus a major element in the construction of the wattle framework. As further examples WD 17 (Fig. 23:11) and WD 5 (elevation shown in figure 23:12, plan in figure 23:7) are shown below.

Fragments WD 58 (Figs. 23:13-14) and WD 89 (Fig. 23:15) show features that have been identified as the casts formed by the plastering of daub onto the inside of longitudinally split bamboo shafts. The best example of this kind of structure unfortunately could not be included in this study as it was taken by Boyd for magnetic residue analysis and dating (Boyd pers. comm.). This fragment, a large section of daub, showed a series of convex casts separated by impressions of the nodal regions of the bamboo. WD 58 (Figs. 23:13-14) shows one such cast. WD 89, another F/2 fragment, shows similar characteristics to WD 58 (Fig. 23:15). When this reconstruction is combined with the evidence from the concave impressions shown above, we may infer that the people of Noen U-Loke made more

efficient use of their bamboo resources by longitudinally splitting the shafts of the bamboo logs. Thus we may make a tentative reconstruction of their building practices where bamboo was in use (Fig. 23:16).

While bamboo appears to have been the most common wood used, other daub fragments bear impressions of different woody structures. These can be divided into Flatwood and Roundwood. Flatwood impressions are present on six fragments from the total sample of 99 (6.1%). However, all bar two of these fragments (67%), come from a single feature (C1 4:8 feature 3). The two fragments bearing a flatwood impression not from this provenance were recovered from different features. One (WD 98) was recovered from C1 4:3 feature 3. This impression is incomplete and distorted. The second (WD 60) is also a distorted impression, recovered from C1 4:5 feature 5. At this juncture, I wish to consider the nature of the wattle structure apparent from the examination of the undistorted flatwood impressions (WD 53, WD 54, WD 55, WD 56). Figure 23:17 shows WD 53 (an F/3 fragment), with a complete flatwood impression. The following page shows a close-up of the flatwood impression preserved on WD 53 (Fig. 23:18). Note especially the cross-wattle running perpendicular to the impression. This photograph also shows a rice grain (centre top of the impression).

Flatwood impressions are relatively standard in size, and five out of six have flat faces. It is therefore apparent that cut timbers ('flatwood' as opposed to bamboo) had a special part to play in building technology at Noen U-Loke. Further consideration of the variation in Flatwood impressions and their relations to other impressions and features will be undertaken in a later section.

Roundwood (defined above as casts of circular section that are clearly not bamboo) impressions are only found on one fragment (WD 48). Because of the solitary nature of this fragment, no analysis has been attempted. It does, however, provide a hint of the variety of materials used for the construction of wattles.

The presence of cross-wattles running perpendicular to the main impression has been observed. McIntosh (1974) notes the presence of lashes used to fix the structure of the wattle together. It is proposed that the cross-wattles are casts of materials used to fill this function at Noen U-Loke. The impressions of cross-wattles are distinguished from chaff temper by being deeper and larger, often over 5 mm in width. They typically run perpendicular to a bamboo impression. Figure 23:9 shows a cross-wattle on WD 4, at the bottom left of the left side impression. Cross-wattles are also visible on WD 58 (Figure 23:13) and WD 53 (Figs. 23:17-18). Of the 99 fragments in this study, 10 have cross-wattles. Unfortunately no evidence is available to illuminate the materials used for these cross-wattles, but McIntosh (1974) in the ethnographic context of a sub-Saharan African village, cites that the inhabitants typically used vines or strips of bark for the purpose of lashing the wattles together. It is possible (but unprovable) that the prehistoric inhabitants of Noen U-Loke used a similar technology.

One of the more unexpected finds was the discovery of matting impressions on several fragments. Figure 23:19 shows WD 21, which, along with WD 7, shows an impression of woven matting on its face. The origins of the matting casts are unknown, but the possibilities of domestic or industrial furniture may be cited. It is also possible that it was pressed against the face during either construction or destruction.

Once the wattle structure is assembled, the next step in wattle and daub construction is the application of daub (McIntosh 1974, Dammers and Joergensen 1996). The materials used to make daub can vary. McIntosh (1974:162) states that the inhabitants of the village of Hani use any "easily available soil" for daub, while Dammers and Joergensen (1996) provide details of a complex system for daub manufacture in medieval Europe. This system involves the procurement of clay from a particular source (usually the nearest available, since large amounts of heavy clay are required for wattle and daub construction [Milisauskas 1972, Startin 1978, Shaffer 1984]), the 'souring' of the clay over a long time period, the sieving



FIG. 23:9 WD 4, C1 4:3 feature 4, shown in plan view, face down. Note the cast of the nodal region of the bamboo shaft, bottom right of the fragment (length 16.3 cm)

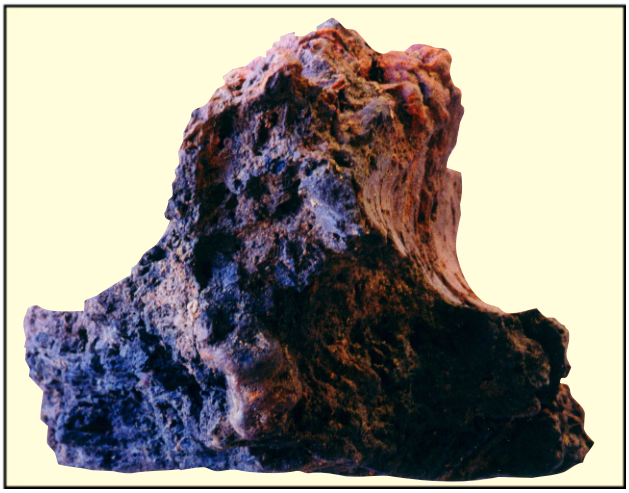


FIG. 23:10 WD 4, C1 4:3 feature 4, shown in elevation. The profile of the face can be seen at the bottom of the illustration (height 6.1 cm)

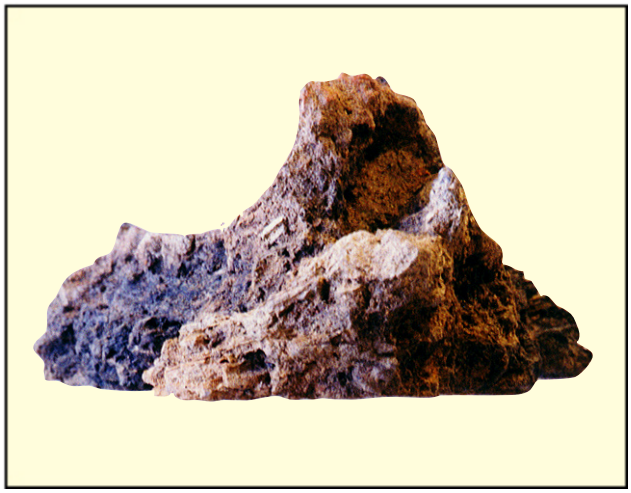


FIG. 23:12 WD 5, C1 4:3 feature 4, another F/1/1 fragment, elevation view. WD 5 is shown in plan view in figure 1 (height 4.3 cm)

of the clay, and finally the addition of various inclusions. We have already seen clear evidence for the use of rice straw as a deliberate inclusion (Figs. 23:8 and 23:20) at Noen U-Loke, but we have no way of identifying any of the other procedures noted by Dammers and Joergensen (1996).

Dammers and Joergensen (1996:639) note that the inclusion of straw in the daub mixture has certain effects on the chemical and physical properties of the daub. Straw reduces the cracking of the daub plaster due to shrinkage when drying, and acts both as a mild fungicidal agent and to increase insulation. Dammers and Joergensen (1996) also propose a series of tests to examine daub remains for evidence of the addition of other additives. They cite that urine, milk and manure were all commonly used in daub manufacture and all have beneficial effects on the finished construction. They propose that tests for Nitrogen and organic Carbon provide an index by which the presence and nature of additives can be assessed. Methodological guides to these procedures can be found in Lewis and McConchie (1994:167-9). Deliberate inclusions are a feature of technology, but other items may find their way into daub as accidental inclusions. Lateritic nodules are



FIG. 23:11 WD 17, C1 4:3 feature 4, an F/1/1 showing bamboo impression. Fragment is face down. Note incomplete impression cast to the left of the fragment (length 4.8 cm)



FIG. 23:13 WD 58, C1 4:9 feature 5, an F/2 fragment, plan view (length 6.9 cm)



FIG. 23:14 WD 58, C1 4:9 feature 5, elevation view. The cast visible running across the fragment is a cross-wattle (height 2.5 cm)

found in the fabric of daub remains with some frequency, but no regularity. Some pieces contain amounts of laterite while others contain none. Figure 23:20 shows WD 49, in which lateritic nodules are quite common. The lack of regularity in the distribution of lateritic nodules in fragments from the same context leads to the conclusion that the nodules were included in the clayey sediment from which the daub was made as a function of their naturally high occurrence in Khorat soils (Boyd 1997). Only one other substance has been found as an inclusion in daub fragments from Noen U-Loke. This was a stray Phimai Black potsherd found embedded in WD 114. It is possible that this inclusion became part of the daub during the process of construction.

Once daub has been manufactured, the next step is to apply the daub to the wattle. Several authors (McIntosh 1974, Dammers and Joergensen 1996) cite that the most common ethnographically recorded technique involved

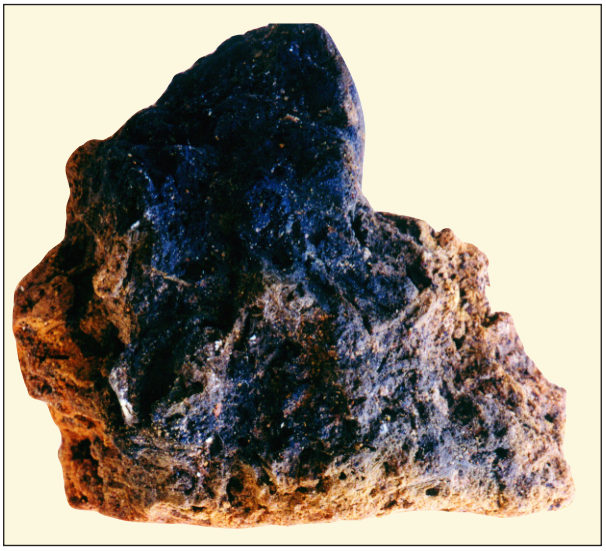


FIG. 23:15 WD 89, C1 4:7 burial 98. elevation view. This figure shows the incomplete cast of the inside of a longitudinally split bamboo shaft (height 4.3 cm)

the throwing of daub onto the wattle from both sides at once. Shaffer (1984), however, notes that his material appeared to be differential in this respect. Daub from some contexts appeared to be representative of heavier plastering than others. Unfortunately, there is no archaeological evidence that can be used to attest this behaviour, but evidence cited above in the reconstruction of building practices. Figure 23:16 suggests that daub was applied to both sides of the wattle. Once the daub was applied to the wall it was then smoothed, either by hand or by the use of wooden implements. Evidence of this behaviour is present in the Noen U-Loke material. Figure 23:21 shows WD 37, a small fragment of daub that preserves what appear to be casts of fingerprints.

Microscopic evaluation of the surfaces of faces indicates that some form of smoothing has been applied to the daub. Ridges and regular pits visible under a low power binocular microscope indicate that some shaping was applied to the faces of daub fragments. It must be mentioned that identification of taphonomic processes active on daub remains is not a factor that has weighed heavily on the minds of any authors cited in this study. Because of this lack of literature it is not wise to make unqualified statements in the identification of surface patterns on daub faces. The evidence would suggest, however, that the daub faces were smoothed by some agency, wooden tools seem to be the possibility most strongly suggested by the ethnographic literature.

Not all the daub sample has flat faces and impressions of botanical structures. Only 46 out of 99 fragments have flat faces. The remainder form a bewildering assortment of shapes, which can be grouped into those with no faces (N/x classification), concave faces (C/x classification), and convex faces (V/x classification). Those with no faces (39 from 99 fragments, or 39.4%) can be seen as coming from within a structure, and simply do not preserve the outside of that structure (Fig. 23:22). The C/x and V/x fragments pose a different sort of problem however. They clearly preserve regular faces. Just as clearly those faces are deliberate constructions (Fig. 23:23).

This variety is not unique to Noen U-Loke, and has

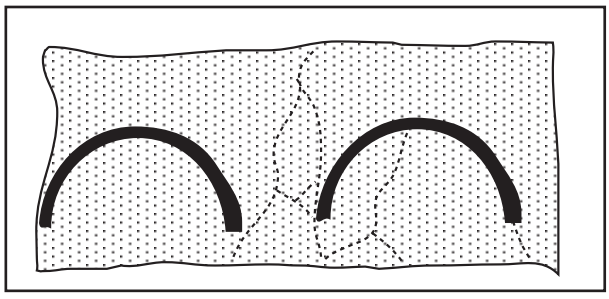


FIG. 23:16 Idealised reconstruction of building practices using bamboo. Dotted lines indicate possible breakage lines that correspond hypothetically to daub fragments able to be recovered archaeologically

been noted by Peterson (in McConnell 1992) and Shaffer (1984). A variety of explanations for these curved shapes has been proposed. Peterson, speaking from a securely domestic context, argues that certain structures within a wattle and daub building may require curved surfaces, and that daub technology was admirably suited to the fulfilment of this requirement. She states that the presence of such features as entryways, smoke holes, wall niches and ledges could explain the existence of curved daub surfaces. It is also possible that clay ovens and salt burning furnaces could feature such curved faces. Shaffer (1984:416) cites evidence that curved corners on daub walls experienced less cracking than strict 90° corners. Shaffer (1984:416) refers to the recovery of daub fragments with "smooth, convex surfaces" at the corners of buildings. While these contributions may help our understanding of many fragments, others (like WD 52 [Fig. 23:23]) do not fit this pattern. These fragments, semi circular in section, are mystifying. While the regularity of their curvature (Fig. 23:23) demands explanation, it is difficult to assign interpretations of their function. Nitta (1991:8-9) has remarked upon similar structures in a different context. He states that his excavations recovered "clay replicas" of "half-split logs" that served as building foundations. He goes on to state that the 'replicas' were formed by the replacement of rotten logs, placed under a building to "prevent non-uniform subsidence", with soils. While this theory, supported by pictures of the 'replacement logs' (Nitta 1991:37, plate 11), looks feasible, if optimistic, the remains from Noen U-Loke that physically resemble these features (if we presuppose that a burning process had baked them hard [eg. WD 52, Fig. 23:23]) are heavily tempered with rice chaff. This fact also undermines theories that these



FIG. 23:17 WD 53, C1 4:8 feature 3, an F/3 fragment. Note the cross-wattle running perpendicular to the impression (length 10.3 cm)

fragments may be fossilised postholes. Nitta's identifications can therefore not be transferred to this particular case. The identification of V/x and C/x fragments cannot be made with any certainty without further whole finds confirming their nature. There is only one example of a C/x fragment, so no analysis of this class will be undertaken. There is, however, notable spatial patterning of V/x remains. Of the 12 V/x class fragments, 10 come from C1 4:9 feature 5. This feature also contains fragments of F/1 classification, however, so we cannot divorce this feature from the broader context of wattle and daub construction. It is clear, however, that this feature preserves evidence for differential construction practices.

QUANTIFICATION OF DAUB FRAGMENTS

It is the task of this section to present some elementary quantification of the variation apparent in daub fragments from Noen U-Loke. The nature of these analyses, because of the very limited sample sizes in the study, is experimental. The entire sample of fragments recovered in the 1997-98 field season numbers 99. Thus achieving statistical significance with the following analyses is a problem. Nevertheless, these analyses have been undertaken, partially because it is believed that they will provide valuable pointers to techniques of construction at prehistoric Noen U-Loke, and partially to set a benchmark for any further work that might be done on wattle and daub remains from this site. In deference to this consideration, however, only very simple quantification will be undertaken, in order to preserve some meaning in the findings. The main aim of these analyses is to try and identify evidence for the existence of cognitive models for construction. Evidence for this is liable to be identified in demonstrated standardisation in certain physical dimensions visible (and subject to measurement) on daub fragments. This sort of analysis is based on the work of Shaffer (1984). McConnell (1992) has tentatively identified the presence of standardised units of measurement in bronze age Sicily , and while this is not possible here, it remains the *raison d'etre* of these analyses.

BAMBOO DIAMETER

The diameter of all bamboo impressions in the study was measured by use of a template, or callipers where possible (Table 23:2). WD 23, 27 and 30 preserve bamboo impressions, but too small in area to be measured and so were not used in this analysis. It seems clear from the above that the size of bamboo was a selected factor. All the bamboo impressions lie between the boundaries of 25-60 mm. Selection factors could be conscious or unconscious; cognitive, or based on the simple occurrence of bamboo of this size around the site. Sadly we lack the contextual data required to address this problem. Ethnographic ob-



FIG. 23:18 Close-up of flatwood impression of WD 53, C1 4:8 feature 3, showing greater detail of cast structure. Note rice grain top centre of photograph (width of impression: 2.1 cm)

servation in the modern environs of Noen U-Loke by the author would suggest, however, that bamboo culm (stem) diameter varies more widely than 35 mm on a single plant. Thus it is possible that bamboo for wattling was selected for size.

ANALYSIS OF DAUB DEPTHS

The distance (D^f)between the flat face of F/1 and F/1/1 fragments and the impressions of those fragments was measured. Figure 23:25 shows this visually. Where distances varied across a fragment $D^f$was calculated as a mean.

$\underline{D^f}$, n=15 for all F/1 and F/1/1 fragment
Mean = 24.46 mm, standard deviation = 3.50

This analysis implies a standardised model for the thickness of daub used at Noen U-Loke. As noted above, this analysis suffers irremediably from a small sample size. Nevertheless, the small size of the standard deviation value gives us reason to suspect a standardised mode of daub application to a wattle framework.

This analysis could, of course, be applied to F/3 and F/3/3 fragments, but as only a handful were recovered,



FIG. 23:19 WD 21, C1 4:3 feature 4, showing matting impressions on face (length 3.4 cm)

such an effort would be rendered useless by the error associated with such a small sample. Another possible analysis involves the measurement of distance between wattle elements (Shaffer 1984) on F/1/1 fragments and the calculation of means and a standard deviation for this figure (D^i). While a lack of enough samples has lead to the omission of this analysis from quantification attempts, this measurement would be a useful addition to this study. It would provide a measure of the standardisation of wattle placement, although it is possible that provenance controls would be required, as different provenances may represent different constructions or different elements of one construction.

FACTORS OF DEPOSITION AND PRESERVATION

The following assessment of the processes of destruction of wattle and daub structures will be made (McIntosh 1974, Bankoff and Winter 1979, Shaffer 1984) before the evidence from Noen U-Loke is considered. This evaluation will then permit inferences about the nature of the daub remains from Noen U-Loke.

Ethnographic destruction of wattle and daub structures (McIntosh 1974, Bankoff and Winter 1979, Shaffer 1984) has described numerous factors of decay. McIntosh (1974) has described the detrimental effects of undercutting, cracking and flaking on earthen structures. These are caused primarily by rain splash at the base of the wall and capillary movement of moisture to promote the destruction of the daub, usually from the base of the structure. Cracks may also form in the daub due to the action of moisture in the fabric, although the presence of straw temper alleviates this problem to a certain extent (Dammers and Joergensen 1996). Drastic temperature alterations cause this effect to be at its most severe. McIntosh states

that, when undercutting has progressed far enough, the wall will fall, only leaving a very small stump. Wattle and daub is very vulnerable to moisture, and McIntosh cites that it required a constant effort to upkeep. He also states that wood used to construct the wattle was often recycled when a building collapsed, thereby nearly destroying the daub structures.



FIG. 23:20 WD 49, showing lateritic nodules in the fabric. They appear as dark rounded lumps in the daub (length 13.7 cm)

McIntosh's (1996) study mentions that the preservation of daub in an archaeological context requires heat treatment. However, he does not examine the nature of firing on daub structures in detail. When one examines the fragments taken from Noen U-Loke, it is obvious that heat modification has taken place. Munsell colour readings for all fragments show that the daub fragments excavated have all been heated under varying conditions.

Shaffer (1984) is responsible for the most complete studies of daub structures, among these being the experimental destruction of daub buildings. He excavated a hut (previously constructed experimentally) destroyed by a fire as a method of refining his analytical tools. It should be noted that Shaffer (1984:80) states that the fire was lit in a way designed to simulate an accidental conflagration. He noted that reddish (Munsell 5YR 3/3 to 7.5YR 3/4) soil stains were found corresponding inexactly to the run of the original daub walls and that daub fragments could be scattered over a wide area. He states that the collapse of the structure was almost certainly a result of the combustion of the wattle framework. With the destruction of the botanical elements of the construction the daub collapsed under its own weight. The colours present on daub fragments from Noen U-Loke would suggest that the daub was subject to burning. It is therefore pertinent to further examine the issue of the behaviour of heated daub.

Shaffer (1984:550) contrasts the evidence from many sites that large quantities of daub are used in construction of wattle and daub buildings (Bankoff and Winter 1979, Shaffer 1984) with the general paucity of daub in the archaeological record. Shaffer's Acconia study was unusual in the large amount of daub recovered, but it must be noted that all the daub was sintered (baked). Clearly daub caught in some form of conflagration is far more likely to survive than unsintered daub, which will normally decay totally (McIntosh 1974, Bankoff and Winter 1979). Bankoff and Winter have provided evidence that the amount of daub that would bake into a state conducive to archaeological preservation is very small. They cite (Bankoff and Winter 1979:13) that only one per cent of the daub in their experimental study was fired to a state that would enable it to survive in an archaeological context.

While it is tempting to use this figure as a base for analysis, it must be remembered that the circumstances of this experiment involve variables that cannot be controlled for in a prehistoric example derived from excavated archaeological evidence (Shaffer 1984). Shaffer's own experiments came to the conclusion that only three per cent of the daub caught in an accidental fire would be sintered. Clearly, these results demonstrate the rather poor survival of daub in constructions destroyed by accidental burning. Shaffer (1984) cites a passage from Vitruvius's *Ten Books on Architecture* (1960:57, cited in Shaffer 1984:553) in which the author derides wattle and daub as being "made to catch fire, like torches". Shaffer cites some evidence that the daub in his study was deliberately sintered in order to preserve it for future construction. His primary argument is the massive quantities of daub recovered at Acconia. This is clearly not the case at Noen U-Loke, and we must rather consider the likelihood of accidental combustion.



FIG. 23:21 WD 37, X1 3:6 feature 1, showing 'fingerprints'. The dark rounded inclusion is a lateritic nodule (length 4.2 cm)

Further evidence for the nature of the fire that preserved the Noen U-Loke daub can be found in the colour of the daub itself. Shaffer's experiments with an "accidental" fire showed that recovered daub differed greatly in colour. It is possible to link this variable to conditions of combus-

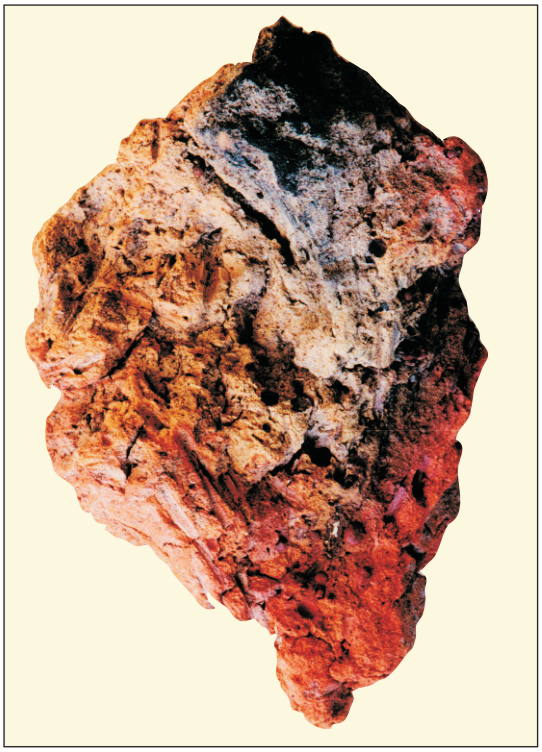


FIG. 23:22 WD 36, C2 4:8 feature 2, an N/5 fragment. Rice chaff inclusions are still very apparent in this fragment, confirming its technological nature (length 10.9 cm)

tion. Shaffer (1984:114-5) states that accidental burning of an experimental burning preserved "unsintered" daub of a dark yellowish brown (10YR 4/4) colour, while "fire-reddened" and "sintered" daub recorded colours of dark brown with reddish brown (7.5YR 3/4 with 5YR 4/3) and red-black (2.5YR 5/6 - 2.5YR 2.5/0) respectively. Bankoff and Winter (1979) do not record Munsell colours for their experiments, but Dammers and Joergensen (1996) record colours for briquettes subject to specific firing temperatures and also specific tempers. They also provide useful information on the survival of straw chaff after firing. Such remains are visible in the Noen U-Loke material under light microscopy, and sometimes under the naked eye (Fig. 23:8). The colours listed below, from Dammers and Joergensen (1996:646, Tables 3[a] and [b]) are given under the untested assumption that no additives other than straw were added to the Noen U-Loke daub (the difference to the colours is not great in any case, and is only found at the value level [Munsell Color 1976]). Table 23:3 summarises the data from this investigation, it must of course be remembered that this experiment took place under highly controlled circumstances and with parameters that differ markedly from that of an accidental fire. Nevertheless, the data on the behaviour of daub under heating is still valuable.

Salmang (1961) notes the occurrence of black specks on the surfaces of clay bodies fired under reducing conditions. He also notes the possible differences in colour on clay bodies fired in the presence of water vapour and other materials. The overwhelming impression is one of diversity in colours, far exceeding the reports of Dammers and Joergensen (1996) and the limited number of colour reports in Shaffer (1984). Fragments at Noen U-Loke vary from very dark (eg. WD 17) to a variety of shades of red and yellow (eg. WD 36). This may be evidence for a widely varied set of combustion conditions, indicative of an accidental destruction (but see Boyd and Parr, chapter XXIV).

The temperature of combustion has also been related to



FIG. 23:23 WD 52, A3, 4:5 feature 1, elevation view, a V/5 fragment. This fragment is heavily tempered with chaff and clearly preserves a semicircular section (height 5.3 cm)

the survival rate of straw chaff (Dammers and Joergensen 1996:646). They cite a range of possible modifications of straw ranging from "completely unmodified" to "white ash". In their experiments at temperatures up to 200°C straw chaff is unaffected, while it converts to "carbonised" material at 300°C, "brown ash" at 400°C, "grey ash" at 500°C, and "white ash" at 600°C and above. The microscopic analysis of Noen U-Loke daub remains revealed both "completely unmodified" and "carbonised" straw temper, but no ash remains. Even when the long period of heating in Dammers and Joergensen's study is taken into account, I agree that the Noen U-Loke daub fragments do not seem to preserve evidence of being in a hot fire. Figure 23:26 shows WD 62,

Table 23:2 *Bamboo impression diameters (mm)*

Diameter	n
0 - 10	0
11 - 20	0
21 - 30	4
31- 40	17
41 - 50	9
51 - 60	4
61 - 70	0
71 - 80	0

n=34 Mean 40.75 mm, s.d. 9.62

adhering to which are white fibrous plant remains and charcoal to the left of the photograph.

The macroscopic data suggest that the preservation of wattle and daub remains at Noen U-Loke is the function of low temperature firing, most probably accidental. The literature, however, is not well endowed with information on the behaviour of daub clays under various conditions of combustion, and thus only very preliminary conclusions can be drawn. These do, however, form an integral part of any consideration of wattle and daub technology.

CONCLUSIONS AND RECONSTRUCTIONS OF HUMAN ACTIVITY

The site of Noen U-Loke preserves a prehistoric sequence rich in evidence of a variety of human activities. The daub fragments recovered in the 1997-98 excavations have been demonstrated to be the material residue of a complex set of behaviours, ranging from the cognitive design of construction practices to the use of additives to improve desirable properties in the daub. This has been outlined in order to ascertain what the wattle and daub might represent in terms of constructional activity.

Three immediate possibilities can be recognised from archaeological and ethnographic evidence. The first proposes that the fired daub could have been part of the working of a kiln or furnace under controlled heating conditions. The daub has been examined for evidence of deliberate heating, and it was found that intact straw temper and variety in colour suggested that this was not the case. Fired clay is commonly found in association with pyrotechnological features in Iron Age Thailand (Nitta 1991), but sintered daub fragments, on careful examination, present a different technology to hearth and kiln features. In a modern ethnographic context, tempered clay constructions are still used in Northeast Thailand to burn charcoal. These burners take the form of small hemispherical mounds placed on the top of larger mounds, through which draft bellows are tunnelled. A burner examined at Ban Nong Ngiu showed that a series of clay layers had been built up on the structure, all heavily-tempered with rice chaff. However, in certain key areas this structure differed markedly from the Noen U-Loke remains. Firstly, the burner did not contain any evidence of a wattle superstructure. Second, the burning apparent on the inside of the charcoal oven presented different colour characteristics to the Noen U-Loke daub fragments, while no bamboo was associated with the burner, despite its presence within 10 m.

The second possibility revolves round the use of daub for domestic structures. Most of the published literature concentrates on such daub (Mate 1970, Milisauskas 1972, McIntosh 1974, Startin 1978, Shaffer 1984, Grygiel and Bogucki 1986, McConnell 1992). This may represent a greater likelihood of archaeologists working in Europe to assign daub to a domestic context. However, many of these studies are backed up by detailed ethnographic and experimental work (McIntosh 1974, Shaffer 1984) and are thorough and rigorous in their reconstructions. Archaeological reconstructions of domestic structures in Southeast Asia are nearly unknown. Recent authors have entertained the notion of domestic constructions as viable interpretations for their excavated evidence (Nitta 1991), but little explicit work has been done on the subject.

Personal observations on modern forms of housing in Northeast Thailand reveals that, if the modern forms can be regarded as representative of construction in prehistory, little evidence of prehistoric construction would preserve in the archaeological record. Much construction is undertaken using solely botanical elements, supplemented by easily available modern materials, such as corrugated iron. Dried clay was observed to have been used as a sealing agent in a rice store, but no examples of wattle and daub construction were noted in the area surrounding the site of Noen U-Loke. Thus, few conclusions can be offered on this second possibility. The use of wattle and daub in domestic construction cannot be discounted, but nor can it be proved.

The third possibility is the use of daub for industrial buildings. This possibility has been cited by Indrawooth *et al.* (1991:99), stating that "it was accustomed for early people in S.E.A. to build the roof of a kiln with bamboo and reed screens which were covered in mud". Kiln reconstructions by Barbetti and Hein (1989:58) show the presence of roofs on both surface and in-ground kilns, but do not list possible roofing materials as part of their excavated sample (Barbetti and Hein 1989:60, Table 1). Indrawooth *et al.* do not qualify or reference their statement, so no further investigations can be undertaken of this possibility. It should be noted that pyrotechnic remains have been recovered at Noen U-Loke in spatial proximity to daub remains, so this possibility must be taken seriously. Unfortunately, a lack of solid evidence prevents any firm conclusions being made.

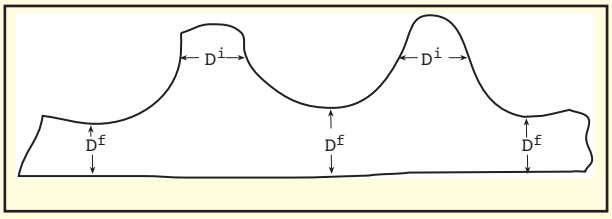


FIG. 23:25 Idealised daub fragment showing analytical measurements

All three hypotheses considered above seem reasonable, but lack any supporting evidence from either the Noen U-Loke excavations or the extant literature. The technological basis of wattle and daub construction is thus firm, but its cultural context is shaky.

The aim of this study has been to illuminate con-



FIG. 23:26 WD 62, C1 4:9 feature 5, showing fibre and charcoal *in situ*

struction practices at Noen U-Loke. The identification of wattle and daub technology has allowed us to consider further the ways in which the people of prehistoric Thailand adapted to their environment. It also proves that such practices as the use of plants and building in clay are phenomena available for investigation to archaeologists in Southeast Asia. It is apparent, furthermore, that the study of prehistoric buildings is able to complement other studies. McConnell (1992) has tentatively identified the presence of a unit of measurement in Bronze Age Sicily, and Shaffer (1984:600) states that his "attention to" the minutiae of building technology stemmed from the belief that much potentially informative variability would be present in those small pieces of buildings that had survived. It is apparent that Shaffer was proved correct in his belief, and it was the design of this chapter to take the first small steps in correcting the sad lack of this attention in the field of Southeast Asian archaeology.

The evidence recovered from Noen U-Loke would suggest that construction of wattle and daub building elements was a careful and detailed procedure. Throughout this study, such terms as wall and roof have been avoided, as they carry implications that cannot be unequivocally supported by the excavated evidence. If we may presuppose, for the sake of these broad conclusions only, that the daub fragments represent a wall construction, then we may easily see how that wall was constructed. Bamboo uprights, split longitudinally and wound about with cross-wattle elements, would have supported a daub plaster mixed with rice chaff. It is also tempting (but, again, little more than supposition) to interpret the flat wood impression bearing daub fragments as functionally distinct from those bearing bamboo impressions.

Several possibilities of further research in this field can be identified. Dammers and Joergensen (1996) have only recently proposed a method for examining daub technology on a chemical level. Applications of this technique on prehistoric daub are unknown to this author, but it would undoubtedly provide an interesting experiment. Shaffer (1984) provides a number of innovative analyses aiming to identify prehistoric construction techniques. As most of these require a large sample, they have not been attempted. Perhaps, if a larger sample of Southeast Asian daub is assembled then Shaffer's techniques would be of use. Experimental archaeology is a field with a great potential utility in the study of prehistoric buildings. Shaffer (1984) has demonstrated how such studies can refine and improve our archaeological interpretations of these structures, while studies such as those by McIntosh (1974) and Bankoff and Winter (1979) have demonstrated vital information on the processes of deposition to which they are subject.

TABLE 23:3 *The Wattle and Daub Sample*

RECORD	PROVENANCE	B. Imp D.	B. Imp D.	F. Imp W.	F. Imp W.	FACE	NOTES	CLASSIFICATION
WD1	c1 4:3 f4	40.0				N		N/1
WD2	c1 4:3 f4	45.0				F		N/1
WD3	c1 4:3 f4	55.0				F	x	F/1
WD4	c1 4:3 f4	42.5	35.0			F	x	F/1/1
WD5	c1 4:3 f4	50.0	35.0			F		F/1/1
WD6	c1 4:3 f4	50.0				N		N/1
WD7	c1 4:3 f4	50.0				F		N/1
WD8	c1 4:3 f4	45.0				N		N/1
WD9	c1 4:3 f4					N		N/5
WD10	c1 4:3 f4	60.0				N		N/1
WD11	c1 4:3 f4	45.0				F		F/1
WD12	c1 4:3 f4					F	x	F/5
WD13	c1 4:3 f4					F		F/5
WD14	c1 4:3 f4					F		F/5
WD15	c1 4:3 f4	52.5				F	x	F/1
WD16	c1 4:3 f4					N		N/5
WD17	c1 4:3 f4	35.0				F		F/1/1
WD18	c1 4:3 f4	40.0				N		N/1
WD19	c1 4:3 f4	55.0				N		N/1
WD20	c1 4:3 f4					F		F/5
WD21	c1 4:3 f4					F		F/5
WD22	c1 4:3 f4	inc.				N		N/1
WD23	c1 4:3 f4	40.0				N		N/1
WD24	c1 4:3 f4	30.0				N		N/1
WD25	c1 4:3 f4					F		F/5
WD26	c1 4:3 f4					F		F/5
WD27	c1 4:3 f4	inc.				N		N/1
WD28	c1 4:3 f4					C		C/5
WD29	c1 4:3 f4	45.0				F		F/1
WD30	c1 4:3 f4	inc.				N		N/1
WD31	c1 4:3 f4					F		F/5
WD32	a3 4:9 f4					F		F/5
WD33	c2 4:8 f2					V		V/5
WD34	c2 4:8 f2					N		N/5
WD35	c2 4:8 f2					F		F/5
WD36	c2 4:8 f2					N		N/5
WD37	x1 3:6 f1					N		N/5
WD38	x1 3:6 f1					N		N/5
WD39	x1 3:6 f1					F		F/5
WD40	x1 3:6 f1					F		F/5
WD41	x1 3:6 f1					F	x	F/5
WD42	x1 3:6 f1	30.0				N		N/1
WD43	x1 3:6 f1					F		F/5
WD44	x1 3:6 f1					N		N/5
WD45	x1 3:6 f1					N		N/5
WD46	x1 3:6 f1					N		N/5
WD47	x1 3:6 f1					F	x	F/5
WD48	x1 3:6 f1	20.0	20.0			F		F/4/4
WD49	c1 4:3 f4	57.5	35.0			F		F/1/1
WD50	c1 4:3 f4	35.0				F		F/1

Table 23:3 *The Wattle and Daub Sample* (cont.)

Record	Provenance	B. Imp D.	B. Imp D.	F. Imp W.	F. Imp W.	Face	Notes	Classification
WD51	c1 4:3 f4	50.0				F		F/1
WD52	a3 4:5 f1					V		V/5
WD53	c1 4:8 f3			26.0		F	x	F/3
WD54	c1 4:8 f3			29.0	20 (inc.)	F		F/3/3
WD55	c1 4:8 f3			15 (inc.)		F		F/3
WD56	c1 4:8 f3			14 (inc.)		F		F/3
WD57	c1 4:9 f5					F		F/5
WD58	c1 4:9 f5	33.5				V	x	V/2
WD59	c1 4:9 f5	37.5				N		N/1
WD60	c1 4:9 f5	35.0		inc.		N		N/1/3
WD61	c1 4:9 f5					V		V/5
WD62	c1 4:9 f5	50.0				F		F/1
WD63	c1 4:9 f5					N		N/5
WD64	c1 4:9 f5					V		V/5
WD65	c1 4:9 f5	40.0				N		N/1
WD66	c1 4:9 f5					V		V/5
WD67	c1 4:9 f5					V		V/
WD68	c1 4:9 f5					V		V/5
WD69	c1 4:9 f5	40.0				N		N/1
WD70	c1 4:9 f5					V		V/5
WD71	c1 4:9 f5					V		V/5
WD72	c1 4:9 f5	40.0				N		N/1
WD73	a2 4:8 f4					N		N/5
WD76	c1 4:7 f4					F		F/5
WD77	c1 4:7 f4					F		F/5
WD80	c1 4:9 f5					N		N/5
WD81	c1 4:9 f5					V		V/5
WD82	c1 4:9 f5					V		V/5
WD83	c1 4:9 f5					N		N/5
WD89	c1 4:7 f4	40.0				F		F/2
WD90	c1 4:7 f4					N	x	N/5
WD91	c1 4:7 f4					N		N/5
WD92	c1 4:7 f4					F		F/5
WD93	c1 4:7 f4					F	x	N/5
WD96	c1 4:3 f4					N		N/5
WD98	c1 4:3 f4	25.0		inc.		F		N/1/1
WD99	c1 4:3 f4	30.0				N		N/1
WD100	c1 4:3 f4					F		F/5
WD101	c1 4:3 f4					F		F/5
WD102	c1 4:3 f4	40.0				N		N/1
WD103	c1 4:3 f4					F		F/5
WD104	c1 4:3 f4					N		N/5
WD105	c1 4:3 f4					N		N/5
WD106	c1 4:3 f4					N		N/5
WD107	c1 4:3 f4					N		N/5
WD108	c1 4:3 f4					F		N/5
WD109	c1 4:3 f4	40.0				F		F/1
WD110	c1 4:3 f4					F		F/5
WD114	c1 4:3 f4					F		F/5

Samples wd9, wd22, wd27 and wd30 have Bamboo Impressions that are too small in area to be measured. Notes: 'x' in the Notes column denotes the presence of a cross-wattle. Measurements in millimetres. F. Imp. W. and B. Imp. D. refer to Flatwood impression width and Bamboo Impression diameter, respectively. Inc: incomplete.

XXIV. GEOCHEMICAL ANALYSIS OF FRAGMENTS OF BURNT AND IMPRESSED CLAY (DAUB) FROM THE THE ARCHAEOLOGICAL LAYERS AT NOEN U-LOKE, AND THE DETERMINATION OF ITS PROBABLE ORIGIN

W. E. BOYD AND J. F. PARR

INTRODUCTION

Amongst the artifacts recovered from the archaeological layers at Noen U-Loke are fragments of burnt clay that exhibit distinctive shapes and surface textures. They have the appearance of material that has been used to build walls of some sort as some form of daub. The surface textures include impressions of bamboo and split wood, and the clay appears in most cases to be burnt (Fig. 24:1). Chetwin (this volume) describes these morphological features in detail, discussing possibilities regarding the origins of the artifacts and the possible functions of daub and wattle at Noen U-Loke. Given the physical and visual evidence available to him, and taking due consideration of published experimental and ethnographic evidence from elsewhere, Chetwin comes to several conclusions, the most important is that the fragments of burnt clay are most likely to be from domestic structures accidentally burnt, rather than from a structure such as a kiln or furnace that has been deliberately exposed to higher temperatures. In this chapter, we offer geochemical evidence to test this interpretation. We argue that determining probable prehistoric firing temperatures of burnt clay recovered from archaeological sites provides opportunities to interpret the design and/or function of prehistoric structures.

This chapter critiques some of the methods for determining firing temperatures of burnt clay, especially using colour and geochemistry as analytical tools. The samples from Noen U-Loke are especially useful for such an analysis in that they have been recovered from a secure depositional context within the Iron Age horizons, thus removing any possibility that the characteristics of the samples may be the product of surficial weathering under tropical conditions. Adopting a multi-method approach, our work examines relationships between colour, micro- and macro-inclusions, elemental and mineralogical composition, physical form, and temperature, through the application of ICP-MS, XRD analysis, magnetic susceptibility, and light microscopy. Our work reinforces the methodological importance of using the combined interpretation of independent measures. This, we believe, provides a better estimate of the original firing temperatures of the archaeological material than has hitherto been possible using individual qualities.

The work reported in this chapter has been published in detail by Parr and Boyd (2002, 2003), and the following provides the main points. Examination of the visual and macroscopic characteristics of the samples (Chetwin, this volume) lead to the conclusion the samples were most probably fired at low temperatures, with a possible industrial source for some of the material. Chetwin's study of the samples recovered from the archaeological site provides a valuable foundation for our study. Providing a detailed descriptive account of the samples, Chetwin discusses the potential and limitations of burning experiments in determining origins for such material. Building especially on issues of colour and the inclusion of surviving rice remains, Chetwin concludes that the evidence he had to hand "would seem to distance the Noen U-Loke daub remains from a pyrotechnological (e.g. kiln or hearth) origin" (p. 460). He then continued to conclude that his data indicated that "the preservation of wattle and daub remains at Noen U-Loke is the function of low temperature firing, most probably accidental" (p.460). He was careful, however, to remind us that this is only a preliminary conclusion.

Chetwin considers three possible origins for the burnt clay recovered from Noen U-Loke. He discards his first possibility, that is that the fragments came from a kiln or furnace, partly on the basis of visual assessment and partly on the basis of lack of good northeast Thai ethnographic equivalent. He notes that local charcoal ovens do not have the wooden or bamboo structure that is implied by the abundant impressions on the archaeological material. We note from our own observations, however, that both bamboo and slit wood is used to frame the opening to such ovens, and indeed were used to create an inner frame over which clay was plastered prior to the first burning; there is ample evidence on the inner surface of these ovens for the impressed remains of a wooden or bamboo frame (Fig. 24:1). Chetwin then comments that two other possibilities are indeed possibilities, although as yet unproven. The first is that the clay is from a domestic structure, although it would only be preserved if the domestic building had been burnt down. The second possibility is that the clay was from some part of an industrial structure, such as a wattle and daub roof over an oven (Fig. 24:1).

Clearly Chetwin's full and detailed descriptions and



FIG. 24:1 Examples of the archaeological material and of modern comparative material under discussion in this chapter. Photograph A illustrates a typical fragment of the archaeological daub. This is from the dated Iron Age archaeological deposits at a site neighbouring Noen U-Loke, Ban Non Wat. This sample clearly shows the artefactual nature of the material. In this case, wood impressions (c. 3cm across) are unlike any structure observed in the natural soils of the region. Photograph B provides a comparative example of the inside structure of a modern charcoal clay oven at the village of Ban Non Ngiu, some 5km from Noen U-Loke. Of importance are the branch impressions, which are, in this case, c. 4cm in diameter. They represent a wooden structure used to build the roof of the oven, and lost on first firing. The oven, now dismantled, but in use in recent years, is shown in photograph E. The composition of the daub fragments examined is illustrated in photograph C, again from Iron Age material collected at Ban Non Wat. The high content (in some cases up to c. 40% volume) of organic material (now as casts and ash concentrations), iron nodules (pisoliths) and occasional fragments of broken pottery, used as temper in this and other clay artefacts throughout prehistory in this region, again is unlike any natural soil feature in the region. A comparative example is illustrated in photograph D, which is the material used to construct the charcoal oven described above and shown in Photograph E. Finally, by way of further example, photograph F illustrates an iron-working oven in Cambodia, constructed from clay, split wood and bamboo. (Photographs by Steve Abbott (A-E) and James Chetwin (F).)

interpretations provide a basis for further analysis. He quite correctly recognizes the limits to interpretation based solely on visual analysis. We suggest that one way to attempt to resolve some of his suggestions is to determine the maximum temperatures for the original firing of these clay fragments. This would provide the clearest discrimination between possible types of original features – a house or other domestic structure, for example, as opposed to an industrial structure such as a kiln or furnace – from which the clay fragments originally came. Furthermore, by examining the chemistry of the samples, it may also be possible to determine the environment under which the clay was burnt.

In building on Chetwin's initial study of the burnt clay at Noen U-Loke, our results may seem slightly at odds with those of his study. This is more illusionary than real, in that we have had a greater opportunity to examine the key indicators of firing temperature and environment than Chetwin had in his visual and macroscopic study. Our study indicates that the archaeological burnt clay samples have been exposed to a range of temperatures from a moderately cool 200°C to a relatively high 1,000°C. It seems highly likely, therefore, that the burnt clay was derived from several types of structures, some of which had experienced rela-

tively high temperatures, and/or from a spatially complex structure, such as an industrial kiln or furnace, which has experienced a range of firing temperatures. The chemical analysis supports the latter, with evidence for firing of ores within confined spaces.

BACKGROUND

Daub is a term used to describe clay plasters applied to a wooden and/or thatched framework to built structures (Chapman 1980). Such structures include buildings, storage and cremation features, pottery kilns, and metal working furnaces (Thomas 1991, McConnell 1992, Higham 1996a). In the study area there are good examples of such use in the construction of rice stores and charcoal burners, while Chetwin has recorded daub being used in rural Cambodia in association with iron smithing (Fig. 24:1).

Remains of burnt clay or daub are recovered from archaeological sites of all ages from across the world, and many techniques have been used to determine, from such archaeological evidence, the original structural design and/or function of such material (Tite 1969, Van Esterik 1973, Chapman 1980, Johnston *et al*. 1988, Lintz 1989, Dammers and Joergensen 1996, Dickinson 1998, O'Reilly 1999, Al-Saa'd and Roussan 1999). However, as is clear in such studies, determining the original function can be difficult because evidence is often fragmentary and slight. Wooden frames, for example, rarely survive the taphonomic processes of site formation. More important, however, is the survival of clay fragments. Samples are often small, and their shapes are of little help in reconstructing the original structural form (McIntosh 1974, Bankoff and Winter 1979, Shaffer 1984). Following the destruction of a structure any daub that remains in its air-dried condition is prone to weathering and, thus, removal from the archaeological record. In some cases, hardened clay may survive; Boyd has noted material from the nearby Ban Non Wat archaeological site, whose characteristics differ markedly from the material being analysed here. These latter materials are either largely un-reddened, or have limited reddening around the outer surface; they may or may not have branch casts or contain temper, and in some cases they have fine surface layers of coloured clay attached to single flat surfaces (possibly plaster or some other surface wash). What is important is that the origin of this material is different, and it has variously been interpreted as being un-baked clay used for some form of structure (possibly walls or floors of buildings) and slightly weathered post-depositionally. Importantly, its character highlights and emphasizes the distinctive nature of the analysed daub samples, and provides evidence of the post-depositional weathering expected of such material under the condition encountered at such archaeological sites. Where, however, only daub that has been burnt survives, there is an immediate taphonomic selection of material available for analysis. Nevertheless, it is important to understand the function of the structures from which such material comes if their relationship to technology and resource management is to be identified.

Initial interpretation may be based on impressions left in the clay of any wooden framework (McIntosh 1974, Chapman 1980). Three groups of techniques are used to interpret archaeological daub: physical analysis; experimental comparison; and geophysical and geochemical analysis. Physical studies include morphological analysis of fragments, examination for framework impressions, and consideration of stratigraphy (McIntosh 1974, Shaffer 1984, O'Reilly 1997). Experimental comparisons focus on construction and destruction of buildings to simulate daub production and deposition (Shaffer 1984). Geophysical and geochemical analyses can determine the environmental conditions under which the material was produced, using, for example, XRD, differential thermal analysis, thermogravimetric analysis, scanning electron microscopy, petrographic techniques, and thermoluminescence analysis, in addition to the use of standard colour descriptions (Tite 1969, Van Esterik 1973, Chapman 1980, Sunta and David 1982, Johnson et al. 1988, Lintz 1989, Lewis and McConchie 1994, Dammers and Joergensen 1996, Dickinson 1998, Al-Saa'd and Roussan 1999).

THE ARCHAEOLOGICAL DAUB AT NOEN U-LOKE

The site of Noen U-Loke is a large mound comprising the accumulated debris of human occupation, including, as detailed in this monograph, pottery and remains of buildings, burials, and industrial activities. Glass beads, bronze and iron burial goods, together with the presence of iron smelting features at the mound edge, are all testament to probable on-site industrial activity in the past. Our question is whether the daub remains are also part of this testimony.

The daub samples discussed here are from secure depositional contexts within the 4.7-m-deep archaeological sediments of the site. They are predominantly found in Layer 4 at 2.0 to 3.7 m below land surface. This layer has been dated to *c.* 2100–1800 yr BP. Both depth of burial and the archaeological evidence that the sediments have remained undisturbed since deposition indicate that the samples examined here only represent conditions during the Iron Age. Importantly, most of the fragments were found in concentrations of *c.* 0.5 m diameter, forming archaeological features that loosely resemble collapsed sub-spherical features. These were very hard to map and excavate, often only being recognised once they are well removed, and there is, therefore, little reliable evidence for the form of any possible structures; we have to rely, as Chetwin also does, on the individual fragments.

Chetwin, likewise, had limited visual evidence to base his interpretation upon. In particular, his interpretation was based on comparison with data from elsewhere.

Comparison of the wide colour range within the Noen U-Loke material with Shaffer's (1984) data, for example, suggested that the Noen U-Loke daub could be explained in terms of accidental burning of buildings. Secondly, the Noen U-Loke material was noted to contain both unmodified and carbonised material but no ash, implying relatively low temperature of burning. This interpretation drew on Dammers and Joergensen's (1996) experimental work with daub briquettes that indicated that ash occurs only at temperatures over 400°C.

Chetwin's interpretation is very useful, however, in that it highlights several key problems with the analytical approaches generally adopted in such studies. A core problem is the use of experimental or observational evidence from unrelated contexts. How reliable is the use of colour as an indicator of temperature? Does, for example, a wide colour variation really or always indicate accidental burning at low temperatures? Alternatively, could colour variability be an indicator that some part of a structure was exposed to very high temperatures while others were less intensely heated? Given the reliance on published experimental studies from other parts of the world, it is relevant to ask what role environmental conditions and the original material composition played in the resulting colouration, and what the significance is of unmodified and carbonised plant material embedded in the Noen U-Loke material. Is Dammers and Joergensen's (1996) evidence that straw in daub briquettes is carbonised at around 300°C, when the experimental briquettes were manufactured from German loess soils and air-dried barley straw, for example, valid to a SE Asian situation using floodplain clays and rice? We know that unmodified and carbonised rice husks are found in archaeological pottery from northeast Thailand, pottery that has apparently been fired at temperatures of 500-800°C (Van Esterik 1973, Bayard 1977, Thompson 1996).

This chapter, therefore, re-examines the evidence for low intensity firing of daub from Noen U-Loke, by looking more closely at relationships between colour, heat exposure, mineralogical and elemental composition, and the physical character of the material. We seek to establish the maximum firing temperatures indicated by these independent measures, assuming that maximum temperatures provide the clearest discrimination between possible original function of the daub, separating, for example, housing from industrial use. Methodologically, it is important that we use a multi-method analytical approach. While all methods will introduce some uncertainty, the combined interpretation of independent measures should provide a better estimate of the original firing temperatures than has hitherto been possible; if independent measures indicate similar conclusions, we can be more assured that original assumptions are valid. In particular, our use of control samples of lateritic material from the immediate surrounds allows credible comparative analysis. The control samples comprise clays from the archaeological mound itself, adjacent channel infill and nearby floodplain sediments. These provide regionally-specific material, as similar as possible to the archaeological sediments.

METHODS

The archaeological samples we analysed comprise 114 fragments of daub examined by Chetwin, from which twelve were selected for detailed analysis. Examination of both sides of each fragment indicated differences in colour; both sides were therefore studied, providing 24 analytical samples. These were assessed for mineralogical composition, trace elements and physical character using XRD, ICP-MS and magnetic susceptibility. To provide local control material, we created samples of floodplain clays collected close to Noen U-Loke. These were oven-dried at 50°C, mixed using the cone and quarter method, and divided into six 4g portions, and then baked at various temperatures. The use of local materials as comparative control samples is an established approach (Wagner *et al.* 1998) and the most appropriate method for this type

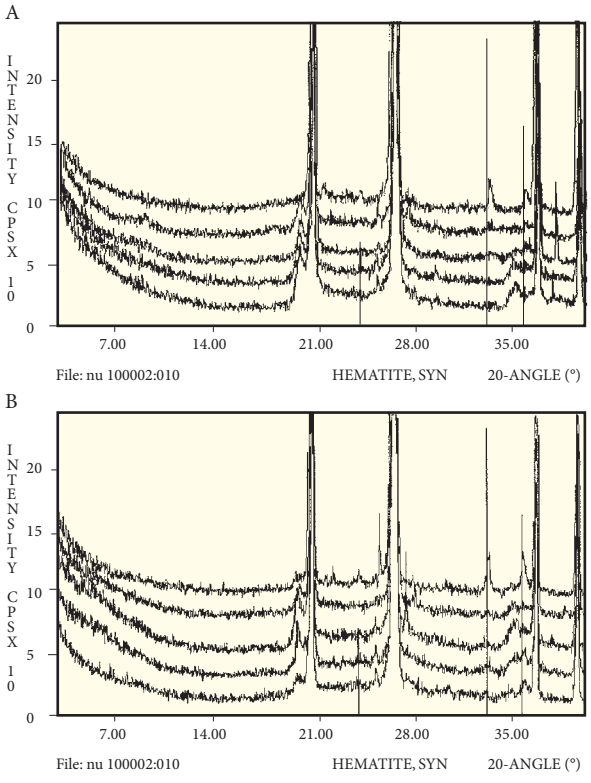


FIG. 24:2 X-ray diffraction results for control samples (A) and archaeological samples (B) from Noen U-Loke. The control samples are stacked in order of firing temperature 200°C (lowermost) to 1,000°C (uppermost). The archaeological samples are stacked by estimated original firing temperature, based on colour-temperature relationships of the control samples. As illustration of the interpretation of such plots, two of the vertical lines rising from the x-axis representing the positions and intensities of hematite peaks (supplied by the XRD graphic software, XPlot), are labelled

of study; our control samples are more appropriate than comparative data from distant contexts such as published in European experimental studies. It should be noted, however, that we do not expect exact equivalence between the control and archaeological samples: the controls merely provide a sounder basis for comparative analysis.

To assess the significance of variations between and within samples, in terms of colour, mineral content and relationships between colour, composition and heating temperature, five portions of the control material were heated at 200°C increments in ceramic crucibles in a Burnstead Thermolyne 62700 muffle oven for one hour in an oxidizing atmosphere. No significant chemical change occurs in clay after heating for one hour (Linz 1989, McConchie pers. com.). Archaeological samples (samples 4, 36, 49, 53 and 62) were also used as controls, and fired to 400°C to detect colour changes and x-ray diffractogram patterning. Following heating, separate analyses assessed changes in the control samples. Colour was recorded for each temperature graduation, using a Munsell colour chart. Recorded colours were compared with the Munsell colours of the 114 samples originally examined, and the 24 re-assessed samples (Table 24:1). Secondly, imprints and materials embedded in the 24 samples were observed, using an Olympus stereo-microscope, and, thirdly, a small subsample (samples 4A, 4B, 37B, 49A, 49B and control samples 2, 3 and 5) were mounted and scanned for organic and biological evidence using an Olympus BH2 trinocular compound microscope.

The fourth analysis was powder XRD on the control samples to assess mineralogical change during the experimental firing. At around 550°C, XRD peaks of several clay minerals, such as montmorillonite and chlorite, alter; those of kaolinite are removed (Lewis and McConchie 1994). Other minerals, such as quartz, may undergo conversion, forming, for example, cristabolite and tridymite at higher temperatures of 870° and 1,470°C (Sunta and David 1982). The control sample patterns at various temperatures were compared to those of the archaeological samples. The XRD analysis was undertaken using a Philips PW 1830 and XPLOT software, following standard preparation and analytical methods, including, to optimise peak change detection, sample orientation by liquid suspension on glass slides (Bish and Reynolds 1989, Raven 1990, Lewis and McConchie 1994). Analysis was repeated after samples were exposed to an atmosphere of ethylene glycol within a desiccation chamber for three days to enhance peak detection and minimise background interference. Finally, the unfired oriented and glycerated control samples were fired at 550°C for one hour to monitor changes.

The fifth analysis comprised measurement of magnetic susceptibility. Due to the abundant presence of iron nodules (pisoliths), all samples were monitored for magnetic susceptibility changes on heating, using the control samples as standards. Magnetic susceptibility of hematite is known to increase over 700°C, thus providing a possible method of distinguishing samples originally heated above such a temperature (Tite 1972). Samples were analysed using a Bartington MS2 magnetic susceptibility meter. Finally, a Perkin Elmer ICP-MS was used to monitor quantities of individual elements before and after firing the control samples, and the results were compared to ICP-MS data for the archaeological samples. Samples were digested in an aqua regia solution using a Perkin Elmer Multiwave sample preparation system. The digested samples were diluted in purified water at a ratio of 1:10 and analysed with the ICP-MS. Such data have been used recently to determine the nature of industrial processes represented by archaeological features (Budd *et al.* 1999, Thomas and Young 1999).

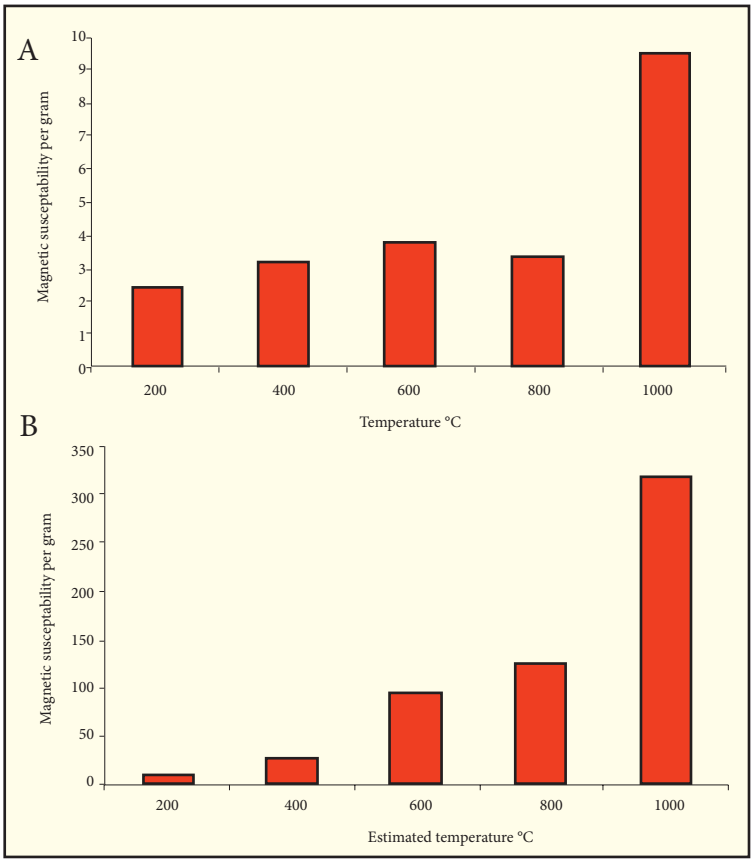


FIG. 24:3 Magnetic susceptibility results for the control samples (A) and archaeological samples (B). Temperatures are the control firing temperatures (A) and colour-based estimated temperatures (B) as described in the text

TABLE 24:1 *Summary of relationships between firing temperatures and resulting daub sample colour for the control samples used in this study. The archaeological samples codes indicate inner surface (A) and outer surface (B) samples*

Firing temperature	Munsell colours of control samples under experimental firing temperatures	Archaeological samples with colours corresponding to, or close to, control colours
200°C	pale red/light reddish brown 2.5YR6/3 and grayish brown 10YR5/2	4B (10YR5/3) 5B (10YR5/2) 17B (10YR5/2) 52B (10YR5/2) 53B (10YR6/2)
400°C	pale brown 10YR6/3 and reddish brown 5YR5/4	4A (10YR6/3) 5A (10YR6/3) 17A (10YR6/3) 53A (10YR6/3) 58A (10YR6/3)
600°C	light brown 7.5YR6/4	21A (7.5YR6/4) 21B (7.5YR6/4) 36B (7.5YR6/4) 37B (7.5YR6/4) 52A (10YR6/4) 58B (7.5YR6/4) 62A (7.5YR7/4)
800°C	reddish yellow 7.5YR6/6 and 5YR6/6	36A (5YR6/6) 49B (2.5YR6/8-5YR6/6)
1000°C	reddish yellow 5YR6/8 and 7.5YR6/6	37A(7.5YR6/6) 49A (7.5YR6/6) 62B (7.5YR7/4) 89A (7.5YR7/4) 89B (7.5YR7/4)

RESULTS

Only one archaeological sample contained charcoal, while most samples contained carbonized plant material and many iron inclusions. Various phytoliths are occasionally present in both the archaeological and control samples. A weathered pottery fragment was found in the matrix of one sample. No visible changes are recorded in colour between unheated and 200°C heated control samples, but sequential changes are noted with each subsequent rise in temperature (Table 24:1). The heated samples range from light browns (e.g. 10YR5/2) at 200°C to orange brown to red (e.g. 7.5YR7/4) at 1,000°C. The colours for both the 114 original and the 24 re-assessed archaeological samples covered the full spectrum represented by the control samples.

For the control samples, both methods of XRD preparation produced results emphasizing particular mineral peaks (Fig. 24:2): 2.5Å and 2.6Å hematite, possible 10Å halloysite, 15Å montmorillonite, and several quartz peaks were detected at various temperatures. The 10Å peak is absent above 200°C, and the 15Å peak shifts laterally at 400°C. The oriented and glycerated control samples heated to 550°C yielded a collapse of the 15Å peak. The non-clay species 2.5Å and 2.6Å hematite increase in intensity from 800°C, and the quartz peak also increases at 1,000°C. In contrast, the archaeological sample diffractograms show little evidence of clay peaks appearing to start at a stage equivalent to the control sample shift in the 15Å peak. Like the control samples, the 2.5Å and 2.6Å hematite peaks are also clearly defined in the archaeological samples; the hematite peaks also notably occur only in the archaeological samples that have colours closely matching those of the controls samples heated to 800°C or more. Quartz peaks

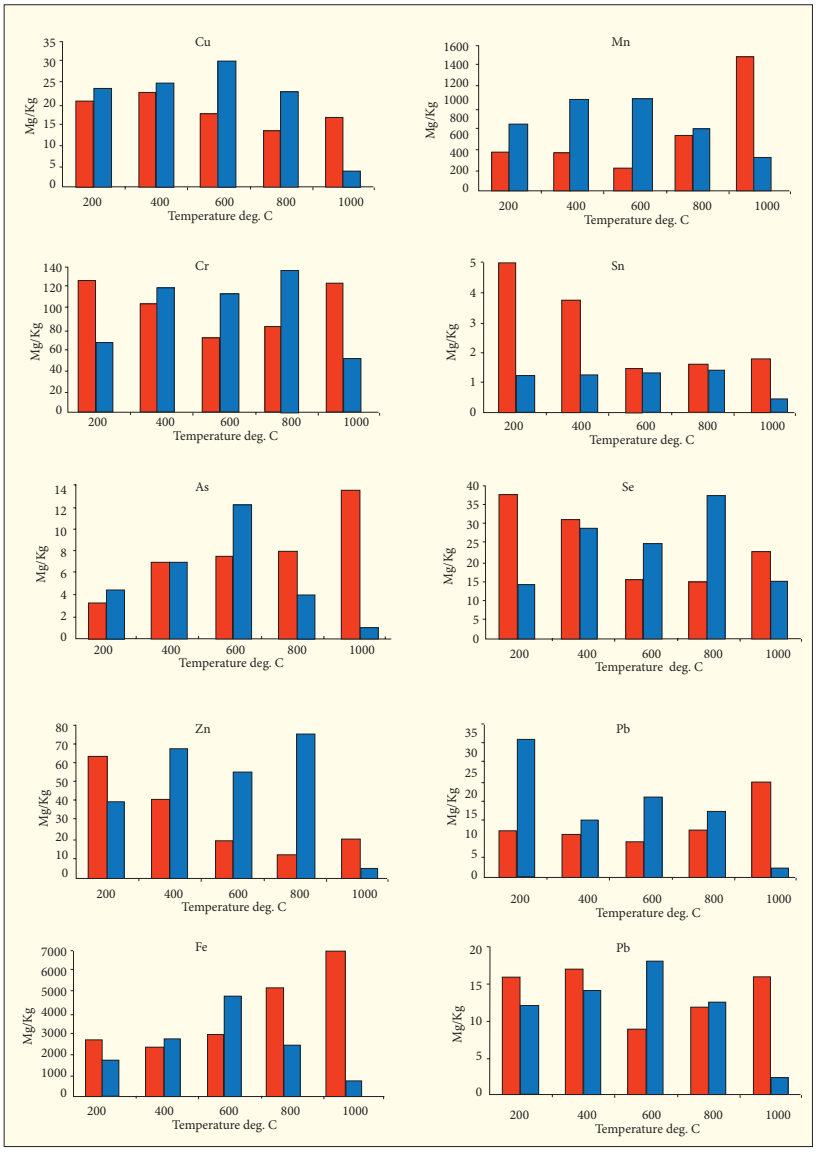


FIG. 24:4 ICP-MS results for control samples (blue bars) and archaeological samples (red bars). The temperatures are measured for the control samples and estimated for the archaeological samples as described in the text

are higher than those of the controls for most samples.

Magnetic susceptibility (Fig. 24:3) for all samples sharply increase at around 800°C (measured temperatures for the control samples, and colour-based temperature estimates for the archaeological samples; see above). The archaeological and control samples, however, differ significantly regarding the ICP-MS element concentrations (Fig. 24:4). Using colour as a guide, the archaeological samples are characterised as follows: at 200°C, Cr, Fe, Ni, Se, Sn and Zn values are higher, and As, Cu, Mn and Pb values are lower, than those of the control values; at 400°C Sn is higher, Ni and Se are slightly higher, and As, Cr, Cu, Fe, Mn, Pd, Sn and Zn are lower; at 600°C, Sn is marginally higher and all other elements are lower; at 800°C As, Fe and Sn are higher and the others are lower; and at 1,000°C all elements are significantly higher. Comparison of residue weights after digestion indicate that at 1,000°C, *c.* 25% of the control material is digested elements with c. 75% converted to silicates; the archaeological samples, on the other hand, comprise *c.* 66% digested elements and *c.* 34% silicates.

DISCUSSION

The first problem we face is to establish if the archaeological material examined simply represents dried daub or material that has been baked or fired in some way (cf. Chapman 1980). The discovery of carbonized plant and charcoal inclusions, and the recognition that the normally-dark-coloured pisoliths tend to turn orange-red under oxidizing burning conditions, however, quickly resolves this issue: the daub has been fired. The next task is to determine the temperature range represented by the daub, and to extract the archaeological implications of that

range. Low temperatures (e.g. at or below 400°C) most likely represent the rapid, aerobic and possible accidental burning of a domestic structure (Shaffer 1984), whereas higher temperatures are more likely to represent managed burning under controlled conditions. In other words, high temperatures are more likely to imply some form of industrial activity.

Comparison of texture and colour with the Noen U-Loke mound sediments indicates that the daub most resembles local source materials. The discovery of potsherds within the daub, and comparisons of XRD data also confirm the local origins of the daub material. Using heated on-site materials as controls yields the most locally-appropriate comparative data on sediment responses to heating. In this way, each of the 114 original archaeological samples and 24 subsequent samples can be ordered by using colour to estimate firing temperature (Table 24:1). While this alone cannot be used to confirm original firing temperatures of any individual sample, further comparison with independent measures strengthens the correlations implied here. Thus, for example, patterns of relationships between sample morphology, biological content, XRD and ICP-MS results and magnetic susceptibility make interpretive sense in terms of temperature-related processes. Furthermore, the completely independent technique of recording presence and modification of phytoliths and other small silica particles supports the colour-based estimation of original firing temperature. Phytolith presence and modification are temperature-dependent (Parr *et al.* 2001). Temperatures up to 500°C have no effect on phytoliths. Both control samples and archaeological samples with measured or estimated temperatures of 600°C or more contain few such silica bodies; those present are typically fused, reflecting Runge's (pers. com.) observations that phytolith melting commences at 600°C. Jones and Handreck (1967) also note the conversion of phytoliths to crystalline silica from 700°C, and here we record absence of phytoliths in samples estimated to have been heated at 800°C and 1,000°C.

The XRD data for the archaeological material shows less evidence for clays, compared with the controls. However, XRD patterns for the archaeological material commence at a level resembling that of the shift in 15Å peaks in the control samples. This implies a minimum temperature of 400°C. As is the case with the controls, the 2.5Å and 2.6Å hematite peaks in the archaeological samples are significantly better defined in samples colour-matched to temperatures at or above 800°C. Al-Saa'd and Roussan (1999) report the intensification of hematite peaks from 800°C onwards in XRD analysis of pottery from Jordan, and they use these peaks in assessing original firing temperatures. These peaks therefore provide evidence supporting the temperatures indicated by the phytolith evidence. At 800-1,000°C, slight changes in quartz peaks resemble changes in the control samples and trends recorded elsewhere (Al-Saa'd and Roussan 1999).

Perhaps the most important evidence to support our interpretation that the archaeological daub had been exposed to temperatures of up to 1000°C is the presence of hematite in X-ray diffraction spectra and an increase in magnetic susceptibility occurring at around 800°C and beyond in our control samples. Based on the formation of red colours, hematite peak formation in X-ray diffraction spectra for the control samples at 800°C and cited evidence from other published studies, we suggest that hematite had formed and was thus contributing to our reported increase in magnetic susceptibility (cf. Tite 1972, Al-Saa'd and Roussan 1999, Jordanova *et al.* 2001). To support the claim of a significant haematite presence, we also examined the control samples using Mössbauer spectroscopy and are currently running the archaeologi-

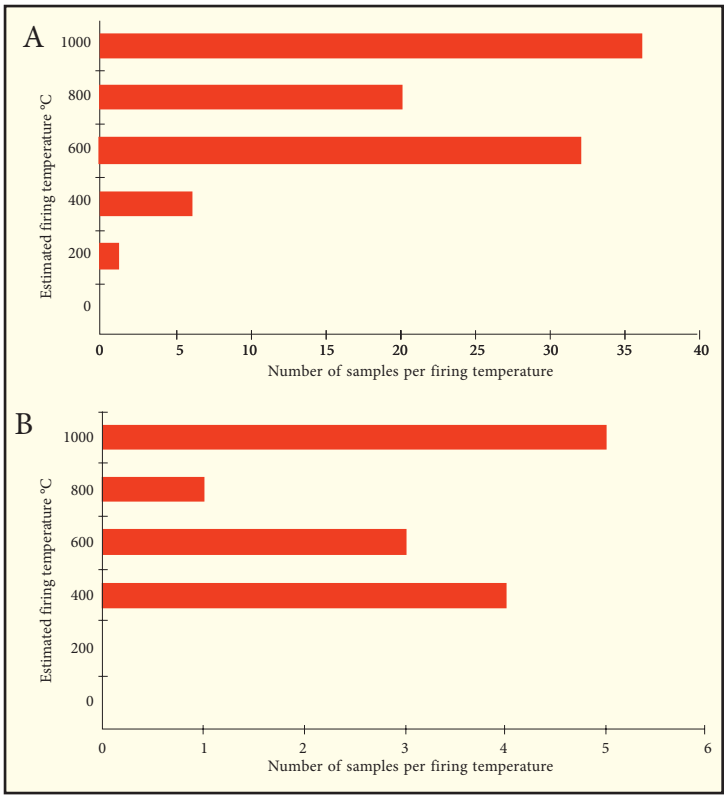


FIG. 24:5 Estimated original temperatures for the archaeological samples assessed here: (A) the 114 samples originally reported by Chetwin; (B) the 24 samples subsequently examined in further detail. The figure shows the frequency distribution of samples estimated to fall within temperature ranges, determined by comparison of the archaeological sample colour

cal samples; the full results will be reported in due course. The Mössbauer spectra for the control samples have confirmed the dominant mineral at both 800ºC and 1000ºC to be hematite; magnetic fields of 50.51 and 50.53 were acquired. The combined data from magnetic fields together with sextets, quadrupole splitting and isomer shift best fit the determination of hematite (Murad and Johnston 1987, Wagner *et al.* 1998).

A sharp increase in the magnetic susceptibility in both control and archaeological samples at around measured and estimated temperatures of 800°C can be explained by the hematite presence noted in the XRD results. Unheated clays containing hematite have randomly-oriented particles, but once heated to *c.* 700°C, particles become aligned, creating an increase in magnetic susceptibility (Tite 1972). Jordanova *et al.* (2001) demonstrate that annealed clay and kiln samples produce highly variable results for magnetic susceptibility, depending on the transformations taking place. Indeed, Vernon *et al.* (1999) report magnetic susceptibilities in excess of 10 x 10-6 kg/m^3 for iron smelting operations. In addition, roasting tests conducted on ilmenite concentrate at temperatures from 740ºC to 800ºC under oxidising conditions resulted in a sixteen-fold increase in the bulk magnetic susceptibility (Luckos and Den Hoed 2001). Significantly, this increase in magnetic susceptibility at these temperatures was found to be due to the oxidation of Fe 2+ to Fe 3+ (i.e. the formation of hematite).

The use of hematite iron ore is known from several archaeological contexts, including the coating of pottery for pigmentation during firing, as a flux for copper smelting, and as a source material in iron smelting (Higham 1996b). It is important to note that small iron nodules (pisoliths) are naturally abundant in the lateritic sediments of Noen U-Loke. On the other hand, the ICP-MS results show that iron content in the archaeological samples estimated at an original firing temperature of 800-1,000°C is significantly higher than in the control samples for equivalent temperatures. Much of ICP-MS data variability between control and archaeological samples may be explained by reference to temperature or weathering process. Temperature changes cause conversion, vaporization and accumulation of elements during firing. The control samples have greatest concentrations of Pb, As, Mn and Cu at the lower temperatures (200-600°C), decreasing at around 800°C (probably through sublimation; cf. Aylward and Findlay 1990). The archaeological samples, on the other hand, have higher concentrations of As, Fe and Sn at 800°C and of all the elements measured (As, Cr, Cu, Fe, Mn, Pb, Se, Sn and Zn) and lower silica values at 1,000°C (Fig. 24:4).

Two explanations are possible. First, the Iron Age firing of the daub in some way altered weathering of the material, resulting in higher concentrations of particular elements than the unfired sediments from the same locality used as controls and fired only very recently as part of the analysis.

Secondly, and more probably, element concentrations are significantly higher for the archaeological samples due to differences in the role played by the baked clays used and analysed here. In the control firing, samples are fired as material within a muffle oven, and thus any elemental loss from the sample would be expressed as a reduction of concentrations in the resulting material. As elements reached melting point and, in some cases volatilisation, they may be converted to silicates but would not increase in quantity; there is, however, potential loss of both organics and trace elements through oxidization, volatilisation and escape of vapours respectively. If the daub, on the other hand, represents a structure, and is thus, for example, the remains of the lining or wall of kilns or furnaces, it will have been the environment of element accumulation, rather than loss. While elemental changes, as noted above, associated with firing of the clay would be expected, the net gain of elements lost by vaporization from the materials being fired within the kiln or furnace would result in a net increase in element concentrations in the clay of the structure lining (Cornell and Schwertman 1996). This is not unusual and is a well-documented phenomenon. Thomas and Young (1999), for example, report similar results for metal working furnaces with the likely loss of Cu through volatilisation yet an abundance of Fe, while Vernon *et al.* (1999) record significantly high levels of FeO in an ancient metal working furnace linings in England. Our archaeological samples also contain an accumulation of iron as indicated by the ICP/MS analysis and, significantly, the site is an Iron Age site that contains evidence of metal-working.

While some of the temperatures for the archaeological daub are estimated to be as low as 200°C, the majority of all the samples represent estimated temperatures of 600°c or higher, with over half the samples representing temperatures of 800-1,000°C (Fig. 24:5). The highest temperature colours are typically similar to that noted for archaeological samples from the inner part of a Bronze Age casting furnace at Ban Na Di (Higham 1996a) and daub samples from the nearby Iron Age site of Non Muang Kao (O'Reilly 1999). The latter samples are also heavily tempered with rice chaff and (probably) pottery fragments, most likely to assist the daub endure repeated firing (Skibo 1992; O'Reilly 1997). At least two types of pottery firing are known from this Southeast Asian region. In open firing, pots are placed on logs covered with light plant material, and allowed to burn for about 1.5 hours (Solheim 1968); we have observed a similar method in the study using palm fronds and rice husks. The alternative method relevant to this study, pottery manufacture in kilns, is estimated to reach temperatures of 700-800°C (Van Esterik 1973), temperatures well within the range indicated here, and significantly higher than the estimated 400°C recorded in experimental house firings (Shaffer 1984) .

All the Noen U-Loke archaeological daub with bamboo imprints have, significantly, colours indicating temperatures up to 400°C, suggesting that a framework was not used to support the daub where the structure was directly exposed to higher temperatures. Alternatively, samples with wood imprints typically have colour-based temperature estimates of around 600°C, while samples with estimated temperatures above 600°C have no imprints. These relationships suggest that the structures were designed to allow firing in select zones to reach at least 1,000°C. Bamboo or wooden frameworks may be unlikely within a kiln or furnace, although the ignition of a frame would have been of little consequence once the daub structure was fully dried and fired; there are impressions of a wooden frame within a recently-used wattle and daub charcoal kiln observed at Ban Non Ngiu (Fig. 24:1), suggesting the use of a wooden frame in the initial construction of the structure.

CONCLUSION

The proposal that the daub fragments recovered from the archaeological site of Noen U-Loke are the most likely the remains of domestic wattle and daub structures accidentally destroyed by low temperature (to 400°C) fires is not fully supported here. This original conclusion reflects the inadequacy of relying on temperature-colour relationships derived from unrelated comparative data and on implications derived from experimental work in unrelated provinces. On the contrary, using combined independent sources of analytical evidence – in particular colour-temperature experiments on local material, and geochemical analysis of the clay fragments – we have argued (Parr and Boyd 2002, 2003) that the daub was probably derived from a complex structure that has been subjected to a range of original firing temperatures of at least 1,000°C. In highlighting the need for site-specific controls and the use of a range of independent analytical methods to interpret the origins of archaeological daub, we conclude that while we cannot identify the exact function represented by the daub, the samples examined here are most likely to represent the remains of a kiln, furnace or similar high temperature firing structure rather than the accidental burning of a domestic structure.

XXV. THE GLASS ORNAMENTS

S.J. SAITOWITZ AND D.L. REID

INTRODUCTION

Significant numbers of glass beads and semi-precious stones have been found in prehistoric sites in Thailand. Although there is reason to believe that they could have been made locally, popular theory supports the notion that they originated in India. Theunissen *et al.* (2000) have cast doubt on the diffusionist assumption that agate and carnelian beads were exotic prestige goods from India and suggests that they were made in Thailand. This chapter contributes a possible technique and results for testing a ssimilar hypothesis, based upon the sample of glass beads from Noen U-Loke.

Most of the beads from this site were found in association with human burials as ornaments worn by the deceased. A few fragments of short, fine threads of glass and a small piece of glass slag or crucible found in the cultural deposits, implied that some beads could have been manufactured *in situ*.

It is not possible to assign the beads to a source on the basis of visual inspection alone. Therefore, quantitative and qualitative chemical analysis was carried out on approximately 50 specimens of glass beads, glass thread and glass slag to investigate the possibility of local production.

In sum, the principal objectives of this investigation were to:

1. Visually classify the glass beads, based on an internationally standardised scheme for comparative and selective analysis.

2. Establish chemical signatures or benchmarks for certain glass beads found at Noen U-Loke to verify the accuracy of visual inspection.

3. Examine some of the glass threads and the possible piece of glass slag.

4. Use Laser Ablation - Inductively Coupled Plasma -Mass Spectrometry (LA-ICP-MS) on a number of glass beads to test the proposition that they may have been made locally or at production centres elsewhere.

GLASS BEAD MANUFACTURE

Glass is made from a combination of commonly found raw materials which are melted or fused together at high temperatures to form an homogeneous mass. Because the composition of glass is so nondescript, most of the major and minor chemical elements offer limited diagnostic parameters for distinguishing between different types of glasses and the raw ingredients used in primary manufacture. According to Hickman *et al.* (1983), it is unfortunate that irrespective of analtytical techniques, no fundamental study has yet determined which elemental variables are the most suitable for classifying or discriminating between glass samples.

In view of the above, we consider the precise results achieved by examining the Rare Earth Elements (REE) or Lanthanide trace element group, using LA-ICP-MS, to be the most beneficial for determining differences between various glass compositions (Saitowitz 1996, 1998, Saitowitz *et al.* 1996).

Laser technology for sample injection offers important advantages over other analytical techniques, especially for archaeologists, because the technique is practically non-destructive, thus making it possible to analyse samples with minimal damage. This feature provides wide opportunities for obtaining artefacts for research, particularly from museums and private collections.

ARCHAEOLOGICAL CONTEXT OF THE BEADS

No glass beads were found in mortuary phase (MP) 1 or 2. They first appear in MP3, dated to the first or early second century AD, and continued to be used as grave goods until the final mortuary phase not long after 300 AD

GLASS BEAD ANALYSIS

The glass bead assemblage was examined using standardised, internationally recognized classification procedures. The system consists of a series, or levels, of analysis based primarily on the methods of manufacture and the physical characteristics of the beads, such as colour, shape, structure, clarity of the glass, size and decoration, arranged in a taxonomic hierarchy. Stylistic variations occur through the modification of the manufacturing process. The results evidence the initial stage of bead analysis in sufficient detail to make comparisons possible. It forms the basis for selecting samples for further chemical analysis. Two totally different types of bead were identified in the Noen U-Loke collection. Various aspects of their production are discussed below.

The analysis of beads excavated at Noen U-Loke followed procedures adopted by glass bead specialists Kidd and Kidd (1970), Karklins (1985), Sprague (1985) and Van der Sleen (1967). For the purpose of this study, the classification has been adapted from the work of Kidd and Kidd (1970) and expanded by Karklins (1985).

MANUFACTURE

There are several techniques for making glass beads from molten glass. However, only two major typological categories are pertinent to the Noen U-Loke assemblage. These are (1) beads made by the drawn process and (2) those made by the distinct "wrapping" technique described below.

Drawn beads

Drawn beads are variously described in the literature as tube, cane or 'seed' embroidery or pound beads (Saitowitz 1988). Other synonyms are 'trade wind' and IPMDGB (Indo-Pacific Monochrome Drawn Glass Beads) (Pilditch 1992:173, O'Reilly 1997:142-5). The name *drawn* is preferred because it refers to the production process rather than the form of the finished product (Karklins 1985:88).

Drawn beads are made from a viscous or rounded molten glass blob or 'gather' on the end of the glassblower's pipe. The gather, which has been perforated either by tooling or blowing, is drawn out into a hollow tube of the required diameter and then cooled. The tube is then chopped into various lengths resulting in sharp and uneven ends and at this stage of the production would be classified as tubular or cane beads.

Smoothing the jagged edges of cut beads involves further processing. Different methods include hot tumbling, cold tumbling or grinding them individually on an abrasive wheel. If the beads are hot tumbled, either over a flame or in a furnace, their perforations must be packed to prevent them from closing once the glass has softened from reheating. Various packing mixtures are used, such as plaster or charcoal dust mixed with fine clay (Saitowitz 1988:42).

Drawn beads have been divided into four classes according to their structure (simple or compound) and manufacturing sub-type (tubular or non-tubular) in both the Kidd and Kidd (1970) and Karklins (1985) systems.

Three classes of drawn beads were recorded at Noen U-Loke:

(1) Ia. Undecorated, monochrome tubular or cane beads with unaltered ends.

(2) IIa. Undecorated, monochrome beads whose broken ends have ben rounded.

(3) IVa. Compound bead, composed of two undecorated layers of glass with rounded ends.

Class Ia and IIa

The dominant kind of bead found at Noen U-Loke is the *drawn* class Ia and IIa with small holes. Most of the latter are monochrome, oblate shaped and made in a relatively limited range of colours (see below). They vary in size but the majority are small (ie < 2 mm, and between 2-4mm). The opaque orange ones in particular occur in longer lengths.

According to O'Reilly (1997:145), class IIa drawn beads were found at Non Muang Kao. Pilditch (1992:172) has recorded beads of a similar description at the late Bronze Age site of Ban Bon Noen in Central Thailand, which was considered to have a time span of about a millennium.

Class IVa (compound beads)

TABLE 25:1 The Munsell colours of the glass beads

	Munsell Colour
Orange	5YR 6/10 - 5 YR 5/10
Yellow (bright yellow to dull)	5Y 8/10 - 5Y 7/6
Turquoise (transparent)	B 5/6
Turquoise	2.5B 4/4 - 5B 4/6
Green	7.5GY 6/6 - 5G 5/4
Bright navy blue (transparent)	2.5PB 3/8
Dark navy	10B 3/6
Brick red or redwood	2.5YR 3/6 - 10R 3/4

Specific class IVa beads found at Noen U-Loke comprise drawn, undecorated compound beads made by combining different coloured textures of glass (multi-layered, Fig. 25:1). Of those examined, the colour of the inner layer or core is brick red or Redwood, and the outside, thinner layer is orange. The beads are oblate shaped. Their sizes are not uniform. Diameters vary from between very small (< 2mm) to small (2mm), and lengths measure 1.5 - 2mm. They were produced mainly in opaque glasses.

Thermal expansion and temperature parameters are important factors related to IVa bead production, particularly because different coloured glasses are fused together. It is essential for the glass properties of the combining layers to be similar. If the outer layer of glass does not meet optimum glass manufacturing requirements or "fit" the core, it could shrink or craze on cooling. This effect could be due to slightly different chemical ingredients causing differences in thermal expansion. Crazing may not necessarily occur with very small beads where the outer layer is thin.

In sum, the manufacturing success of compound IVa beads relies on sophisticated, precisely formulated physiochemical properties involving viscosity, thermal expansion rate and chemical composition.

Wrapped beads

The proposed method of manufacture for wrapped beads presented here is based on microscopic examination of samples that had been sectioned longitutinally to expose the perforation, and, on beads of transverse section, which had been mounted in resin and polished flat using a series of abrasive papers and diamond paste. Two categories were distinguished: (1) short cylinder or

ring beads with large diameters: and (2) oblate beads with smaller perforations. Both kinds of wrapped beads from Noen U-Loke are made of opaque, orange coloured glass. The short, cylinder ring beads are unique in appearance and almost immediately recognizable. The oblate ones are not so easy to distinguish and can be confused with the drawn Ia and IIa categories.

We suggest that wrapped beads were formed by rolling flattened glass longitudinally around a metal former or rod to create a hollow cylinder. Once the glass has cooled or was stiff enough to hold its shape, the internal rod was removed producing a hollow glass cylinder, which was then chopped into various short lengths. It is difficult to gauge whether the ends were softened or altered by tumbling methods or by user wear. The diameter and lengths of the ring beads vary in size and are off centre. This could be due to the rolling or marvering action of the glass around the internal metal form. The polished sections of different beads show a seam along which the glass was joined. Clearly this technique is not indicative of blown glass technology.

Wrapped cylindrical ring beads have been reported from other sites in Thailand such as Non Muang Kao and Ban Bon Noen (Pilditch 1992:175). In addition, Gorman and Charoenwongsa found beads of similar description at Ban Chiang (White 1982:76).

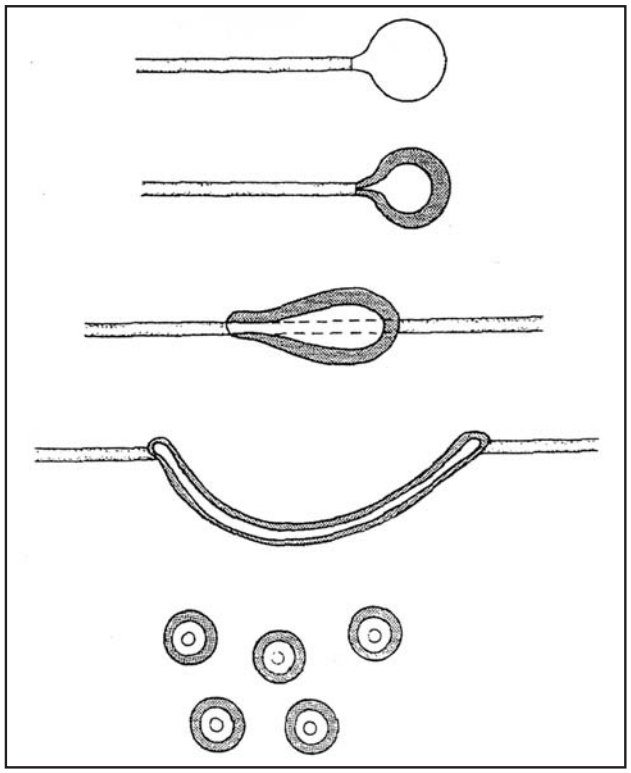


FIG. 25:1 Compound, or two layered drawn beads composed of two undecorated layers of glass: Class IVa. From the top: Glass 'gathered' onto pontil or rod; Another coloured glass layer added to the gather - outer 'dipped'; Perforation 'blown' or manipulated; Glass drawn into lengths; Section of completed bead

GLASS CHEMISTRY

Background

Glass is a unique material. It is a non-crystalline, supercooled liquid which requires special conditions of manufacture from raw materials that are not in the least similar to the finished product. Although it is amongst one of the oldest man-made materials, the precise origins of glass making are unknown. The chances are that observations during related pyrotechnologies used by metal smiths led to the discovery of siliceous slags.

Recipes for making glass have been formulated and written in countless variations (Henderson 1985). Nevertheless, glass-making is really just heating and fusing together of no more than two or three raw materials: a siliceous ingredient (sand or quartz), a fluxing agent (soda or potash) and a stabiliser (clay for alumina and magnesia; lime). Several minerals are used for colouring, contributing elements such as cobalt, copper and manganese. Iron is usually present as an impurity in the sand and or clay. Decolourants can be added to the glass to eliminate the effects of certain colour-imparting impurities.

Most of the major constituents are essential for successful glass production and thus tend to be ubiquitous in all specimens, thereby reducing their diagnostic value. Variations in certain major components such as Silica (SiO_2) or alkalis (Na_2O and K_2O) are usually the result of intentional changes in recipe, and hence easily reproducible throughout diverse manufacturing sites. However, it is possible that sources of major constituents in ancient glass could possess trace elements signatures that are characteristic of a specific locality, since the degree of refinement would not have been as prevalent as it is today. In this chapter, we report on preliminary results of a study into the chemical characterisation of ancient Thai glass.

The rationale for selecting particular elements for chemical analysis of glass tends to vary between studies. A review of some of the work shows an emphasis on major elemental analysis for silica, calcium, potassium and sodium, and on particular colourants added intentionally during manufacture, such as cobalt and copper to make blue beads. However, some researchers, such as Djingova and Kuleff (1992:53-61), question the validity of investigating colouring agents altogether. They prefer to use clear glass for analysis in order to overcome a bias toward colour classification.

Sayre and Smith (1961: 1824-6), whose work predated that of Djingova and Kuleff by over thirty years, also

1 The viscosity/temperature relationship of glass for bead manufacture must allow for successive hot and cold finishing operations within a wide range of temperatures. These operations can be extreme, involving cutting or snapping, followed by cold finishing such as grinding or polishing - heating or reheating to a soft stage for "tumbling" and annealing before slow cooling.

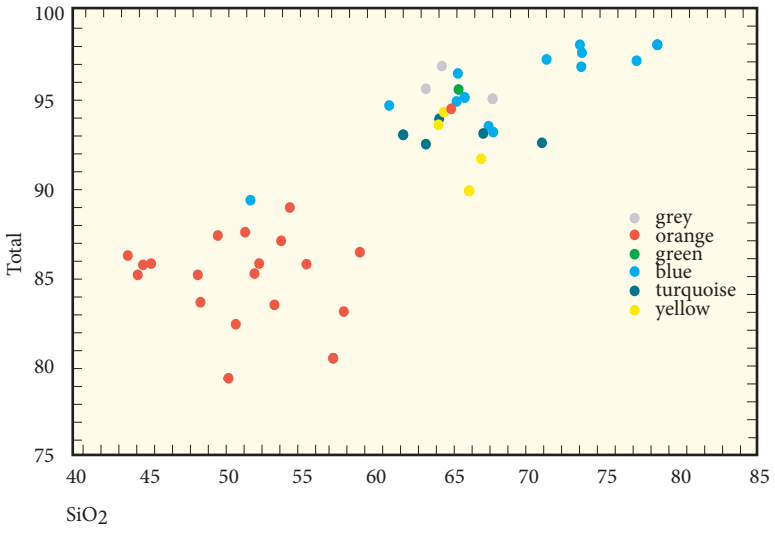


FIG. 25:2 Plot of Silica (SiO_2) versus analytical total (sum of all major oxides). The departure from 100% is interpreted as being due to dissolved volatiles

elected not to use colour as a denominator to 'avoid undue bias of colour'. They classified ancient glasses from Europe, Western Asia and Africa from roughly 1400 BC to AD 1100, based on five main compositional categories of the elements of glass. These were magnesium, manganese, antimony and lead.

In this study we preferred the Rare Earth Elements (REE) trace element group for a number of reasons. Most important is the fact that the REEs occur at only trace levels. They are elements which are dispersed amongst a number of common major rock-forming minerals in the earth's crust such as zircon, monazite, garnet and tourmaline. These minerals are resistant to alteration, e.g. by weathering, and are, therefore, relatively stable in surface geological processes (Henderson 1985). The stability of the REE gives them an advantage over other elements for chemical characterisation.

ANALYTICAL METHODS

The analytical techniques employed in this study minimize the amount of sample preparation and are largely non-destructive, both highly desirable features when dealing with archaeological specimens. Major oxides have been determined by Electron Microprobe Analysis (EMPA), while a select group of trace elements were determined by Laser Ablation - Inductively Coupled Plasma - Mass Spectrometry (LA-ICP-MS). Specimens of glass were mounted in epoxy and the surface polished, but it is not absolutely necessary for such pre-treatment, since EMPA only needs a reasonably flat surface capable of being carbon coated to be presented to the electron beam. Laser ablation does not even need a flat surface, and the sputtering action does limited cosmetic damage, since the craters are minute. However, ICP-MS is a technique that requires internal standardization and major element analysis must be carried out beforehand. Definition limits for the mono-isotopic REE elements such as La, Pr, Tb, Ho, Tm and Lu are of the order of 0.05 parts per million. For the remainder of Lanthanide group, the detection limit is 0.1 parts per million. Overall precision is 10-15 % at the 95% confidence level. Further details about EMPA in general are documented in Willis (1986:861) and Potts *et al.* (1995), while the LA-ICP-MS technique is adequately described in Perkins and Pearce (1995). Instrumentation at the University of Cape Town includes (1) Cameca Camebax Microbeam Electron Microprobe, with four wavelength dispersive spectrometers, operated at 15kVC and a defocussed beam of 30 microns, (2) Perkin-Elmer/Sciex ICP-MS with a Nd-YAG laser supplied by CETAC.

MAJOR ELEMENT COMPOSITION

The most abundant major oxide in the Thai glass beads is Silica (SiO_2), while other important constituents include Alumina (Al_2O_3), CaO, Total Fe expressed as FeO, MgO and the alkalis Na_2O and K_2O. Despite abundance data for ten major oxides being reported, the analytical totals depart appreciably from 100 weight per cent, which is most likely due to the presence of dissolved volatiles, such as Water (H_2O), Carbonate (CO_2) and possibly Chlorine. Such volatiles are also intentionally incorporated into the glass recipe to lower the melting temperature and facilitate handling and fashioning. Using the departure from 100% in the analytical total as a proxy for volatile content, it is clear from figure 25:2 that there is a significant variation, which correlates well with Silica. No other major oxide correlates as well with volatile content so the variation pattern in figure 25:2 can be attributed to recipes involving different ratios of Silica and volatiles. Some of the glasses contain a few percent of Lead (Pb), as indicated by the LA-ICP-MS analyses, which do not significantly alter the pattern shown in figure 25:2.

Since there is a wide variation in the analytical total it could be argued that the major oxide data needs to be recalculated to 100% on a volatile-free basis (a common practice in geochemical studies of geological materials such as igneous rocks), before comparisons are made. The effect of such a recalculation is illustrated in figure 25:3, where Silica has been plotted against Alumina. Low Silica (and by inference a low total analysis) samples show a greater change in composition, and while there is a compression in the data range, the overall pattern of variation is unaffected. Consequently it is not considered essential to carry out the normalization procedure.

If the colour is taken into account, figure 25:2 reveals

that orange glasses are characterized by low Silica, in the range of 40-60% while the blue glasses range up to high Silica values of nearly 80%. Most of the other colours show a limited range in Silica. The only other major oxides whose abundances show some rational grouping are illustrated in figure 25:4, where Silica is compared with the alkalis (Na_2O and K_2O). The low Silica orange glasses appear to form two groups distinguished by Na_2O content, while a subset of blue glasses contain extremely high K_2O levels.

While there is some correlation between certain colours and major oxide composition, there is not sufficient definition in the chemical patterns to allow confident interpretation. Clearly the Thai glass beads show a wide range in major oxide composition, but all could be attributed to specific recipes what were not particularly characteristic of any one manufacturer or site.

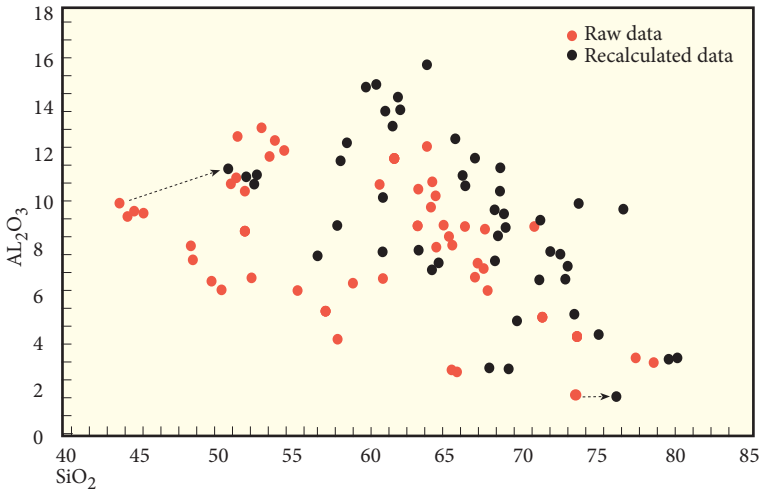


FIG. 25:3 Major element composition of Thai glass beads determined by Electron Microprobe Analysis (EMPA). Plot of Al_2O_3 versus SiO_2 (the most abundant major oxides) showing the effect of recalculating the data to a volatile-free basis. Dashed arrow represents absolute change, the magnitude of which varies with $Si0_2$

GLASSY SLAG

There are several ways to investigate whether glass or metal was made on site. One of them is through residual materials, such as slag. Metal or vitreous slag is light, glass-like waste material left when the metal ore or the material substance is separated from its natural rock.

A small piece of black ceramic fabric with a glass coating on both surfaces and part of a broken edge was found at Noen U-Loke. Qualitative compositional analysis of the bubbly glass and pottery fabric was applied using EDAX and the Scanning Electron Microscope. The glassy substance contained many quartz sand grains. The analysis of the pottery piece showed a large peak for Al and Si and small peaks for K, Ca and Fe. This is exactly what one would expect from fairly poor quality clay.

The spectra for the glass are variable but basically differ from that of the clay by the much greater size of the calcium peak (there are also some small peaks for Cl, P, Mg, Na and C). Similar coatings are often found on crucibles and furnace interiors. This glassy consistency is probably the result of reaction between clay and wood ash, the latter produced by the combustion of charcoal.

There is no indication of the purpose for which the ceramic sherd was used. From the fact that the glass coating extends over a broken edge, we deduced that it was a fragment of ceramic crucible that was broken before it fell into a fire pit. It evidently lay there long enough to build up a reaction rim of 1-2 mm, and to partially sinter (vitrify) the ceramic interior.

TRACE ELEMENT COMPOSITION

The Rare Earth Elements are frequently divided into two groups: Light (LREE), La to Sm, and heavy (HREE), Gd to Lu. Variation patterns in normalised REE data can best be demonstrated using ratios, such as Ce/Ce* and Eu/Eu*, which offer a measure of the departure of Ce and Eu from predicted abundance levels. Data for glass beads are plotted in figure 25:5, where anomalous compositions have been highlighted. A 'High Ce' group can be defined with Ce/Ce*>1.1, while 'High Eu' and 'Low Eu' groups are characterised by Eu/Eu*>1.1 and <1.1 respectively. The rest of the samples can be regarded as having 'normal' Ce/Ce* and Eu/Eu*, and have been further classified using the ratios La/Sm and Gd/Lu, which effectively measure the degree of light REE and HREE fractionisation respectively. Four groups can be recognized in figure 25:6, although some contain very few samples and the differences are more subtle than those identified in figure 25:5.

Full normalized REE patterns show that the high Ce groups show the distinctive positive Ce anomaly. The other groups separated by their different La/Sm and Gd/Lu ratios effectively display subtle changes in the slope of the LREE and HREE profiles.

The positive Ce anomaly of the high Ce group is probably the most distinctive feature encountered in this study. Such an anomaly is rarely encountered in geological materials and is interpreted as a signature inherited from a specific raw material used in the glass making. How this pattern came to be developed in the raw material will not be discussed in detail but suffice it to say that the source is probably sufficiently uncommon as to suggest that it might be site-specific.

Glass samples with the negative Eu anomaly are also

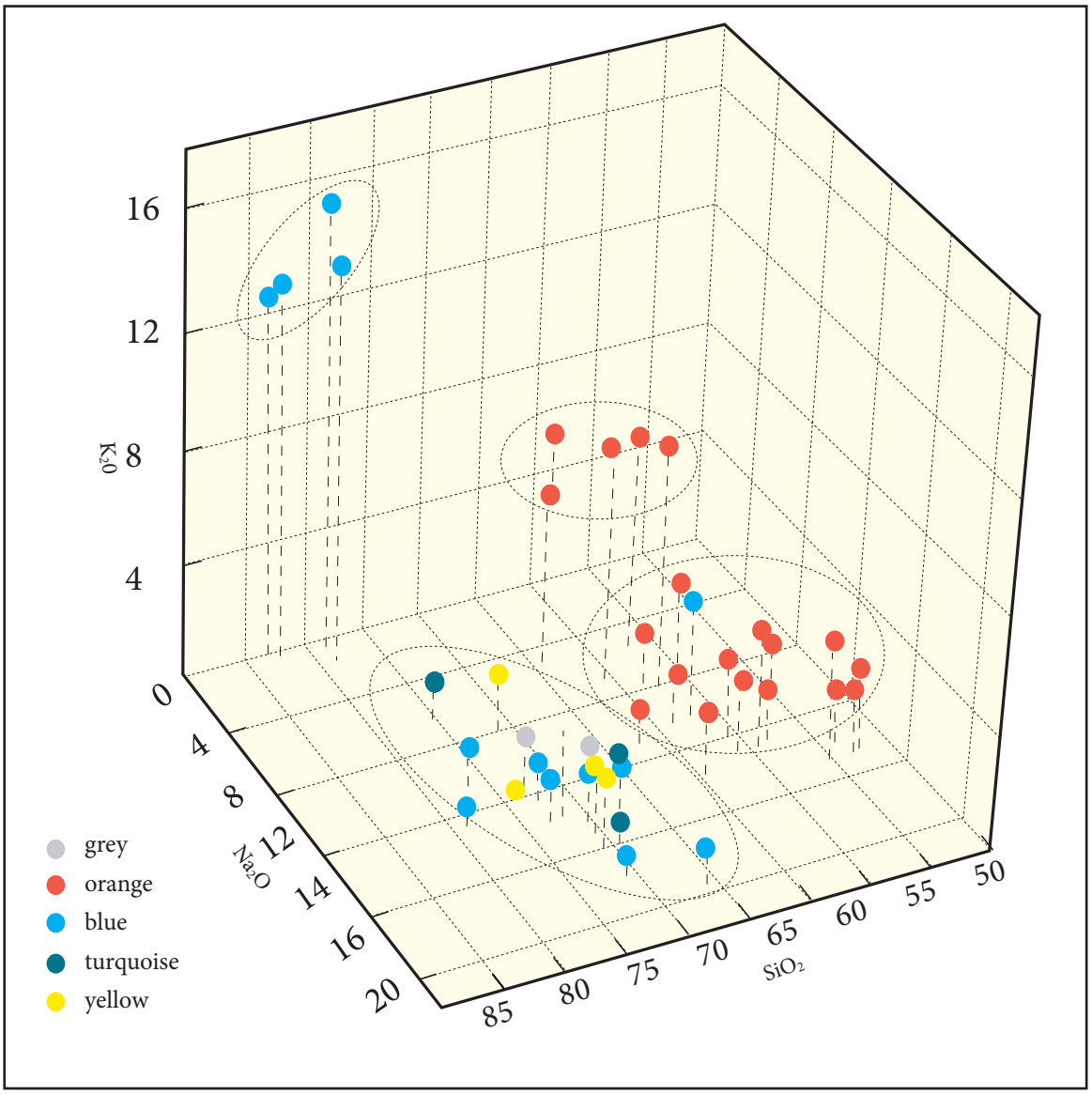


FIG. 25:4 Plot of the major oxides SiO_2, Na_2O and K_20 results in the best separation of chemical groups

distinctive, but this pattern is much more common in geological materials that could act as raw material sources. Most upper crustal materials usually exposed in outcrops, such as granites and the sediments derived from them by erosion, possess this negative Eu anomaly, so the patterns will seldom be site specific.

Groups characterised by the absence of Ce and Eu anomalies are not easily very distinct between themselves but in view of the discussion above concerning the prevalence of geological materials with negative Eu anomalies, the REE profiles all point to derivation from geological materials restricted to certain environments where upper crustal processes that fractionate Eu from the other REE did not develop. Examples would be ocean islands, such as Hawaii, or island arcs such as Japan. In terms of the Thailand setting, the nearest suitable geological environments are the Thai peninsula and Indonesia. Continental Thailand and most of SE Asia is underlain by typical upper crustal rocks that build most continental regions.

In summary, the REE patterns suggest that the Thai glasses contain two broad compositional groups, one of which could be site specific (high Ce), while the other is characteristic of a special geological environment (normal Eu) that is known to occur in the region.

DISCUSSION

The advent of glass blowing, attributed to a Roman invention in the 1st century AD, had a revolutionary impact on glass making world wide, resulting in relatively inexpensive and efficient manufacture of glass objects and the introduction of new forms.

Many innovative techniques were used for making glass beads from molten glass, some of which appear decep-

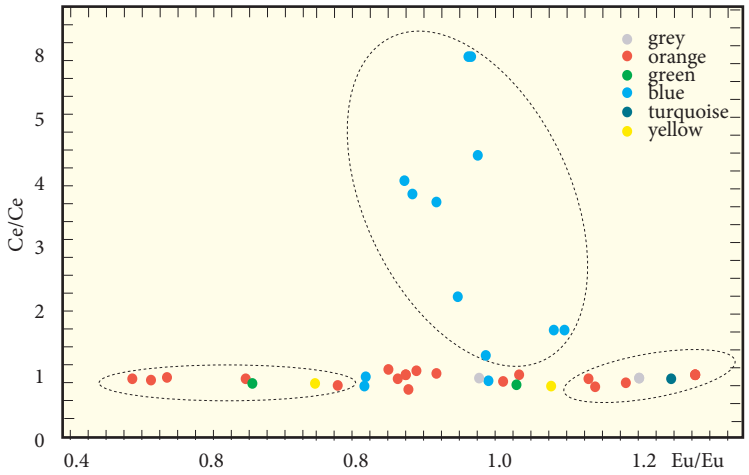


FIG. 25:5 Trace element characterisation of the Thai glass beads. Selected ratios of chondrite-normalised Rare Earth Element (REE) abundances reveal chemical grouping

tively simple. However, the expertise necessary for their production required a high level of glass working knowledge and craftsmanship that relied heavily on a number of parameters involving the selection of raw materials, chemical composition, viscosity of the glass, thermal expansion and furnace conditions. In many instances, characterisation studies such as those presented here, produce information that reflects some of these findings.

Visual classification of the Noen U-Loke collection showed that two vastly different glass-making industries were used to make the beads. These methods involved beads made by the drawn process, and the other by wrapping glass around a former or rod. Drawn beads are usually associated with mass production and glass blowing procedures, which involve perforating the glass to make the aperture of drawn beads by tooling or blowing a bubble of air into it before the tube is drawn or pulled out. Contrasting with this complex procedure, wrapped beads made by the manufacturing process proposed here, indicate that 'hot' glass methods of 'blowing' glass were unknown to their makers.

Bearing in mind the differences between the two techniques, it is not unreasonable to suggest that they originated from different industries. However, the elemental evidence obtained from REE analyses shows remarkable similarities. This evidence suggests that the bead makers were using similar materials, presumably from the same or very similar sources. It does not rule out that primary glass ingots were traded for secondary working but that is a matter for further exploration.

On the basis of the SEM and qualitative EDAX analysis of furnace residue excavated at Noen U-Loke, we cannot confirm that it was used in a glass making situation, nor that the glass coating was a real glass used for making beads. At this stage we also feel that a representative sample of fine glass 'thread' thus far discovered, is insufficient evidence to support that premise that glass or glass beads were produced at Noen U-Loke.

CONCLUSION

The physical attributes coupled with the additional elemental analyses used in this study have characterised the glass beads in sufficient detail to make unequivocal comparisons possible.

The information gained from visual classification (based primarily on methods of manufacture and appearance) shows that two distinctive types of glass beads, made by different processes, were present at Noen U-Loke. The extreme differences between them were significant enough to consider several production centres.

However, REE compositional analysis of the beads

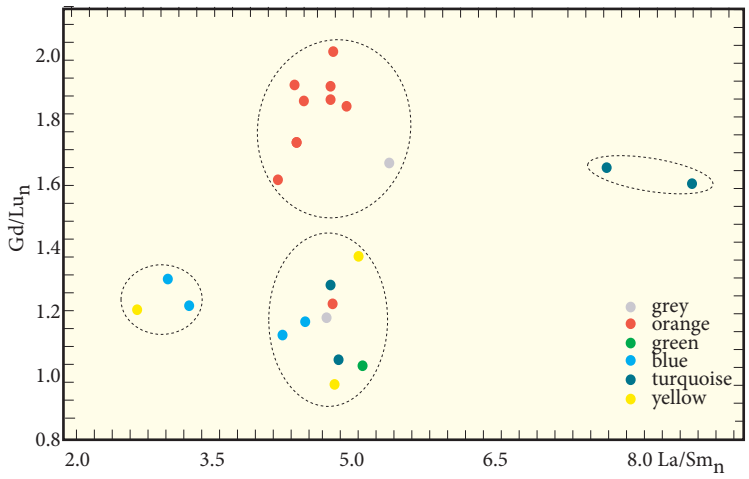


FIG. 25:6 Further use of REE abundance ratios enable chemical groupings of samples that do not fall into the High CE, High and Low Eu groups defined in figure 25:4

byLA-ICP-MS confirmed that, although glass bead making techniques were used, the glass from which they were fabricated is almost identical. These results suggest that the two types of bead were made from the same or very similar raw materials, though we are unable at this stage to say that they were manufactured in the same factory, or whether the glass simply came from the same area.



FIG. 25:7 Glass beads from Mortuary Phase 3 burials. A. Cat. 492 burial 37 MP3A, B. cat. 338, burial 23 MP3B, C. cat. 431 burial 29 MP3B, D. cat. 466 burial 32 MP3B, E. cat. 533 burial 45 MP3B, F. cat. 633 MP3B, G. cat. 675 burial 53 MP3B, H. cat. 683 burial 52 MP3B, I. cat. 690 burial 49 MP3B

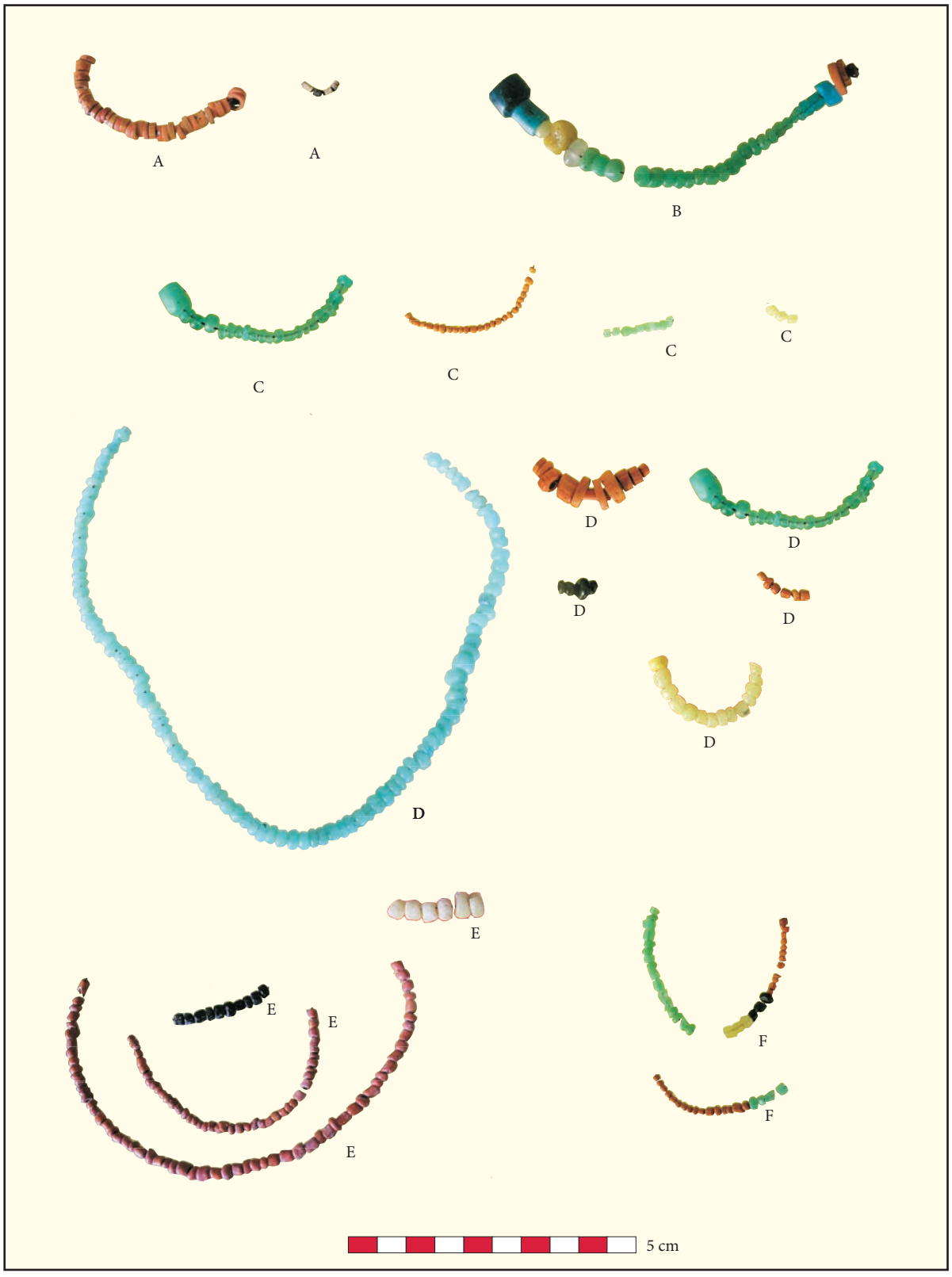


FIG. 25:8 Glass beads from Mortuary Phase 4A burial 94, B. cat. 1254 burial 95, C. cat. 1457 burial 105, D. cat. 1465 X1 layer 3:13, E. cat. 1666 burial 80, F. cat. 1741 burial 121

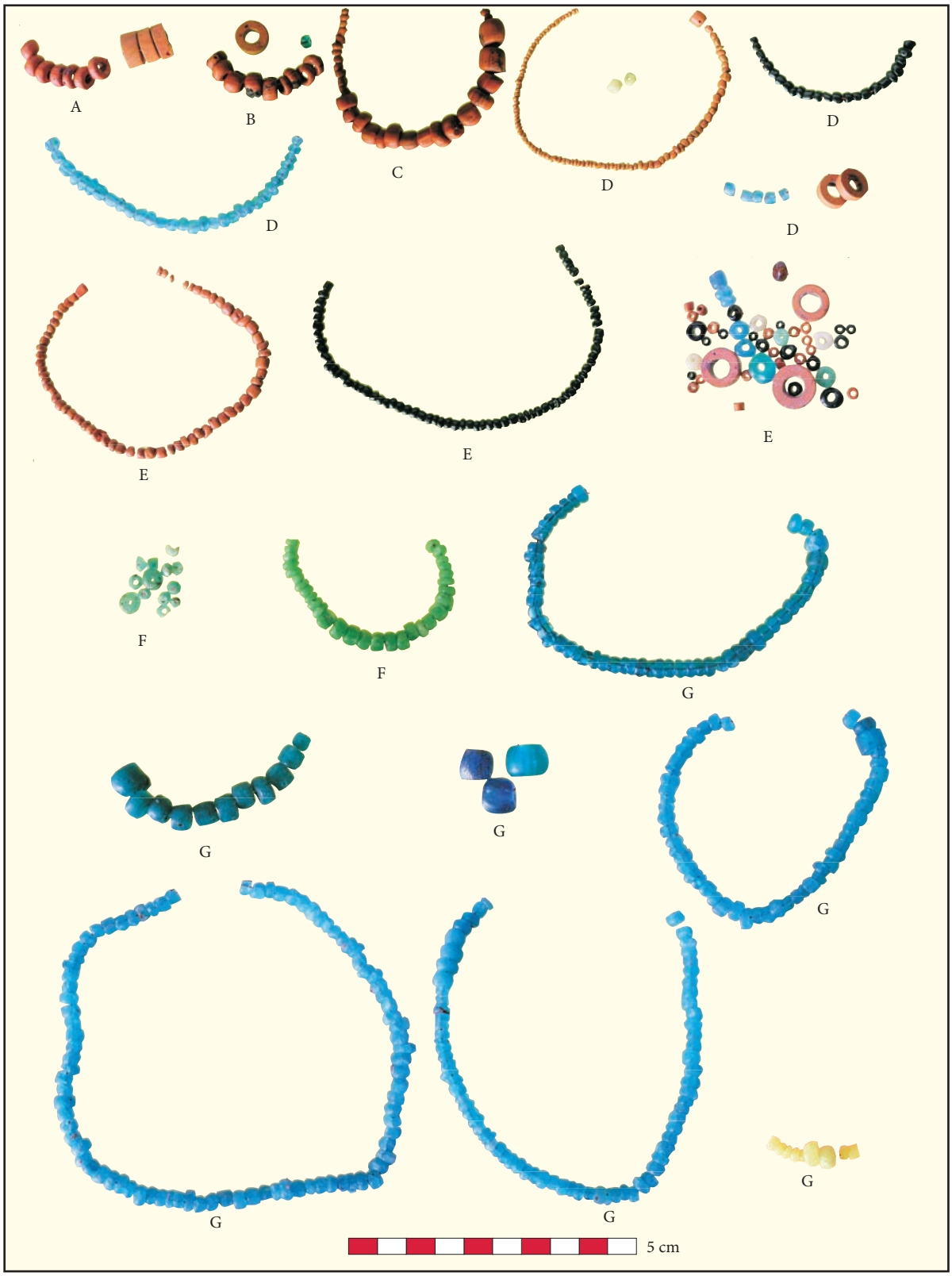


FIG. 25:9 Glass beads from mortuary phases 4B and 4D. A. cat. 504 burial 25 MP4B, B. cat. 516 burial 25 MP4B, C. cat. 541 burial 25 MP4B, D. cat. 776 burial 25 MP4B, E. cat. 555 burial 47 MP4B, E. cat. 1196 burial 103 MP4B G. cat. 178 burial 14 MP4D

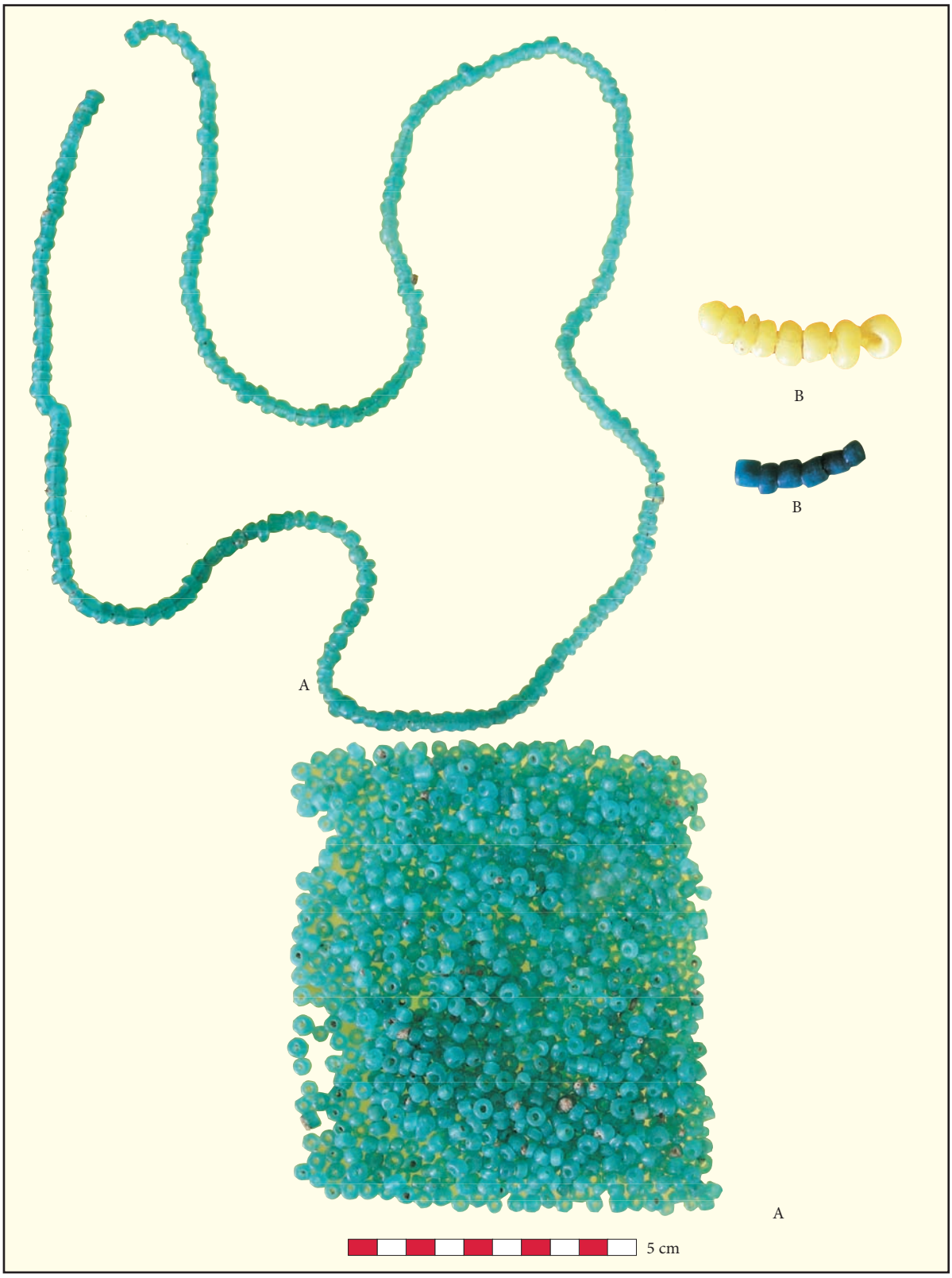


FIG. 25:10 Glass beads from Mortuary Phase 4D. A. cat. 236 burial 13 MP4D B. cat. 311 burial 21 MP4D



FIG. 25:11 Glass beads from Mortuary Phase 5 and layer 4:9. A. cat. 1414 burial 102, B. cat. 1628 burial 116, C. cat. 670 B2 4:9

XXVI. THE CERAMICS

J. VOELKER

INTRODUCTION

The ceramic assemblage from Noen U-Loke comprises 350 complete and/or reconstructed vessels that are associated primarily with burials and features. This assemblage consists largely of Phimai Black vessels, but spans transitional phases from the Bronze Age to the Iron Age and into the Early Historic Period as well. Vessel forms include bowls, small dish pedestal vessels, and jars of various sizes. Surface finish includes cord marked, plain, and slipped and burnished vessels. Also at the site of Noen U-Loke, 279 lot bags representing sherds with a total weight of 1,593 kilos were washed, sorted, and sampled at the Archaeology Laboratory at the Fine Arts Department in Phimai from 1997 to 1999. This chapter provides an overview of the ongoing ceramic analysis at the site of Noen U-Loke. A more thorough presentation of the ceramic data and analysis results will be detailed in a separate monograph devoted solely to the ceramics from the sites excavated by the Origins of Angkor Project. Objectives of the ceramic research include the examination of the development of ceramic technology and manufacturing processes, and its relationship to cultural development in the upper Mun Valley of Thailand from *c.* 2100 BC-AD 500. Several lines of evidence including results from petrographic, compositional, and technological analyses have been utilized and integrated for this summary.

COMPOSITIONAL ANALYSIS

Resources within the project area were assessed in terms of the availability and suitability of raw materials for ceramic manufacture. A survey to identify and sample clay sources yielded 60 clay samples. Following collection and testing of clays, compositional analysis was undertaken to determine the mineralogical make-up of clays identified as usable for pottery manufacture. A goal of the analysis was to obtain profiles of available clay resources. The 60 samples were observed under an incident polarizing microscope and a scanning electron microscope. A small "smear" was taken from each clay sample. An area scan, which determines the bulk composition of the clay matrix, was conducted on the samples. Although the identification, characterization, and location of clay resources near the Origins of Angkor sites have been discussed in detail elsewhere (Voelker 2002), the results of the compositional analysis include the determination that variation among samples was perceptible, but no distinct categories were observed. The observations from the compositional analyses of the clay samples have archaeological implications: clays within the project area are not distinct; therefore intra and inter-site comparisons of pottery production are not possible. However, regional and inter-regional comparisons may be feasible and further studies are currently in progress to test these findings.

PETROGRAPHIC ANALYSIS

Objectives of the petrographic analysis include identifying the nonplastic inclusions used as temper in the prehistoric ceramics from Noen U-Loke and other Origins of Angkor study sites. Interpretations of petrographic data require looking for groups of similar samples. Mineral paste groups can be sorted using type, size, shape, orientation, and density of mineral inclusions in thin sections (Rice 1987). Point counting or modal analysis determines the percentage of inclusions. Petrographic analysis can inform on the mode and quality of ceramic production since both the texture and organization of the inclusions of the paste are preserved (Druc 1998:25).

Initial determination of fabric texture and types of inclusions added as temper were made using a binocular microscope. Samples were selected for petrographic analysis from the corpus of reconstructable vessels and several rim sherds from Ban Lum Khao, Noen U-Loke, and Non Muang Kao. Thin section analysis was conducted at the Department of Geology at Dickinson College where 37 polished thin sections were examined under a polarizing microscope using an 800 count modal analysis by Dr. William Vernon. The samples consist of 23 sherds from Ban Lum Khao, 9 sherds and 1 wattle and daub sample from Noen U-Loke, and 4 sherds from Non Muang Kao.

RESULTS OF THE PETROGRAPHIC ANALYSIS

Petrographic analysis of thin sections from the three sites revealed eight major temper groups and three subgroups. Temper Group 1 consists primarily of organic material and lesser amounts of quartz. Temper Group 2 consists primarily of quartz with lesser amounts of organics and grog. Temper Group 3 consists primarily of grog with lesser amounts of quartz. Temper Group 4 consists of mineral sand while Temper Group 5 is predominately rice chaff or other organic material. Temper Group 6 is similar to Group 1 except that the organic temper is rice chaff. Temper Group 7 consists of quartz, grog, and rice chaff. Temper Group 8 is composed of rice chaff and mineral sand.

Temper Groups 1, 2, and 3 have subgroups, 1.1, 2.1, and 3.1 respectively. The subgroups differ in that each subgroup

TABLE 26:1 *Temper types from Ban Lum Khao, Noen U-Loke and Non Muang Kao*

Sample	Provenence	Temper Group	Principal additives – observations
BLK #4	A1:A 1:2	6	Minor quartz (some polycrystalline grains), predominately organic material (=rice chaff)
BLK #13	A1:A 1:5	2	Minor quartz (some polycrystalline grains), grog, predominately organic material
BLK #29	A1:A 2:4	6	Minor quartz (some polycrystalline grains), predominately organic material (=rice chaff)
BLK #51	A1:A 2:7	2.1	Quartz, grog, a little organic material, some sponge spicules
BLK #52	A1:A 2:7	2.1	Quartz, grog, a little organic material, some sponge spicules
BLK #53	A1:A 2:7	3	Grog, quartz
BLK #54	A1:A 2:7	2.1	Quartz, grog, a little organic material, some sponge spicules
BLK #73	A1:A 3:3	2	Quartz, grog, a little organic material
BLK #88	A1:B 1:4	3.1	Quartz (a few polycrystalline grains), a little grog, some sponge spicule fragments
BLK #103	A1:B 2:3	2.1	Quartz, grog, a little organic material, some sponge spicule fragments
BLK #165	A1:B 3:2	2.1	Quartz, grog, a little organic material, some sponge spicules
BLK #173	A1:B 3:3	3.1	Quartz, grog (at least 3 types), some fresh water sponge spicule fragments, some gemmules
BLK #198	A1:C 2:5	2	Quartz, grog, a little organic material
BLK #213	A1:C 2:10	2	Quartz, grog, a little organic material
BLK #214	A1:C 2:10	3	Quartz, grog, several grains of green hornblende
BLK #217	A1:C 2:10	4	Mineral sand
BLK #250	A1:C 3:2	2.1	Quartz, grog, organic material, some sponge spicule fragments
BLK #332	B1:A 2:1	2	Minor quartz (some polycrystalline grains), grog, predominately organic material
BLK #373	B1:A 3:1	2	Quartz, grog, a little organic material
BLK #447	B1:B 3:1	3.1	Quartz (a few polycrystalline grains), grog, some sponge spicule fragments
BLK #446	B1:B 3:1	3.1	Quartz, a little grog, sponge spicule fragments, gemmules
BLK #478	B1:B 3:3	1	Minor quartz (some polycrystalline grains), predominately organic material
BLK #480	B1:B 3:3	2.1	Quartz, grog, a little organic material
NUL #332	A2 4:5	5	Mixture of organic material including rice chaff
NUL #747	A2	8	Organic (=rice chaff) and quartz sand
NUL #750	B2 6:7	8	Organic (=rice chaff) and quartz sand
NUL #836	B3 2:2/3	4	Mineral sand
NUL #840	C1 2:3	8	Organic (=rice chaff) and quartz sand
NUL #1027	C2 3:13	5	Mixture of organic material including rice chaff
NUL #1283	B3 4.4	8	Organic (=rice chaff) and quartz sand
NUL #1543	B3 6.2	5	Mixture of organic material including rice chaff
NUL #1782	A3 6.8	3	Quartz sand and grog
NUL #WD48	X1 3.6	-	Natural clay – large amount of quartz
NMK #25	A1 2.3 Fea. 1	8	Organic (=rice chaff) and quartz sand
NMK #49a	A1 2:5 Fea. 2	8	Organic (=rice chaff) and quartz sand
NMK #56	A1 2.3 Fea. 9	8	Organic (=rice chaff) and quartz sand
NMK #92b	A1 2:6 Fea. 24	5	Mixture of organic material including rice chaff

Temper Groups: Group 1: organic, quartz, Group 1.1: organic, quartz, sponge spicule fragments, Group 2: quartz, organic, grog, Group 2.1: quartz, organic, grog, sponge spicule fragments, Group 3: grog, quartz, Group 3.1: grog, quartz, sponge spicule fragments, Group 4: mineral sand, Group 5: mixture of organic material including rice chaff, Group 6: organic (=rice chaff), quartz, Group 7: quartz, grog, organic (=rice chaff), Group 8: organic (=rice chaff) and quartz sand

also has sponge spicule fragments in the clay matrix. The spicules are indicative of a freshwater ponded source for the clay but analysis thus far precludes the determination of whether it is a single clay source or multiple ponded sources. Results of the petrographic analysis suggest that all the tempering agents are available within the study area although their use varied through time. Temper Groups present at Noen U-Loke will now be discussed in more detail.

RESULTS OF TEMPER ANALYSIS AT NOEN U-LOKE

Of the whole and/or reconstructable vessels recovered from excavations at Noen U-Loke, 248 vessels were included in the temper analysis. Of these, 98 vessels are from mortuary contexts while the remaining vessels are both lidded vessels that are often placed near mortuary features and pottery from features. Sample sherds were selected from this group for thin sectioning and petrographic analysis. Pieces of the remaining samples were examined under a binocular microscope at 20x and 40x magnification and assigned to one of the temper groups described above. Whole and reconstructable vessels were chosen primarily because of their known context and provenence at the site but also to ascertain if vessel morphology was linked to temper type.

The temper analysis of ceramics from Noen U-Loke is complex but interesting (Table 26:2). Several different tempers were used to manufacture vessels during the initial settlement at Noen U-Loke. In layer 5 and 6, temper contains rice chaff and quartz sand (Temper Group 6), or a mixture of organic material including rice chaff (Temper Group 5), or grog and quartz (Temper Group 3), or a combination of quartz, grog, and rice chaff (Temper Group 7). Twenty vessels are present in these lower layers and morphologically several vessels are similar to those from the later layers at nearby Ban Lum Khao. Significantly, 95% of these vessels have rice chaff present in their temper. Only one vessel from Noen U-Loke, from layer 6.8, the lowest layer at the site, is not tempered with rice.

Temper in layer 4 continues to show much variation. Although Temper Groups 5 and 6 have prominence, Groups 6 and 7 are also represented; and all four groups are quite similar in composition. All vessels from layer 4 contain at least some rice chaff as a tempering agent and in Layer 4, Phimai Black vessels first appear.

By layer 3 at Noen U-Loke, all vessels contain a mixture of organic material including rice chaff as a tempering agent. In layer 2, particularly in the lower contexts there is a preference for Temper Groups 5 and 8 in the manufacturing of pottery. In the upper contexts of Layer 2 there are four vessels that are similar in shape to vessels from the early historic period in the region; and notably all four are tempered only with mineral sand.

TABLE 26:2 *Temper group distribution by layer*

Layer	Group 3	4	5	6	7	8
2.1	-	2	-	-	-	-
2.2/3	-	2	-	-	-	-
2.3	-	-	-	-	-	1
2.4	-	-	-	-	-	1
2.5	-	-	5	1	-	5
2.6	-	-	5	1	-	5
3.1	-	-	5	-	-	-
3.2	-	-	2	1	1	5
3.3	-	-	1	-	-	6
3.4	-	-	1	-	-	3
3.5	-	-	4	-	1	5
3.6	-	-	5	-	-	-
3.7	-	-	1	-	-	1
3.8	-	-	4	-	1	2
3.9	-	-	5	-	2	2
3.10	-	-	3	-	-	1
3.11	-	-	2	-	1	3
3.12	-	-	5	-	1	-
3.13	-	-	6	-	-	7
3.14	-	-	7	-	-	-
4.1	-	-	7	1	-	9
4.2	-	-	4	-	1	3
4.3	-	-	3	-	-	-
4.4	-	-	10	-	4	1
4.5	-	-	5	-	1	3
4.6	-	-	11	2	3	7
4.7	-	-	4	-	-	1
4.8	-	-	6	-	-	5
4.9	-	-	4	-	-	2
4.10	-	-	6	-	1	2
4.12	-	-	1	-	-	-
4.12	-	-	1	-	1	-
4.14	-	-	1	-	2	-
5.2	-	-	5	-	2	-
6.2	-	-	5	4	-	-
6.4	-	-	1	-	-	-
6.6	-	-	1	-	-	-
6.8	1	-	-	1	-	-

SUMMARY OF TEMPER ANALYSIS AT NOEN U-LOKE

Although the analysis of differing tempering additives used by prehistoric potters has proven complex, some trends are evident at the site. It is clear that organic material, specifically rice chaff, was preferred by prehistoric potters at Noen U-Loke. Sometimes rice chaff was used in combination with other tempering additives such as grog and quartz, or other organic material, but it remained part of the tempering recipe for prehistoric potters. This remains true regardless of the many forms and styles of vessels made. This use becomes more pronounced over time until the final occupation of the site, when a small sample of vessels shows that mineral sand becomes the preferred choice of temper.

The ubiquity of rice as a temper additive parallels other shifts at the site including the mortuary ritual of rice bed burials. Together, these changes may signal the availability and perhaps the surplus of rice at these sites during this period. From a ceramic standpoint, rice husks offer no added benefit from other organic tempers. In both cases, organic temper may have aided in the thermal shock properties of the manufactured vessels yet within the examined assemblages most vessels do not appear to have been used for cooking. Therefore, it is possible that rice chaff was used by the prehistoric potters because it was easily obtained and available in large quantities. Further examination will determine if other changes at the site can also be related to the availability of rice and agricultural intensification inferred by the temper analysis.

CERAMIC MANUFACTURE AT NOEN U-LOKE

Vessel Forming

Vessels at Noen U-Loke were shaped and their walls thinned by the use of paddles and anvils. Anvil impressions are often found on the jar interiors and cord-marking on vessel exteriors is found throughout the occupational sequence at Noen U-Loke. Although many bowls, particularly the Phimai Black ones, are smoothed which obfuscates the anvil impressions, vessels were still handmade; there is no evidence that vessels were wheel made. Instead, even the finely-made Phimai bowls are often slightly misshapen and/or not perfectly rounded.

Phimai style bowls and jars mark a shift in the manufacture of pottery within the region in part because of the thinness of vessel walls. These vessels are often just 3 to 7 mm at the maximum diameter of the vessel as well as the vessel base. The thinness demonstrates the potter's skill but also reflects the shapes of vessels during this period and the tempers used as additives. Unlike the earlier angular and rim-heavy Bronze Age Prasat vessels, Phimai Black vessels regardless of size are usually rounded. The rounded contours of these vessels, including their bases, can be formed in one stage by beating the paddle and anvil against the vessel walls until the desired shape is achieved.

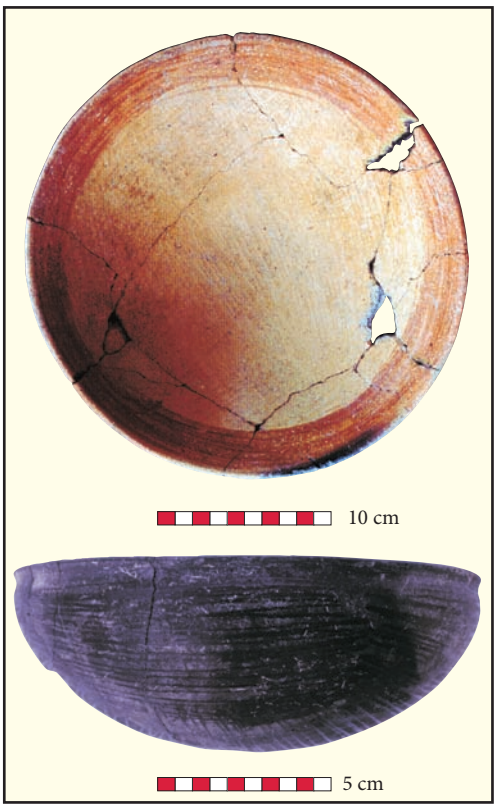


FIG. 26:1 Ceramic vessels from Noen U-Loke. Above, cat. 750, B2 layer 6:2. Below, cat. 999, C2 3:12 feature 2

Vessel Finishing

Finishing techniques at Noen U-Loke include slipped, burnished, cord-marked, and painted vessels. The most common vessel finish at the site is streak burnishing. This technique results from a blunt tool being scraped along the vessel walls to create a noticeable and often lustrous impression. These impressions are often located on bowl interiors and form spirals and/or geometric designs. Although this technique is usually associated with Phimai Black vessels, it is apparent from the vessel assemblages at both Ban Lum Khao and Noen U-Loke, that streak burnishing apparently began with shallow bowls that have red slipped and burnished banding found in a transitional phase between the Bronze and Iron Age at both sites. The pictured vessel (Fig. 26:1 upper) is from this transitional phase and illustrates the technique of streak burnishing. It is later, when reduced firing is prevalent and Phimai Black bowls are common at the site, that this technique was perfected (Fig. 26:1 lower).

Vessel Firing

Plain and corded vessels are found throughout the occu-

pational sequence, while red slipped and burnished vessels are associated only with the earliest layers at Noen U-Loke. Plain, corded, and red slipped and burnished vessels continued to be fired in an oxidizing atmosphere, the firing tradition noted at nearby Ban Lum Khao. Fire clouds are evident on some vessels, many vessels are mottled in colour, and vessel cores remain black, which are all results of variable control over the duration, temperature, and atmosphere of the firings. Fire clouds are common with open-air firings and are caused when vessels are not protected from contact with the fuel or from drafts (Rice 1987:155). The varied colour of vessels reflects the fluctuations in firing temperatures common to open-air firings whereas the black vessel cores indicate that the firing was not sufficient for organic material to be burned out of the clay matrix.

From the vessel assemblage at Noen U-Loke it is apparent that two different techniques involving oxidizing and reducing atmospheres were used to fire pottery; both methods can use open-air bonfires to achieve the desired end products. A firing atmosphere is controlled by the amount of air available to burn the fuel; if there is insufficient air during firing, reducing conditions are produced and when there is excess air compared to fuel available, oxidizing conditions are created (Rye 1977:25). Plain, corded, and red-slipped and burnished wares are typically fired in an oxidizing atmosphere while Phimai Black vessels are fired in a reducing atmosphere. Phimai Black vessels are known for their lustrous black colour.

The change in firing regimes at Noen U-Loke is reflected in the introduction and preference throughout much of the occupational sequence at the site for black pottery, known locally as Phimai Black. This blackened pottery could have been obtained by a technique often described as smudging. In smudging, vessels are blackened by covering pots immediately following an open-air firing with a pile of fine material including powdered manure or sawdust. This serves to cut off the oxygen supply so that carbon is deposited on the surfaces and in the pores of vessels (Rice 1987:158). As Rye explains, blackening is done after the vessels have reached maximum temperature and are beginning to cool; although most of the carbon deposition occurs within the first minutes of closing air off, vessels are kept in this environment to prevent carbon from being reoxidized (1977:115). Fine material such as rice chaff may have been used to obtain a reduced atmosphere necessary to achieve the blackened vessels. This process of carbonization would also help to explain why so many of the recovered Phimai Black vessels and sherds are exfoliated.

Reduced firing occurs at Noen U-Loke beginning in Layer 4 and continues throughout the remainder of occupational sequence. The preference for Phimai Black pottery has been noted at other sites both within the study area and the surrounding region. At the present, it is unclear whether this is a local adaptation or was brought about by external contact or influences.

EVIDENCE OF CERAMIC PRODUCTION

Vessels at Noen U-Loke were shaped and thinned using paddles and anvils. Four anvils and anvil fragments were recovered from excavations and all were from the lower layers at the site (Table 26:3). Two anvils were recovered from Layer 6, another was recovered in layer 5.2 and the fourth was located in layer 4.7.

The anvils recovered at Noen U-Loke have two distinct shapes. One is small and squat, while the other is larger, with a more rounded head (Fig. 19:4). Generally, smaller anvils are used for vessel smoothing and the larger for shaping. It is possible that the prehistoric potters made similar distinctions.

Although many hearths and other burnt areas were noted during excavations at Noen U-Loke, none was convincingly associated with pottery manufacture. Instead, in the earliest occupation layers when prehistoric potters were making vessels at Noen U-Loke, firing was apparently not in the immediate vicinity but may have been nearby. Later in the occupation sequence of the site, if people were making pots on site it also did not occur within the excavated areas.

SUMMARY OF NOEN U-LOKE CERAMICS

The ceramics from Noen U-Loke span the late Bronze Age through the Iron Age and into the early Historic Period. The presence of anvils provide evidence for ceramic production at Noen U-Loke and it is revealing that the only evidence for on-site ceramic production occurs in the earliest layers and that the associated ceramics recovered *in situ* from these layers appear to relate to a transitional

TABLE 26:3 *Noen U-Loke anvils*

Area	Layer	Handle length	Handle width	Anvil head width	Anvil head length	Comments
B1	4.7	3.3	4	5.6	6.9	Hollow handle, rough head
A1	6.4	3.6	1.6	6.0	4.01	Squat; handle tip is corded
A1	6.5	4.2	1.7	4.7	4.8	Squat; head is rough
B1	5.2	-	4	10.5*	4.4*	Large anvil; fragment

* not complete. Dimensions in cm

phase between the late Bronze and early Iron Ages. Later in the sequence there is a noticeable absence of anvils yet vessels continue to be shaped using paddles and anvils. It is possible that in the later sequence at the site pottery is made in another area of the site or perhaps pottery was now manufactured off-site.

Although the analysis of differing tempering additives used by prehistoric potters has proven complex, some trends are evident. Except for the final sequence at the site, potters preferred organic material as temper; specifically rice chaff. Sometimes rice chaff was used in combination with other tempering additives such as grog and quartz or other organic material but it remained part of the tempering recipe for prehistoric potters. This remains true regardless of the many forms and styles of vessels made. The ubiquity of rice as a temper additive parallels other shifts at the site including the mortuary ritual of rice bed burials at. In tandem, such evidence may signal the intensification of rice production in the area.

Another change that is reflected in the ceramic assemblage at Noen U-Loke is the introduction and preference throughout much of the occupational sequence for black pottery produced through a reduced atmosphere firing regime. This shift occurs fairly early (layer 4) at the site and continues throughout the remainder of occupational sequence. This preference for Phimai Black pottery has been noted at other sites both within the study area and the surrounding region. At the present, it is unclear whether this is a local adaptation or was brought about by external contact or influences.

RELATIONSHIP TO CULTURAL CHANGE WITHIN THE REGION

Examination of the ceramic data from the three sites of Ban Lum Khao, Noen U-Loke, and Non Muang Kao demonstrates some continuity between these sites over time in potting preferences. The adoption of new manufacturing techniques by prehistoric potters is also evident. By viewing ceramic assemblages which span an entire sequence within the study region, it is possible to determine which vessel types are diagnostic for specific periods. In this framework, it is believed that the following vessel forms can be used to signal the transitional phase between the Bronze and the Iron Ages with the region. These vessels are found at both Ban Lum Khao and at Noen U-Loke. The red slipped banding with streak burnishing are the defining features for this characterization (Fig. 26:2 A-B, E-G).

Two vessel forms known at both later Noen U-Loke and at Non Muang Kao can serve as diagnostic forms for the late Iron Age with the region. This gobular jar with its distinct shoulder decoration has been recovered at other sites within the region including Ban Suai and Ban Non Wat (Fig. 26:2 C-D). Interestingly, there seems to be variability, perhaps by site or temporally, in the shoulder design associated with this vessel.

CONCLUSION

The ceramic analysis from Noen U-Loke is ongoing. Findings to date illustrate that prehistoric potters used their local environment in adapting potting techniques and traditions. An example of prehistoric production methods is the adoption of rice chaff as a temper to the clay matrix. Rice chaff (and other organic material) as an additive serves to reduce the plasticity of the naturally sandy clay found in the study area. By 200AD, at the site of Noen U-Loke over 90% of the pottery recovered from excavations was rice chaff tempered. This shift to the almost exclusive use of rice chaff temper parallels other changes at the sites including the introduction of "rice-bed burials" in mortuary contexts.

This research provides a solid base for future ceramic studies on pottery production in the Phimai region. Further research will incorporate findings from the present study to examine questions of exchange within the region in prehistory.



FIG. 26:2 Ceramic vessels from Noen U-Loke and compararative sites. A. cat. 475, B. Ban Lum Khao cat. 155, C. cat. 1901, D. cat. 1027, E. cat, 1898, F. Ban Lum Khao cat. 401, G. cat. 750, H. from E. Nitta, I. cat. 840.

XXVII. THE FAUNAL REMAINS

M. M^{C}CAW

The sample of faunal remains from Noen U-Loke is unparalleled for the Iron Age of Southeast Asia. All material excavated was subject to screening, and cultural material from grave fill and pits were passed through the flotation procedure. The conditions for the preservation of bone were excellent. Morag McCaw undertook the analysis of the bone, excluding the fish bone, and the shellfish for her M.A. dissertation. Her results are summarised below.

INTRODUCTION

The objective of this chapter is to evaluate the subsistence economy of Noen U-Loke through faunal analyses. To fulfill this aim, certain areas will be explored. A species list will be constructed in order to determine the variety of species exploited. This is traced through time to note any changes in species abundance. The concept of species richness measures the variety and abundance in which they are found (Horwitz 1996). It is noted that less common species will be affected by sample size, and have a greater chance of being omitted from the assemblage, while the more common species will almost always be represented.

Measurements are taken to distinguish between wild and domestic species, indicating whether the community were predominantly hunters or farmers. Modern work conducted on the dimensions of Thai bovine specimens (Kijngam 1979:14) has uncovered clear evidence for sexual dimorphism. Certain male bones tend to be longer, as well as broader. Analysis of the wear and eruption of bovine and suid teeth provide mortality frequencies, from which patterning can be identified.

As in any analysis, materials recovered from mortuary contexts are a wealth of potential social and economic information. An analysis of faunal remains from mortuary contexts allows for the consideration of the relative ritual importance of mammalian fauna within a particular site. The identification and quantification of shellfish remains allows for an examination of species exploited for dietary reasons, while noting change through time. The analysis of molluscs contributes to a reconstruction of the palaeoenvironment.

IDENTIFICATION

All excavated material was identified where possible. The unidentifiable material was weighed. The recovery of faunal material was aided by the use of 6.4mm sieves and a flotation unit. Once recovered, all bone material was cleaned and labeled with provenance data in the form of square, layer, spit, and feature. A catalogue number was allocated if the bone came from a grave or was modified.

The primary sort identified and separated material from features, burials, and occupation layers. The material from occupation layers was organised according to layer and spit. The remains from individual features, such as grave fill, pits or middens, were identified separately. Faunal remains recovered from burials were identified by a catalogue number. These three groups were analysed as separate entities. This makes it possible to consider the function of the features, general occupation layers, and add insight into burial rituals.

Bone fragments were assigned to genus and, where possible, species. In some instances identification was limited to the family level. The analysis continued by calculating the minimum number of individuals (MNI) per species per layer, or feature.

During the identification process, complete and, if possible, partial bones were measured. While the analysis was undertaken, charring and butchery marks were noted. Only a preliminary examination of the recovered bone was conducted as the excavation proceeded. During intermittent phases, the faunal remains were stored in a manner that assisted in their proper conservation until the complete identification and analysis of the remains was conducted.

It is particularly difficult to ascribe ribs and vertebrae to species, as such their identification was not attempted. This did not hinder the calculation of MNIs nor alter the composition of the Noen U-Loke faunal spectrum. It is important to note, however, that these bones were present in the faunal record.

Large bovine bones that could not be classified without doubt to either water buffalo or cattle were grouped as "Bovidae". This is a widespread problem in Southeast Asia and has been encountered frequently (Kijngam 1979, 1984, Welch and McNeill 1990). When calculating and analysing minimum numbers, this needs to be taken into account. Such indeterminate specimens included fractured long bones, mandibles, and maxillae. Certain bones, such as the phalanges, metapodials, and carpals, were easier to identify as they hold certain characteristics to their species. Water buffalo bones tend to be broader and more robust, in harmony with their larger body mass.

The cervid family also posed problems during the identification process. This is not uncommon. Wapnish and Hesse (1991) encountered similar difficulties when analys-

ing Persian deer remains from Tell Dan. Seven deer species are found in Thailand, and the similarity between size and structure of these species causes identification problems. The two large deer, *Cervus unicolor* and *Cervus schomburki*, have been grouped together, although most are almost certainly the former. The size of *Muntiacus muntjak* and *Axis porcinus* limb bones significantly overlaps. Thus, they are often referred to as small deer (Kijngam 1979:44). In this analysis, the two species will be grouped together under the name *Muntiacus muntjak. Cervus eldi* stands alone as the middle-sized deer. Mouse deer (*Tragulus*) could be easily identified, but none was encountered. The identification difficulties pose a problem as the deer species have rather distinct habitats, which would prove valuable when reconstructing the prehistoric environment. Antlers are species specific, but their rarity in the archaeological record eliminates this as a possibility of determining the relative frequency of different species. Identifiable antler was assigned to the appropriate species.

The suid bones have been ascribed to *Sus scrofa*, which refers to both wild and domestic pigs in Thailand (Lekagul and McNeely 1977:662). Six small cats are indigenous to Thailand, all but one having a prehistoric range that included the Khorat Plateau (Kijngam 1979:46). The problem with identifying feline species is that they are all of similar size. In this analysis it was not possible to identify the bones below the generic level. At least twenty-three species of rat could be represented in the faunal spectrum, but due to identification difficulties these were grouped as *Rattus* sp. No attempt was made to distinguish whether there were different species of rat at the site. Bird bones were found occasionally throughout the sequence, and these bones have been identified as the domestic chicken, *Gallus gallus.*

The frog most likely to be found at Noen U-Loke is *Rana tigrina*. This species is adapted to flood plains and is common today in village rice fields (Kijngam 1979:67). Fragments of either turtle or tortoise carapace were found regularly throughout the sequence. Attempts at distinguishing between the tortoise and turtle remains were made, but with no success. In this analysis the remains will be listed as Trionychidae. Two species are found in Northeast Thailand, *Trionyx cartilagineus* and *Chitra indica* (Kijngam 1979:69). Distinguishing between the two is very difficult, for this reason the carapace remains will be listed as *Trionyx*/*Chitra*, as in previous analyses (Higham and Kijngam 1982:20).

COMPARATIVE COLLECTION

The complete analytical process was undertaken at the Phimai National Museum in the Nakhon Ratchasima province. Comparative material was somewhat scarce, though material identified from previous excavations, especially the Ban Lum Khao specimens, proved most useful.

Modern samples of bovine bones had been collected previously and used to identify the species and sex of bovine remains. The co-ordinates used in previous analyses (Kijngam 1979) are implemented in this study. A lack of prehistoric comparative material means that using modern samples is the most accurate method available. There remains an overlap between different sexed species, and for this reason only tentative conclusions can be made.

BUTCHERY EVIDENCE

Evidence for any butchering activity by way of cut marks or fractures is of particular interest. The characteristics and location of cut marks can provide information on skinning, defleshing, marrow extraction, and filleting. Particular areas of interest include proportional frequencies of cut-marked specimens, evidence indicating different butchery techniques, and whether these changed over time.

An investigation into whether high meat value bones were predominantly and more heavily cut than low meat value bones is important. This would indicate that the animal was primarily used for consumption. Disarticulation is indicated by cut marks on low meat areas, such as phalanges.

MEASUREMENTS

The decision to take measurements of archaeological material is only relevant when the results may respond to a research question. The measurements need to be reliable, consistent, replicable, and relevant to the questions asked (Mason *et al.* 1998:308). The number of measurements taken per bone will depend on the detail required by the research (Beck 1981:364; Hesse and Wapnish 1985:79). Ideally, all measurements should be taken, but due to time constraints this is not always possible.

Measuring animal bones from archaeological sites is not as common as might be expected. Faunal analyses are often primarily interested in constructing species lists, relative frequencies and mortality frequencies. Archaeologists have been accused of not maximising the full potential of information stored in archaeological records (Clutton-Brock 1978:49). Including measurements in a faunal analysis moves one step closer to rectifying this. Boessneck and von den Driesch (1978:25) outline the benefits of bone measurements as being:

1. Differentiation of animal species.
2. Determination of individual variation.
3. Investigation of size changes in wild animals through time.
4. Investigation of size changes in wild animals through space.
5. Determination of sex and the study of sexual di-

morphism.

6. Differentiation of domestic animals from their wild forebears.

7. Documentation of size changes in domestic animals through the course of pre- and early historic times.

8. Investigation of proportions and differences in populations.

For this study, measurements were taken so that the faunal populations could be reconstructed, by way of size trends and distributions as well as the proportion of domestic to wild species. *Bos s*pecies were identified by measuring the bones and comparing them to dimensions of known species. Dial calipers were used, giving measurements to the nearest first decimal place. Measurements were taken using the guidelines implemented by von den Driesch (1976) ensuring a standardized result table. She developed a guide for the measurement of archaeological animal bones to allow for valid intersite comparisons. The measurements have been specifically developed to be replicable with little room for variation, while allowing for the fragmentary nature of archaeological remains.

This analysis was to some extent dictated by previous research. In order to make the Noen U-Loke data comparable to other sites, measurements universal to other site analyses were taken. This in itself determined certain aspects of this research and highlights the call for a standardized approach to the manipulation and analysis of faunal material (Grayson 1973).

Modern samples of Thai bovids have been measured in an attempt to reveal differences between species and sexes (Higham 1975a; Kijngam 1979:14). Male animals are, on average, heavier than females, which affects the skeletal structure (Thomas 1988:86). The distal end of the metacarpal is particularly sexually dimorphic (Boessneck and von den Driesch 1978:34; Thomas 1988:83), as are the first and second fore phalanges, and the magnum (Kijngam 1979). This information is relevant when reviewing bovine remains. Measurements were taken so as to help distinguish domestic from wild specimens. Disparities between wild and domestic dimensions have proved to be substantial (Higham and Leach 1971; Higham 1977a:397; Payne and Bull 1988).

Measurements of teeth were taken from all mandibles (including Bovidae), and of all maxillae (excluding Bovidae). In the case of bovine maxillae, the teeth, when absent from the maxilla, could not be identified as either the first or second molar, leaving the measurements redundant. The stage of wear on the teeth was also noted. During an analysis based entirely on size dimensions, a number of other factors need to be taken into account, to ensure that the data from which conclusions are drawn are valid. Age-related change, sexual dimorphism, and residual individual variation are the most prevalent variables (Payne and Bull 1988:29).

QUANTIFICATION

The minimum number of individuals (MNI) was estimated for each species. Methods were based on the identification of bones and their relative age. This analysis was conducted with detailed consideration of size and age differences. The minimum numbers were calculated separately for material from features and general occupation material.

Mandibles were the most commonly-found element, especially in the case of bovids and suids, and were used for calculating MNIs. Wear and eruption patterns provided an estimated age of death from which the number of individuals could be calculated. Epiphyseal fusion was also noted, in some instances this increased the number of MNIs. If mandibles and maxillae were not present, the size of the bones and the degree to which the epiphyses were fused were used to identify individuals.

MORTALITY FREQUENCIES

Caution is needed when estimating the age of death from skeletal remains. Some evidence suggests that the age of fusion of some epiphyses do not correlate with other aging methods, for example, tooth wear (Weinstock 1993). These discrepancies need to be noted and acknowledged. The only way to be consistent is to use the same method throughout the study and avoid different factors for determining mortality stages.

Dentition development and wear determined mortality stages. This method was preferable because mandibles are among the best-preserved bones (Gordon 1993), and were reasonably common at Noen U-Loke. The bovine mortality frequencies were based on an adaptation of guidelines implemented by Silver (1963). Table 27:1 details the criteria on which the analysis was based.

The suid mandibles were also given a mortality stage, based on guidelines used by Kijngam (1979; 1984a). Table 27:2 outlines these.

MOLLUSC ANALYSIS

The shellfish analysis is determined by their state of preservation, which means certain methods will be inaccessible. The main destructive factors are the acidity of the shell's immediate surroundings and the degree of abrading forces (Shackley 1981:126). The power of these processes largely depends on the shell's resistance. At Noen U-Loke, the majority of the shells were complete and no extensive crushing occurred. It was, therefore, considered that counts would prove more informative than weights.

Recovery and Identification

Shellfish were present during most of the excavation. An inventory of the different species of shellfish was conduct-

TABLE 27:1 *Mortality stages for bovine mandibles*

Stage	Dentition development	Age
1	Deciduous teeth erupting	Birth – 3 weeks
2	Deciduous teeth just worn	1 – 4 months
3	Deciduous teeth all in wear, M1 erupting	5 – 13 months
4	Deciduous teeth in secondary wear, M1 early wear, M2 erupting unworn	14 – 18 months
5	M2 in primary wear	19 – 24 months
6	M1/M2 worn, M3, PM1-3 erupting	25 – 30 months
7	M3, PM1-3 just worn	31 – 35 months
8	M3, PM1-3 in primary wear, M3 touched on 2 cusps	36 – 37 months
9	M3, PM1-3 in secondary wear, M3 worn slightly on all 3 cusps	38 – 39 months
10	M3, PM1-3 worn heavily on all cusps	40 – 50 months
11	Terminal wear on all teeth, very heavily worn	50 months

ed, with two classes, bivalves and gastropods, identified. Identification of the shellfish remains was based largely on a comparative collection provided by the Thai Fine Arts Department. As with the animal bones, the shellfish were identified to genus and to species, if possible. They were analysed as separate entities based on their provenance.

Measurements

A decision was made at the beginning of the research to examine the possibility of the over predation of *Pila ampullacea*. This was based on the hypothesis that shell size would decline over time. Measurements taken must be meaningful and relevant to the scientific investigation, and attempt to provide the best approximation of the truth (Mason *et al.* 1998:308). The dimensions developed for this analysis were considered easily replicated and an accurate representation of the shell size. As *Pila ampullacea* is a gastropod, the logical measurement to reveal a decrease in size is the maximum length of the aperture (ML). All complete specimens were measured, and those that were almost complete were estimated, a procedure considered valid as the shape of the shell is consistently proportioned.

Quantification of the shellfish remains

The quantification of each shellfish species, per layer and feature, was conducted. Different methods were used for the two classes of shellfish. Gastropods were identified and quantified by intact shells and apertures. The small number of opercula meant that using these for quantification was arbitrary. Bivalves were counted by the frequency of complete hinges, the different sides of the shell being taken into account.

MNIs were calculated for both classes. This technique was considered the most accurate for determining the function of the shellfish. The validity of shell weights is always controversial (Bailey 1975:47 ; Ceci 1984:70; Mason *et al.* 1998) and as the shell remains from Noen U-Loke were in very good condition, it was considered that shell counts would prove to be the most informative.

Palaeoenvironmental Assessment

An evaluation of the prehistoric environment at Noen U-Loke is strengthened by an analysis of shellfish species and their preferred habitats. This analysis is severely limited. A multidisciplinary approach incorporating palynology, sedimentology, and phytolith analyses would be optimal.

Palynology is concerned with the pollen and spores of prehistoric plants preserved in the archaeological record. Pollen is a reflection of the vegetation that produced it, the sequence that builds up in sediments is a record of past vegetation (Pearsall 1989:245). The life history of sediments is influenced by environmental conditions and is used to reconstruct processes involved in the formation of archaeological sites (Hassan 1978:199). The analysis of phytoliths leads to a greater understanding of the relationship between plants and humans in prehistory. It assists in the reconstruction of the palaeoenvironmental conditions by identifying the species of plants that were present (Pearsall 1989:311). The analysis of Noen U-Loke sediments is set out in chapter 3, and should be considered in conjunction with these findings.

Shellfish Evaluation

By analysing the species list and MNIs, and identifying the prominent species and their habitats, an evaluation of the palaeoenvironment is made possible. This analysis will map the MNIs of the two dominant species, *Pila ampullacea* and *Filupaludina*, in order to reconstruct the palaeoenvironment and any fluctuations present.

TABLE 27:2 *Mortality stages for suid mandibles*

Stage	Dentition development	Est. age
1	Deciduous premolar unerupted	Foetal
2	Deciduous PM2,3,4 in primary eruption	birth – 1 week
3	Deciduous PM2,3,4 in secondary eruption	1 - 4 weeks
4	Deciduous PM2,3,4 in tertiary eruption	4 - 7 weeks
5	Deciduous PM4 in primary wear, M1 unerupted	2 - 4 months
6	M1 in primary eruption	4 - 5 months
7	M1 in secondary eruption	5 - 6 months
8	M1 in tertiary eruption	6 - 7 months
9	M1 in primary wear, M2 unerupted	7 - 8 months
10	M1 in secondary wear, M2 unerupted	8 - 9 months
11	M2 in primary eruption	9 - 10 months
12	M2 in secondary eruption	10 – 11 months
13	M2 in tertiary eruption	11 – 12 months
14	PM2-4 in primary eruption	12 – 14 months
15	PM2-4 in secondary eruption	14 – 15 months
16	PM2-4 in tertiary eruption	15 – 16 months
17	PM4 in primary wear, M3 unerupted	16 – 17 months
18	M3 in primary eruption	17 – 19 months
19	M3 in secondary eruption	19 – 21 months
20	M3 in tertiary eruption, cusp one in primary wear	21 – 23 months
21	M3 cusp one in secondary wear	23 – 25 months
22	M3 cusp two in secondary wear	25 – 27 months
23	M3 cusp three in secondary wear	27 – 29 months
24	M3 all cusps in late secondary wear	30+ months
25	M3 all cusps in early tertiary wear	Adult
26	M3 all cusps in late tertiary wear	late maturity
27	M3 all cusps in quaternary wear	very old

XXVIII. THE FAUNAL REMAINS: MAJOR VARIABLES

M. M^{C}CAW

The faunal remains have been analysed in three groups: those from occupation layers, features, and burials. The bone was in extraordinarily good condition, with the exception of material from rice bed burials. In the case of the latter, identification was possible but measurements were not considered accurate, as the bone was very flaky. Most measurements taken are set out in the appendix on page 521. The last section of results details the shell analysis. The shellfish remains were in good condition with little fragmentation.

SPECIES LISTS AND MINIMUM NUMBER OF INDIVIDUALS

The identified species are listed, with the identifiable bone noted, and the number of individuals calculated from each layer. Faunal remains were found in features throughout the sequence. A feature is a discrete unit, such as a pit, posthole or grave cut. These results have been listed in sequential order, with every identifiable bone measured if possible. The minimum number of individuals has been conducted based on outlined principles.

Faunal Remains from Burials

Faunal remains found within mortuary contexts are an important aspect of any analysis. The results are listed in order of mortuary phase. Anything found within a burial is given a catalogue (cat.) number from which the remains can be referenced. The majority of faunal remains within burials come in the form of sacrificial animals. The material from each cat. number is described in full detail, with measurements taken if possible.

Mortuary Phase 5

Burial 72.

Loose bone fragments from grave fill.

Bos: Phalanx 1, phalanx 2, femur, ulna fragment, metapodial distal epiphysis. One individual.

Bubalus bubalis: Phalanx 2 fore. One individual.

Sus scrofa: Two mandibles and three DE mandible fragments, scapula, maxilla. Four individuals, 1 adult, 1 subadult and 2 very young.

Burial 115.

Cat. 1612. The shed antler of *Cervus eldi*.

Mortuary Phase 4B

Burial 31.

Cat. 1895. An egg found left of the pelvis area. L 57.5; W 22.9.

Mortuary Phase 4C

Burial 62.

A suid M^2 and upper incisor, both well worn, were found in the vicinity of this burial. It is considered not a grave offering, but grave fill.

Burial 63.

Cat. 1897. The remains of an adult dog's mandible. The teeth are all heavily worn. It is not known whether it was deliberately placed, but is more likely to be from grave fill.

Mortuary Phase 3A

Burial 37.

Cat. 649. A complete pig's skeleton. Deciduous dentition erupting and unworn, indicating that the pig was newly born.

Burial 41.

Cat. 623. A young pig's ulna, scapula, two humeri, pelvis fragments, two ribs, vertebrae, cranium, mandible and maxilla were found in the vicinity of this burial. The deciduous dentition was erupted but unworn.

Burial 42.

Cat. 662. The complete skeleton of a young pig placed alongside the left upper arm. Mortality stage 2. Deciduous PM2 in early eruption, PM3/4 erupted but unworn.

Mortuary Phase 3B

Burial 28.

Cat. 446. The complete and articulating fore phalanges of a water buffalo. As the bones were situated in a rice bed burial, they are in exceptionally bad condition.

Cat. 447. The articulating first fore phalanges and metapodials from a very young pig.

Cat. 448. The metapodial and second phalanx of a young dog.

Burial 30.

Cat. 558. A pig's tibia at the left arm of the individual. The bone was from a rice bed burial and was in a poor condition.

Cat. 1896. Fragments of a young pig's skull and teeth found beyond the head of this burial. The deciduous teeth were erupting and unworn. One young individual.

Burial 40.

Cat. 601. The remains of a pig's skeleton. Cranium, scapula, mandible, maxilla, and the left and right DE of a humerus. Deciduous dentition erupted and unworn. One young individual.

Burial 49.

Cat. 761. A pig's mandible was found in this rice bed burial. Deciduous dentition erupted and unworn. One very young individual.

Mortuary Phase 2

Burial 26.

Cat. 511. A left forelimb of an immature pig, including all metacarpals and phalanges. It was placed between the two femora.

Cat. 522. A left forelimb of an immature pig was placed near the left arm. All metacarpals, and first and second phalanges are unfused. All metapodial and phalanges are present, but no carpals.

Cat. 526. Two pig's tusks, each with a hole drilled through them, probably for suspension.

Burial 27.

Cat. 483. Four tiger's canines at the neck, with holes drilled through them for suspension.

Cat. 523. A mass of young pigs' forelimbs, representing five individuals: (1) The right limb of a sub-adult, the distal end close to fusion, first and second phalanges fused and third in position; (2) The left forelimb of an adult, distal end fused; (3) The left and right forelimbs of a sub-adult, metacarpals unfused; (4) The left forelimb of a young pig, metacarpal DE unfused; (5) The left and right forelimbs of a young pig, metacarpal DE unfused. In addition to the pig bones, there were four turtle carapace bones.

Cat. 547. The complete left forelimb bones from a sub-adult pig were found under the left pelvic area. All bones complete from carpals to third phalanges. The metacarpals DE fusing.

Cat. 613. The left forelimbs representing three individual pigs were found inside a pot (cat. 487).

Cat. 614. Six fragments of turtle carapace, a fragment of turtle bone and one vertebra, which almost certainly came from the same individual as cat. 523.

Cat. 1894. The complete left forelimb from a young pig. All bones were represented from the metacarpal to the third phalanx.

Pottery vessel cat. 476 contained the phalanx II/V and third phalanx from a young pig in addition to six fragments of turtle carapace.

From flotation: a pig's phalanx II/V, two third phalanges and two phalanges III/V, all probably from the same animal. These remains are probably from the articulating specimens of cat. 523.

From grave fill, a young pig's second and third phalanx, in addition to two phalanx II/V; two fragments of turtle carapace and two turtle bones.

Burial 108.

Cat. 1908. The right forelimb of a young pig was found with this burial. All bones from the metacarpal to the third phalanx were present with unfused epiphysis. A turtle humerus was also present.

MEASUREMENTS

Certain bones are both sexually dimorphic and species specific, thereby allowing insight into aspects of herd management or hunting. The most useful bones are the first fore phalanx, the second fore phalanx, the magnum, and the metacarpal. These results will be given below, with the remainder in the appendix. The measurements of these bones will then be superimposed onto a graph including the dimensions of modern Thai domestic cattle. This process will assist in identifying the species of cattle.

The measurements are listed below in order of layer, feature and burial. Abbreviations and a description of measurements taken are listed in the abbreviation section. Estimated values are indicated by *. Intimate knowledge of the bones allowed for estimations to be made if only a small portion of the bone was missing.

Bos Magnum

The magnum is an extremely useful bone, because it articulates with the proximal end of the metacarpal, which is sexually dimorphic (Kijngam 1979:17). Magna are also easily distinguished as either from a *Bos* or *Bubalus*.

TABLE 28:1 *The dimensions and provenance of* Bos *magna (cm)*

Context	MW	ML	W:L
4:13	41.0	33.8	121.3
4:10	33.3	30.1	110.6
3:14	31.0	26.4	117.4
3:8	34.6	32.6	106.1
3:6	37.5	32.9	114.0
3:4	33.8	29.6	114.2
3:4	31.4	29.8	105.4
3:1	31.8	28.9	110.0
2:7	32.2	29.5	109.2
2:6	33.0	29.9	110.4
2:1	32.8	29.7	110.4
C1 3:10 F1	33.9	31.2	108.7
B1 3:S5 F1	34.0	30.0	113.3
C3 3:S8 F1	36.0	32.1	112.1

S: surface F: feature

TABLE 28:2 *The dimensions and provenance of* Bos *second fore phalanges (cm)*

Context	L	PW	DW	MW
4:15	-	27.6	-	-
4:14	38.7	28.0	24.0	23.2
4:3	31.0*	27.0	-	-
4:1	34.0*	24.0*	21.3	21.0
3:10	35.7	26.2	21.2	22.8
3:10	32.2	25.3	20.5	19.8
3:7	35.9	26.2	20.3	22.4
3:6	32.4	24.9	19.7	29.8
3:6	34.4	23.2	19.2	20.3
3:5	34.4	27.4	23.7	22.0
3:5	38.9	28.6	22.9	23.8
3:4	40.0	28.8	23.1	22.2
3:4	35.4	27.9	24.3	22.9
3:3	32.7	26.6	22.2	20.6
3:3	29.0	25.2	20.5	21.4
3:3	-	24.2	-	-
3:2	35.9	26.1	20.8	20.6
3:1	33.9	24.3	22.2	20.1
2:5	36.2	29.4	25.0	25.0
2:1	33.0	26.2	27.8	21.1
C1 3:9 F1 33.8	24.6	19.1	20.1	
C3 3:S8 F1	53.8	37.3	30.2	31.3
C3 3:S8 F1	55.6	40.2	31.8	30.2
C3 3:S8 F1	53.6	37.4	27.6	27.6
C3 3:S8 F1	54.4	35.4	29.8	27.0
A1 3:3 F2 36.1	29.8	27.7	24.5	-
B2/B3 3:S1 F1	-	-	22.2	-

Bos Second Fore Phalanges

The bovid second fore phalange is a further useful bone, because being weight-bearing, it tends to be sexually dimorphic. This is not, however, as marked as in the first fore phalanx or the metacarpal.

Bos First Fore Phalanges

The first fore phalange is useful for a number of reasons. Measurements will help to identify the sex and species. Figure 28:1 displays the clear demarcation between the first fore phalanges of water buffalo and cattle. The measurements for *Bubalus bubalis* first fore phalanges are set out in the appendix. *Bos* first fore phalange measurements are listed in table 28:3.

Bos Metacarpal

The metacarpal is one of the most sexually dimorphic bones in the bovid skeleton. Unfortunately, very few survive intact.

TABLE 28:3 *The dimensions and provenance of* Bos *first fore phalanges (cm)*

Context	L	PW	DW	MW
5:1	52.5	24.0	25.5	22.9
4:15	55.7	23.7	22.0	21.2
4:15	53.0	26.0	26.8	22.4
4:13	-	28.8	-	-
4:10	54.8	28.0	24.5	24.4
C3 4:10 F1	-	-	26.4	-
4:9	51.3	25.5	23.8	21.5
4:9	-	30.4	-	-
4:9	52.1	30.5	25.4	26.2
4:8	62.5	30.5	27.8	25.6
C2 4:8 F1	-	-	26.7	-
A1 4:1 F1	-	-	35.0	-
4:1	52.6	24.1	22.1	21.5
3:9	50.8	27.8	25.2	25.4
3:8	52.4	25.0*	24.1	23.0
3:8	-	-	24.7	-
3:7	58.5	26.8	24.7	22.4
3:7	57.0*	29.0*	26.0	26.6
3:6	57.1	25.5	25.2	23.6
3:6	-	24.4	-	-
3:5	53.0	26.2	24.9	22.3
3:5	-	29.6	-	-
3:4	58.0*	29.6	-	-
3:4	-	-	23.5	-
3:4	-	-	23.1	-
3:3	53.2	27.6	26.5	23.1
3:2	58.0*	29.0	-	25.0*
3:2	57.0*	29.4	-	-
3:2	-	29.0	-	-
3:2	54.0	-	-	-
3:2	-	25.8	-	-
3:2	-	-	26.7	-
3:1	64.6	36.0	33.6	32.0
3:1	54.3	26.3	24.0	23.2
3:1	-	34.0	-	-
2:4	55.5	27.9	25.0	23.4
2:4	57.0*	29.0	27.0	26.9
2:3	53.2	26.5	22.1	22.3
2:3	56.5	26.2	26.3	23.7
2:2	53.4	26.7	25.8	23.7
2:2	51.7	25.6	21.5	23.1
C3 3:8 F1	-	-	39.1	-
C3 3:8 F1	50.7	27.5	26.2	24.2
C3 3:8 F1	51.9	26.1	22.6	22.9
A1 3:3 F2	58.4	30.5	26.1	26.0
B1 2:6 F1	56.0	29.5	25.4	26.1
A1 2:6 F3	-	-	34.0	-

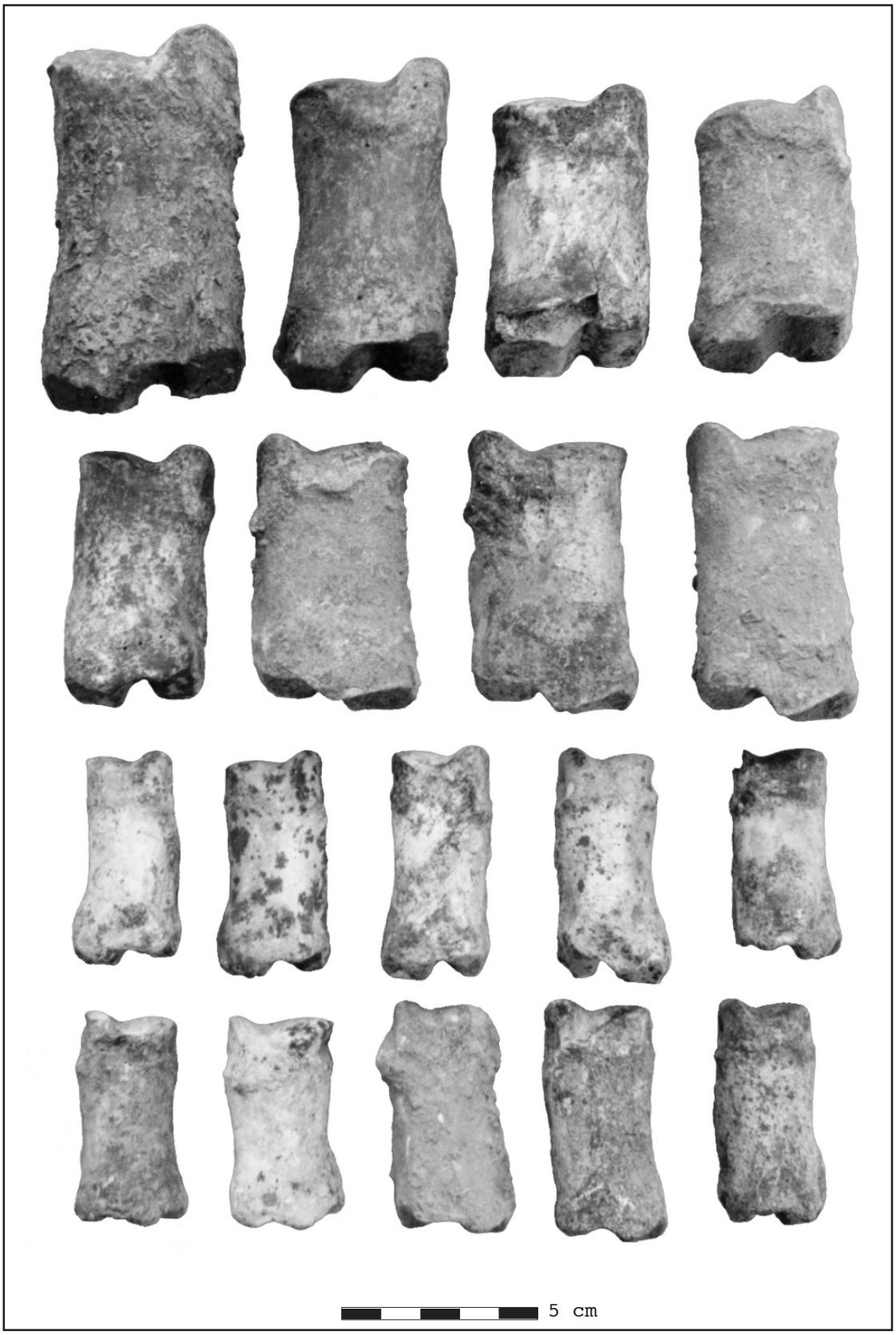


FIG. 28:1 Water buffalo first fore phalanges (top two rows) and cattle first fore phalanges

MORTALITY FREQUENCIES

Mortality frequencies were assembled to identify consistent patterns in the age of death of the animal population. The results of the mortality frequencies are listed in tables 28:4-7. The material from the layers, features, and burials were kept separate, so that any possible difference between the compilation of the assemblages could be identified. Bovid and suid mandibles were examined for tooth eruption and wear and were assigned a mortality stage accordingly.

BUTCHERED SPECIMENS

Butchered remains have been quantified in tables 28:8-9. All cut marks or fractured bone, by means of human activity (Figs. 28:2-4), were counted and the provenance noted. *Sus scrofa* mandibles and crania are prominent in the butchered specimens.

MOLLUSC FREQUENCIES

The gastropods and bivalves were given a minimum number during the analysis. The gastropods were counted by the frequency of the aperture whorl, while the bivalves were counted by the number of hinges present. Listed below (Table 28:10) are the results from the MNI analysis.

PILA AMPULLACEA MEASUREMENTS

Pila ampullacea shells were measured to examine the possibility of over exploitation. The technique was designed to allow for complete replication when measuring each individual. A decrease in size would indicate an over predation of this species. A continual trend in size indicates an unobtrusive exploitation of the species

RESULTS

The results displayed in this chapter aim to identify the relative abundance of the different species found at Noen U-Loke. Aspects of the faunal population will be revealed through an analysis of the mortality frequencies, butchery marks, and species abundance through time. An in-depth review of the shellfish material will highlight issues of subsistence, while providing valuable insight into the

TABLE 28:4 *Mortality frequencies of bovid mandibles from general layer material*

Layer	Stage 1	2	3	4	5	6	7	8	9	10	11
6	0	0	0	0	0	0	0	1	1	5	0
5	0	0	0	0	0	0	1	1	0	1	0
4	0	0	0	1	3	0	2	2	1	21	2
3	0	0	0	3	0	0	0	0	4	45	17
2	0	0	0	0	0	3	0	2	4	11	8
Total	0	0	0	4	3	3	3	6	10	83	27

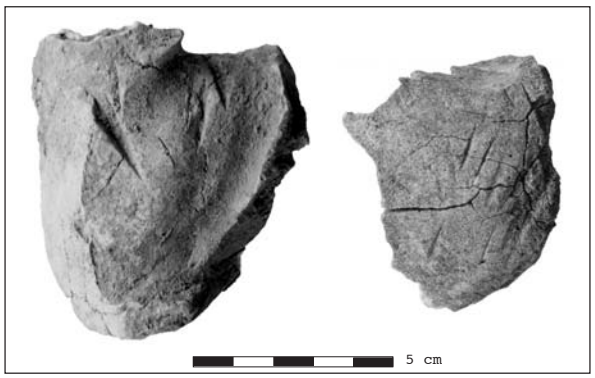


FIG. 28:2 Butchered *Sus scrofa* crania

Table 28:5 *Mortality frequencies of bovid mandibles from features*

Layer	Stage 1	2	3	4	5	6	7	8	9	10	11
6	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	1	0	0	1	3	5	0
3	0	0	0	0	0	1	0	0	6	26	6
2	0	0	0	0	0	0	0	0	2	6	6
Total	0	0	0	0	1	1	0	1	11	37	12

TABLE 28:6 *Mortality frequencies of suid mandibles from general layers*

Layer	Stage 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6		0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	2	1	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4		0	0	0	0	0	0	1	6	3	0	0	0	1	0	1	2	1	0	1	0	2	0	1	1	0	0
3		0	0	2	12	9	1	1	10	2	4	1	13	5	3	17	2	0	1	5	2	3	1	0	1	0	0
2		0	0	0	0	1	0	1	6	0	0	2	4	5	0	3	1	0	0	1	0	0	0	0	0	0	0
Total		0	0	2	12	11	1	3	22	7	4	3	17	13	3	21	7	2	1	7	2	5	1	1	2	0	0

Table 28:7 *Mortality frequencies of suid mandibles from features*

Layer	Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0
4		0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0	0	2	1	0	0	0	0	0	0
3		0	0	0	3	0	0	0	0	1	0	1	8	3	0	3	2	1	0	0	0	0	0	0	1	0	0	0
2		0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Total		0	0	3	0	0	1	0	1	1	2	8	5	1	4	5	3	1	0	3	1	0	0	1	0	0	0	0

TABLE 28:8 *Butchered and burnt specimens from features*

Species	Context	Bone	Description	Frequency
Bos	B2 5:S2 F1	phalanx 1	charred	1
	B1 4:S14 F3	metacarpal PE	charred	1
	A1/B1 5:S1 F6	upper molar	charred	1
	C2 4:1 F8	patella	charred	1
	B2/B3 3:3 F1	Metatarsal	heavily cut	1
	B2/B3 3:3 F1	cuboid navicular	heavily cut	1
	B2/B3 3:3 F1	Astragalus	heavily cut	1
	B2/B3 3:3 F1	calcanium	heavily cut	1
	A1 3:S3 F2	humerus	butchered	1
	A1 3:S3 F2	metatarsal	butchered	1
	A1 3:S3 F2	calcaneous	butchered	1
	A1 3:3 F2	cuboid navicular	butchered	1
	A1 3:S3 F2	carpal	butchered	1
	A1 3:S3 F2	ulna	butchered	1
	A1 3:S3 F2	astragalus	butchered	1
	A1 3:S3 F2	radius	butchered	1
	A1 3:S3 F2	metacarpal	butchered	1
	A1 3:S3 F2	phalanx 1 fore	butchered	1
	A1 3:S3 F2	phalanx 2 fore	butchered	1



FIG. 28:3 *Sus scrofa* mandibles fractured at the distal end. Scale 5 cm

TABLE 28:8 *Butchered and burnt specimens from features (cont.)*

Species	Context	Bone	Description	Frequency
	C3 3:S8 F1	metacarpal	broken across shaft	2
	C3 3:S8 F1	humerus	broken across shaft	1
	C3 3:S8 F1	horn core	cut	1
	A1 3:S6 F3	femur	butchered	1
Bubalus bubalis	C3 5:S2 F1	tibia	charred	1
	C3 3:S8 F1	metatarsal frags	broken across shaft	2
	C3 3:S8 F1	humerus	broken across shaft	1
Bovidae	C3 3:S8 F1	femur	Broken across shaft	1
Cervus eldi	A3 4:S1 F1	antler	cut	1
	B1/B2 2:S6 F1	skull	cut across, antler removed	1
Cervus unicolor	C3 5:S2 F1	antler fragment	charred	1
	C3 5:S1 F2	ulna	charred	1
	C2 4:S8 F1	antler	cut	1
Muntiacus muntjak	A3 5:S1 F1	metapodial fragment	charred	1
Sus scrofa	C3 5:S2 F1	radius	charred	1
	C3 5:S2 F1	metapodial	charred	1
	C3 5:S2 F2	calcanium fragment	charred	1
	C3 5:S2 F2	metatarsal	charred	1
	B2/B3 5:S2 F2	phalanx 1	charred	1
Trionyx/Chitra	A3 5:S1 F1	carapace fragment	charred	1

TABLE 28:9 *Butchered and burnt specimens from general layer material*

Species	Context	Bone	Description	Frequency
Bos	3:6	cuboid navicular	cut marks	1
	3:6	metatarsal	cut marks	1
	3:6	astragalus	cut marks	1
Bovidae	6:1	astragalus	smashed	2
	6:1	metacarpal	smashed across proximal end	1
	4:15	tibia	split longitudinally	1
	4:3	mandible	smashed	1
Bubalus bubalis	6:2	tibia	smashed	1
	5:1	metacarpal	distal end butchered and split longitudinally	1
	4:13	humerus	smashed against trochlea and charred	1
	4:9	radius	proximal end split longitudinally	1
	4:8	metacarpal	smashed across the shaft	1
	4:5	metacarpal	smashed longitudinally	2
Canis familiaris	4:13	mandible	crushed	1
Cervus eldi	4:6	metapodial fragment	charred	1
Sus scrofa	5:1	pelvis	cut marks on acetabulum	1
	5:1	femur	heavily charred	1
	4:15	ulna fragment	cut marks	2
	4:15	tibia	cut across articular surface	1
	4:12	mandible	smashed across distal end	1
	4:11	mandible	smashed across distal end	2
	4:9	mandible	smashed across distal end	2
	4:8	mandible	smashed across distal end	1
	4:4	lower premolars	charred	1
	4:3	mandible	smashed across distal end	2
	4:1	mandible	smashed across distal end	2
	3:13	mandible	smashed across distal end	2
	3:11	mandible	smashed across distal end	2
	3:9	mandible	smashed across distal end	1
	3:8	mandible	smashed across distal end	1
	3:7	mandible	smashed across distal end	2
	3:6	mandible	smashed across distal end	7
	3:5	mandible	smashed across distal end	2
	3:4	skull	cut marks	3
	3:3	mandible	smashed across distal end	6
	3:2	mandible	smashed across distal end	7
	3:1	mandible	smashed across distal end	2
	2:5	mandible	smashed across distal end	2
	2:3	skull	cut marks	1
	2:3	mandible	smashed across distal end	3
	2:2	mandible	smashed across distal end	3

TABLE 28:10 *The minimum number of shell species from features and general layer material*

Layer	*Filo-paludina*	*Idiopoma*	*Pseud-odon*	*Hyrio-posis*	*Adamietta*	*Trochotaia*	*Scabies*	*Ensidens*	*Pila polita*	*Pila ampullacea*	*Pilsbry-oconcha*	*Clea Helena*
6:6	44	1	0	0	0	0	0	0	0	10	0	0
6:5	55	1	1	0	0	0	0	0	0	1	0	0
6:4	826	5	10	1	1	0	0	0	5	22	0	0
6:3	2171	21	2	0	5	11	5	0	14	259	0	0
6:2	219	5	0	0	3	4	0	0	4	20	0	0
6:1	1545	25	12	0	32	4	0	1	5	111	0	0
5:2	2525	25	10	0	11	9	5	0	15	24	0	0
5:1	2165	152	0	0	7	7	1	0	3	51	0	0
4:14	3191	21	1	0	12	9	2	0	9	66	0	0
4:13	120	7	2	0	0	2	0	0	6	0	0	0
4:12	327	0	2	0	0	1	0	0	2	14	0	0
4:11	723	3	2	0	4	0	0	0	1	7	0	0
4:10	807	24	3	2	8	2	0	0	3	42	0	0
4:9	138	11	0	0	1	2	0	0	0	0	0	0
4:8	638	21	24	0	7	2	1	3	1	113	0	0
4:7	483	8	10	0	3	0	0	0	1	26	0	0
4:6	1783	34	11	0	16	10	0	0	5	59	1	0
4:5	407	2	17	0	6	1	0	0	5	49	0	0
4:4	411	19	5	0	7	2	0	0	2	78	1	0
4:3	246	4	10	1	0	0	1	0	2	31	0	0
4:2	398	17	1	0	37	5	274	0	5	29	1	0
4:1	866	61	6	1	141	0	3	1	12	432	0	0
3:14	89	6	2	0	6	0	1	0	0	26	0	0
3:13	300	17	11	0	8	0	1	0	3	334	0	0
3:12	448	71	9	0	65	3	8	0	19	389	0	0
3:11	77	2	0	0	0	4	3	0	3	114	0	0
3:10	168	9	9	0	3	2	0	0	1	248	0	0
3:9	226	36	1	0	5	3	2	0	5	344	3	0
3:8	548	94	12	1	19	3	15	0	0	577	1	2
3:7	157	38	1	0	4	0	0	0	4	46	1	0
3:6	444	37	3	0	2	10	2	0	7	351	0	0
3:5	368	38	6	0	3	1	1	1	5	423	1	0
3:4	544	12	12	1	3	0	0	0	5	153	2	0
3:3	591	30	4	0	5	2	0	0	3	145	0	0
3:2	44	1	0	0	0	0	0	0	0	24	0	0
3:1	0	35	0	0	0	0	1	0	0	0	1	0
Total	24092	893	199	7	424	99	326	6	155	4618	12	2

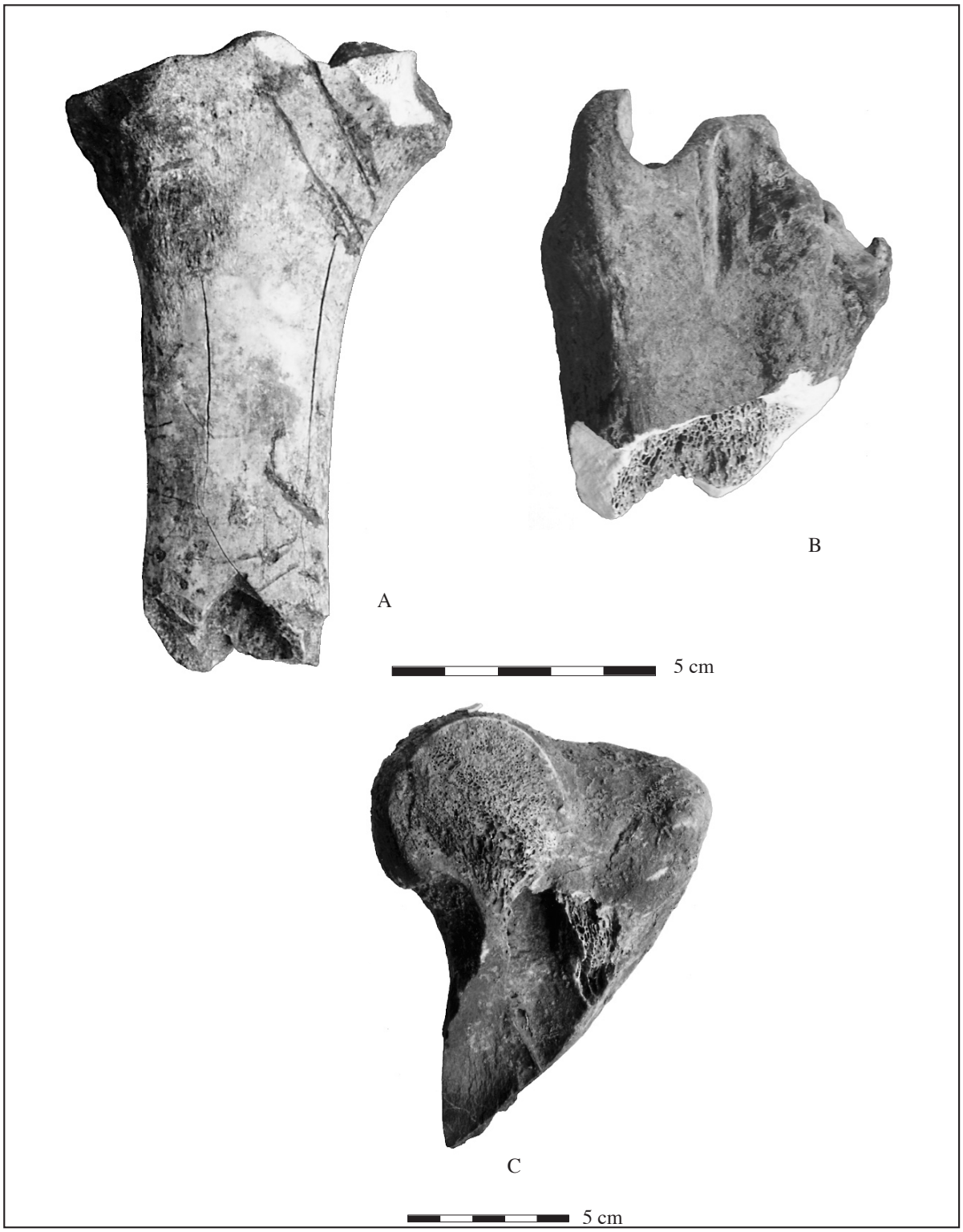


FIG. 28:4 Bovid radius (A) and tibia (B), with cut marks, and fractured bovid humerus (C) split longitudinally

TABLE 28:11 *The average length of* Pila ampullacea *by layer*

Layer	n	Average ML	Layer	n	Average ML	Layer	n	Average ML
6:6	12	24.8	4:8	109	23.7	3:10	208	25.3
6:4	15	26.3	4:7	23	24.3	3:9	260	25.1
6:3	210	23.7	4:6	46	27.0	3:8	463	25.9
6:2	16	25.9	4:5	42	24.6	3:7	38	23.6
6:1	102	25.3	4:4	73	26.0	3:6	274	25.3
5:2	112	24.7	4:3	31	23.4	3:5	313	25.2
5:1	39	23.9	4:2	29	26.0	3:4	122	24.9
4:15	4	28.4	4:1	348	23.1	3:3	114	26.1
4:14	46	23.3	3:14	22	24.6	3:2	20	25.0
4:12	11	25.8	3:13	308	23.1	3:1	29	24.0
4:11	7	23.7	3:12	267	25.6			
4:10	39	26.4	3:11	116	25.6	Total	3868	25.0

ABBREVIATIONS

DW	Distal width	SLC	Smallest length of the *Collum scapulae*
PW	Proximal width	GL1	Greatest length of the lateral half
L	Length	LG	Length of the glenoid cavity
MW	Middle width	Alv.	Aveoli length
BP	Greatest breadth of proximal end	PM1-3	Premolars
DC	Greatest depth of the *caput femoris*	LM1-3	Lower molars
BFd	Breadth of the *facies articularis distalis*	UM1-3	Upper molars
DW	Distal width	PM	Row Premolar row
DLS	Diagonal length of sole	M	Row Molar row
GB	Greatest breadth	ML	Maximum length of the aperture
BT	Breadth of the trochlea	Cat.	Catalogue number
DPA	Depth across the *Processus anconaeus* to the caudal border of the ulna	J	Juvenile
		YA	Young adult
SDO	Smallest depth of the olecranon	SA	Sub adult
BPC	Breadth across the coronoid process	A	Adult

XXIX. THE FAUNAL REMAINS: RESULTS AND CONCLUSIONS

M. M^{C}CAW

The results of the analysis undertaken are used to infer questions of animal exploitation activities. This chapter will review and discuss aspects of the Noen U-Loke faunal spectrum in terms of frequencies, butchery practices, mortuary rituals, population characteristics and regional continuity.

TAPHONOMIC CONSIDERATIONS

A thorough investigation into possible taphonomic and disturbance processes has revealed that the Noen U-Loke assemblage was unlikely to have been greatly disturbed by natural or cultural processes. Layers 5 and 6 largely accumulated naturally, so little cultural information can be derived from their contents. Layers 3 and 4 accumulated through occupation and industrial activities. The state of the burials has revealed that to a large extent most skeletal parts are still in anatomical position, indicating little interference. There is also no evidence indicating bioturbation by burrowing beetles. Of particular interest, is the possible impact of taphonomic processes on the surface marks seen on some bones. A close examination of the bones identified several instances of root etchings, but no evidence of carnivore damage. With the exception of the feline found in layer 2:1, which appears to be modern, there does not seem to be any other evidence that would have disturbed or altered the archaeological record to make it unrepresentative of the original Noen U-Loke assemblage.

THE FAUNAL SPECTRUM OF NOEN U-LOKE

The faunal spectrum of Noen U-Loke has been compiled by constructing species lists and MNI tables. At its most basic, a species list identifies what is present and what is not. Caution must be taken when using MNI indicators. It must be remembered that they are indices of relative abundance within a given collection and should not be used as an absolute measure.

Occupation Layer Material

The earlier phases of the spectrum, Layers 5 and 6, are dominated by bovine and pig remains, which make up 73% of the total fauna. Water buffalo are noted but do not appear in great quantities, the largest frequencies being found in Layer 4, while numbers remain stable through Layer 3. Table 29:1 identifies a wider variety of species present in Layers 3 and 4 with the introduction of the frog, small mammal, rat, unidentifiable birds and felines. It is also at this stage that the chicken and dog become more prevalent. The greater variety of species is symptomatic of human occupation, as people exploited the resources around them.

Bos MNIs remain reasonably stable throughout the sequence, however there is a pitch of intensity between Layers 3:6 and 3:1. The group of bones termed "Bovidae" increase in frequency in Layer 4 and between Layers 2 and 3. This may indicate a period in which animal husbandry initially developed at Noen U-Loke, and later, when it prospered. It must be remembered that these bones may represent either water buffalo or cattle. The large number of Bovidae in the later sequence is attributed to the number of bovine mandibles recovered from the assemblage.

The pig is present throughout the sequence, ranging from between 25% and 35% of the total fauna. The Eld's deer and sambar are present during Layers 5 and 6, contributing 11% and 4% respectively. During Layer 4 the Eld's deer increases in frequency, after which it decreases to little more than 5%. This may indicate a concentrated period of hunting, after which the resource may have been depleted. The sambar is never dominant, with only 19 individuals identified in the entire sequence. The small deer, the muntjak, is consistent in small numbers though out the sequence, but appears to have been more frequent in Layer 4.

Rats were absent in Layers 5 and 6 but become reasonably frequent in Layers 3 and 4. Rats are usually associated with the storage of food and with burials. This is also the period when small mammals become prevalent, again associated with the fossicking of stored food. Dogs are reasonably consistent throughout the sequence, remaining between 5-3% of the total fauna from Layer 5 to 2.

Turtles are found consistently thoughout the sequence with the exception of Layer 6, though MNIs are not indicative of the abundance. The nature of the carapace fragments makes it very difficult to distinguish between individuals. It is more a note of presence rather than abundance. Felines were only found in Layers 2 and 3, but never in great quantity. The only frog found in the spectrum comes from Layer 4. Birds, other than the domestic chicken, are not dominant at any stage during the sequence, with only one individual located in Layer 4.

Material found within occupation layers indicates a dominance of cattle and pig. It appears that the domestic species remain stable throughout the sequence, while the

TABLE 29:1 *The distribution of individuals per species in the occupation layers*

LAYER	*Bubalus bubalis*	*Bos*	*Bovidae*	*Sus scrofa*	*Cervus eldi*	*Cervus unicolor*	*Muntiacus muntjak*	*Canis familiaris*	*Felis* sp.	*Trionyx/Chitra*	*Gallus gallus*	small mammal	*Rattus* sp.	*Rana tigrina*	bird indet
6:9	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
6:8	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
6:6	-	-	1		1	-	-	-	-	1	-	-	-	-	-
6:5	1	1	1		-	-	-	-	-	-	-	-	-	-	-
6:4	-	1	1		1	-	-	-	-	-	-	-	-	-	-
6:3	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-
6:2	1	2	1	2	-	-	-	-	-	-	-	-	-	-	-
6:1	-	-	3	4	-	1	-	-	-	1	-	-	-	-	-
5:2	2	1	2	1	1	-	-	-	-	1	1	-	-	-	-
5:1	1	1	4	3	1	1	-	1	-	1	-	-	-	-	-
4:15	-	1	2	2	1	1	-	1	-	1	-	-	-	-	-
4:14	1	1	6	4	1	1	-	1	-	1	-	-	1	-	-
4:13	1	1	3	4	1	1	1	2	-	1	1	-	-	-	-
4:12	1	1	2	2	2	-	1	1	-	1	-	1	-	-	-
4:11	1	1	4	3	2	-	1	-	-	1	1	1	1	-	-
4:10	1	1	4	6	2	1	-	1	-	1	1	-	1	1	-
4:9	1	1	3	5	1	-	1	1	-	1	-	1	-	-	-
4:8	2	1	4	4	1	-	1	-	-	1	-	-	-	1	-
4:7	3	1	3	3	2	-	1	-	-	-	-	1	1	1	-
4:6	3	-	4	5	1	1	1	1	-	1	1	1	-	-	-
4:5	2	1	4	1	1	-	-	1	-	1	1	-	-	-	-
4:4	-	-	1	3	1	-	-	-	-	-	-	-	-	1	1
4:3	2	2	2	3	-	1	1	1	-	1	1	1	1	-	-
4:2	-	1	-	1	1	-	-	-	-	1	-	-	-	-	-
4:1	1	1	2	6	1	2	1	2	-	1	1	-	-	-	-
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3:12	1	1	4	2	2	-	1	-	-	1	-	1	-	-	-
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3:10	2	1	2	2	-	-	-	-	-	1	1	-	-	-	-
3:9	-	2	2	5	2	-	-	1	-	-	-	-	-	-	-
3:8	1	1	9	5	1	1	1	-	-	1	-	-	1	-	-
3:7	1	-	5	7	1	-	-	1	-	1	-	-	-	-	-
3:6	1	2	5	7	1	-	1	-	-	1	-	-	-	-	-
3:5	1	2	7	13	-	-	1	-	-	-	-	-	-	-	-
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2:3	1	1	4	3	1	-	1	1	-	1	-	-	-	-	-
2:2	1	1	4	5	1	-	-	-	1	1	-	-	-	-	-
2:1	1	1	5	4	1	-	-	1	1	1	-	-	-	-	-

TABLE 29:2 *The minimum number of individual animals in features*

Layer	*Bubalus bubalis*	*Bos*	*Bovidae*	*Sus scrofa*	*Cervus eldi*	*Cervus unicolor*	*Muntiacus m.*	*Canis familiaris*	*Trionyx/Chitra*	*Gallus gallus*	small mammal	*Rattus* sp.
6.6	-	-	-	1	-	-	-	-	-	-	-	-
6:5	-	-	-	-	-	-	-	-	-	-	-	-
6:4	-	3	1	1	1	1	-	-	-	-	-	-
6:3	-	1	-	1	1	-	-	-	1	-	-	-
6:2	2	2	-	1	1	-	1	-	-	-	1	-
6:1	-	-	-	-	1	-	-	-	-	-	-	-
5:2	1	4	-	6	2	4	2	-	-	1	1	-
5:1	2	3	-	4	1	1	1	-	1	1	-	-
4:15	-	1	-	1	-	-	-	-	-	-	-	-
4:14	-	2	-	4	-	-	2	2	-	-	1	1
4:13	-	1	-	-	-	-	-	-	-	-	-	-
4:12	1	-	-	-	1	-	-	-	-	-	-	-
4:11	1	-	1	-	-	-	-	-	-	-	-	-
4:10	2	3	3	3	3	1	-	2	-	-	-	-
4:9	-	1	-	1	1	-	-	-	-	-	-	-
4:8	3	4	1	3	1	1	-	-	-	-	-	-
4:7	-	2	1	1	1	-	-	-	-	-	-	-
4:6	-	-	-	3	-	-	-	-	-	-	-	1
4:5	2	-	-	-	-	-	-	-	-	-	-	-
4:4	-	1	1	1	-	-	1	-	-	-	-	-
4:3	-	-	-	-	-	-	-	-	-	-	-	-
4:2	1	3	2	4	1	-	-	-	-	-	-	-

Layer	*Bubalus bubalis*	*Bos*	*Bovidae*	*Sus scrofa*	*Cervus eldi*	*Cervus unicolor*	*Muntiacus m.*	*Canis familiaris*	*Trionyx/Chitra*	*Gallus gallus*	small mammal	*Rattus* sp.
4:1	1	5	-	10	2	-	-	2	-	-	-	1
3:14	-	-	-	1	-	-	-	-	-	-	-	-
3:13	-	-	-	-	-	-	-	-	1	-	-	-
3:12	-	2	2	3	1	-	-	1	-	-	-	-
3:11	-	1	2	1	-	-	-	-	-	-	-	-
3:10	1	3	2	5	1	-	-	-	-	-	-	-
3:9	-	1	1	3	-	1	-	2	-	-	1	-
3:8	3	9	7	8	1	1	1	1	1	-	-	2
3:7	-	2	-	-	1	-	-	-	1	-	-	-
3:6	2	7	3	6	-	1	-	1	-	1	-	-
3:5	1	4	8	3	-	-	-	-	1	-	-	-
3:4	-	2	3	2	-	-	-	2	-	-	-	-
3:3	2	9	21	11	3	-	4	1	-	-	1	-
3:2	1	2	3	1	-	-	-	1	-	-	-	-
3:1	-	1	1	1	-	-	-	-	-	-	-	-
2:7	-	-	-	-	-	-	-	-	-	-	-	-
2:6	2	10	8	6	1	1	-	-	1	-	-	-
2:5	-	-	1	1	-	-	-	-	-	-	-	-
2:4	-	-	-	-	-	-	-	-	-	-	-	-
2:3	-	-	-	-	-	-	-	-	-	-	-	-
2:2	-	-	2	-	-	-	-	-	-	-	-	-
2:1	-	1	1	-	-	-	-	-	-	-	-	-

frequency of wild species decreases in the later stages.

Material from Features

Cattle, pig and deer dominate the early stages of the feature sequence (Table 29:2). *Cervus eldi* and *Cervus unicolor* are especially predominant during Layers 5 and 6, after which they significantly taper off. In Layer 5, the sambar makes up 15% of the total fauna, while only six sambar are noted in the rest of the sequence. The muntjak is never dominant, with only 12 individuals in the sequence. It appears that while the occupants of Noen U-Loke were hunting deer, it was never a large part of their diet.

Bos ranges between 20 – 38% of the total fauna during the entire sequence, while *Sus scrofa* ranges between 18 – 30%. The water buffalo is never numerous, but remains stable between 4 – 11% of the total fauna. After contributing 5% in Layer 6, nothing in Layer 5 and 15% in Layer 4, Bovidae increases to 30% of the total fauna in Layer 3 and over 30% in Layer 2.

In Layer 2 *Bos* and Bovidae dominate with 65% of the total fauna. It is possible that these bones are the remains of what once was a strong herd of cattle. Small animals are less common in features. The dog is found only in Layers 3 and 4, contributing 4% and 6% respectively. As with occupation layer material, rats are again only found in Layers 3 and 4. The recovery of turtles is far less than those recovered from general layer material, while the frog and bird are completely absent.

Layers 5 and 6 identify consistent levels of deer, after which they decrease through time, while domestic species consolidate their dominance. Small animals are by no means dominant or consistent. Features are dominated by bovines and pig remains, with well over half the total fauna (Tables 29:1-2).

Mortuary Behaviour

The people of Noen U-Loke preferred pigs as burial offerings during mortuary phases 2 and 3. Table 29:3 shows a clear dominance of *Sus scrofa* remains over all other species. Complete skeletons, or limbs, were regularly interred. Of particular interest is the overwhelming majority of left forelimbs. Of the sixteen forelimbs recovered, eleven were

TABLE 29:3 *The faunal remains found as mortuary offerings*

Species	Burial	Cat. Number	Bone	Description
Sus scrofa	26	511	Left forelimb	Immature specimen placed between the human femurs
	26	522	Left forelimb	Immature specimen placed near the left arm.
	26	526	Two tusks	Each with a hole drilled through them.
	27	523	Right forelimb	Sub-adult.
	27	523	Left forelimb	Adult.
	27	523	Left forelimb	Sub-adult.
	27	523	Right forelimb	Sub-adult.
	27	523	Left forelimb	Immature specimen.
	27	523	Left forelimb	Immature specimen.
	27	523	Right forelimb	Immature specimen.
	27	547	Left forelimb	Sub-adult found in the pelvis region.
	27	613	Left forelimb	Found within a pot (Cat. 487).
	27	613	Left forelimb	Found within a pot (Cat. 487).
	27	613	Left forelimb	Found within a pot (Cat. 487).
	27	1894	Left forelimb	Immature specimen.
	28	448	Forelimb	Immature specimen.
	30	558	Tibia	Found at left arm, from rice bed burial.
	30	1896	Cranium	Young individual.
	37	649	Complete skeleton	No more than 1-2 days old.
	40	601	Remains of skeleton	Immature specimen.
	41	623	Remains of skeleton	Immature specimen.
	42	662	Complete skeleton	Immature specimen found along the left humerus.
	49	761	Mandible	Immature specimen.
	108	1908	Right forelimb	Immature specimen.
Panthera tigris	27	483	4 canines	Each with a hole drilled through them.
Trionyx/Chitra	27	523	4 carapace fragments	
	27	614	6 carapace fragments	
	27	614	Vertebrae	
	108	1908	Humerus	
Bubalus bubalis	28	446	Fore phalanges	Complete and articulating, from a rice bed burial.
Canis familiaris	28	448	Metapodial	Young specimen.

left, four rights, and one unknown. When the right forelimbs were present they were usually found in association with the left forelimb of the same animal. Five of the individuals were either sub-adult or adult, the rest were all very young.

Burials 26, 27, and 108 belonged to Mortuary Phase 2, where all of the forelimbs are found, with the exception of a forelimb interred with Burial 28 (Mortuary Phase 3 cluster B). The rest of the faunal remains from burials are from Mortuary Phases 3 cluster A and 3 cluster B, except for Burial 115 (Mortuary Phase 5) which contained a shed *Cervus eldi* antler, Burial 31 (Mortuary Phase 4 cluster B) which contained an egg, and Burial 63 (Mortuary Phase 4 cluster C) which was interred with a dog mandible. Burials within Mortuary Phases 3A and 3B were often interred with the complete skeleton of a young pig, a change from Mortuary Phase 2 where the suid remains were almost exclusively forelimbs.

Bovine bones were rare in mortuary contexts, with the exception of Burial 28, which had the complete and articulating fore phalanges of a water buffalo. In the case of *Trionyx*/*Chitra* (all found within Mortuary Phase 2) and *Canis familiaris* (found within Mortuary Phases 3B and 4C) remains it is unclear whether these were deliberate interments. The distinction between grave fill and those of genuine grave offerings is at time difficult to identify. The nature and volume of these remains seems to indicate that these were incidental inclusions rather than deliberate placements. The four *Panthera tigris* (Mortuary Phase 2) canines appear to be an exclusive event with no other tiger remains found at the site.

There is a change in the variety and type of skeletal elements interred with burials through the different Mortuary Phases. An explanation of this may be found in the apparent gradual increase in the wealth of the Noen U-Loke community. The foundation of such is cemented in the development and incorporation of new techniques in agricultural practices. The potential to create an agri-

cultural surplus introduces many alternatives and developments for the community. It is also at this period in the sequence that the percentage of wild animals tapers off while the proportion of domestic animals increases.

The dominance of *Sus scrofa* remains in the early mortuary contexts is probably best explained by their dominance in the overall spectrum. Pigs have remained a stable resource throughout Thai prehistory and appear to have been available in relatively plentiful quantities.

SUMMARY

When combining material from features, occupation layers and burials there remain a number of interesting patterns. Again, it is cattle and pigs that dominate numerically, *Sus scrofa* are prevalent in burials, representing well over half the assemblage. There is a distinct impression that all species of deer became less abundant through time as did the water buffalo. All four species were present, but the water buffalo never exceeded 15% of the total fauna, while none of the deer species outnumbered 20% at any stage during the occupation. Combined they made up less than 10% of the total fauna in Layer 2.

Canis familiaris was absent in Layer 6, with only one individual identified in Layer 5. The occupation contexts in layers 2-4 had 39 individuals between them, indicative of the social nature of this animal. As time progressed the number of dogs increased, and the only specimens within mortuary contexts were found in later layers. The arrival of *Felis* sp. remains did not occur until Layer 3, and were never significant numerically. This pattern was followed by *Rana tigrina*, *Rattus* sp. and unidentifiable bird, all entering the spectrum in Layer 4, after which they decrease.

Cervus eldi, *Cervus unicolor*, and, to a lesser extent, *Muntiacus muntjak* are present in consistent numbers in the early layers. With industrial activities the numbers increase slightly but then decline in later layers. This may represent a flurry of hunting at the beginning of the site's occupation and then a decrease as the resource declined. This situation may also reflect the impact of forest clearance. The proportion of bovines and pig increase steadily throughout the site's occupation. This may indicate a consolidation of animal husbandry.

BUTCHERY EVIDENCE

Humans inadvertently make cut marks during the processing of a carcass. These marks are useful for deciphering processing and butchery techniques. Of particular interest is whether observed cut marks represent meticulous actions or large powerful strokes. Examination of the cut marks shows the majority had a V-shaped cross section.

Occupation Layers

Cut marks were identified on low meat value sections of *Bos*, such as the cuboid navicular and astragalus. This probably represents the disarticulation of the lower limb. Major limb bones of the water buffalo and Bovidae were often split longitudinally or smashed across the shaft, the aim of which was probably for marrow extraction. Many of the bones were smashed which indicates the execution of force and the implementation of a powerful instrument.

The majority of butchered remains were pig. Four *Sus scrofa* crania were recovered with heavy butchery marks. The V cross section of these indicates the use of a heavy instrument with a modified edge. The large number of fractured pig's mandibles leads to questions of procurement. It is not considered that these were the result of the butchery process because the mandible is extremely low in meat value. Of all butchered material found within occupation layers, only three specimens exhibited evidence for charring, while only 12 were considered as having a high meat value.

Features

Cut marks were identified on low meat value elements such as antlers, horn cores, crania and calcania. *Bos* remains appear to have been heavily butchered, especially on high meat value elements, such as the humerus, radius, metacarpal and femur. Of 42 butchered specimens found within features, half are considered as having a high meat value. Antlers and horn cores are a notable part of the collection, these were absent in occupation layers. Charred specimens are reasonably common. All large cut marks have a V shaped cross section. Two butchered limbs were recovered from two separate features, which may indicate the function of these pits as refuse areas.

Summary

A major difference between layer and feature material is the lack of pig mandibles in the latter, the reason for which remains problematic. The majority of charred remains are found within features, rather than occupation layers. Comparatively, they have different proportions of low meat value specimens, 81% in occupation layers, 50% in features. Heavily butchered material is more likely to be found in features.

BOVIDAE

The identification difficulties between water buffalo and cattle make it difficult to categorise these two species. It must be remembered that the value of the water buffalo today is not only for meat but also as traction.

The occupants of Noen U-Loke raised domestic cattle, a conclusion drawn from the dimensions of the bones, as well as tooth wear and eruption. Known dimensions of *Bos* and *Bibos* specimens were plotted on a graph with the dimensions of Noen U-Loke specimens. This process proved invaluable. The Noen U-Loke magna fell within the distribution of female and male *Bos taurus*, as well as male *Bibos gaurus* (Fig. 29:1). On the basis of the second

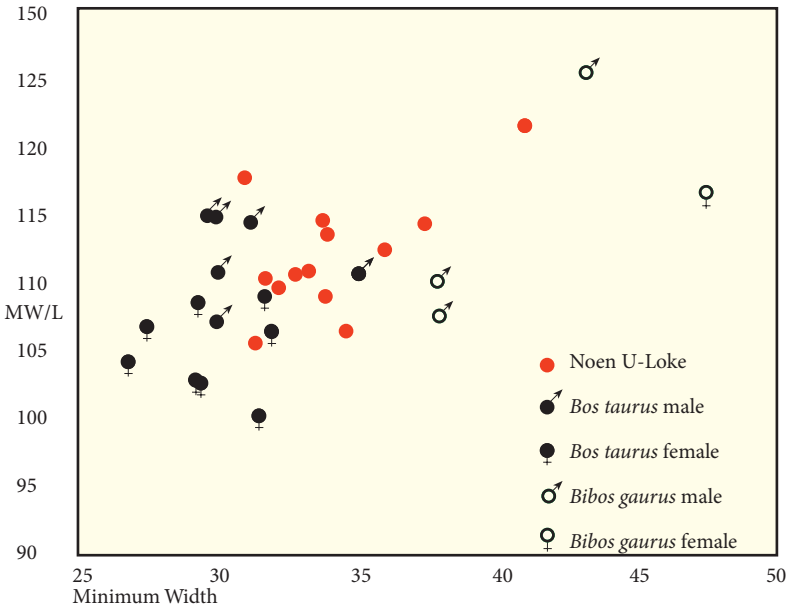


FIG. 29:1 Dimensions (mm) of *Bos* and *Bibos* magna

fore phalanges (Fig. 29:2), it appears that the Noen U-Loke occupants had access to female and male *Bos taurus*. First fore phalange distributions (Fig. 29:3) also fall within the range of male and female *Bos taurus*, but also include female *Bibos gaurus*. Noen U-Loke metacarpal specimens (Fig. 29:4) support the data that male and female *Bos taurus* were regularly used.

Before conclusions are drawn it must be remembered that the size dimensions of the Noen U-Loke specimens are being compared to modern populations. It is not expected that dimensions will be exact, rather that trends can be identified from grouped data. From the following tables it is possible to identify sexual dimorphism within the modern and archaeological populations. These results reveal that the majority of the Noen U-Loke specimens fall within the range of modern male and female *Bos taurus*, indicating the management of domestic herds. Evidence for the domesticity of bovines is also found in B3 4:S11, feature 4, where there are indications of osteoluiotitis, a bone pathology that leads to deformities. A common result of domesticating animals is the occurrence of deformities and diseases within herds. It is also clear that the Noen U-Loke occupants were hunting male and female *Bibos gaurus* or *javanicus*.

It is evident from mortality frequencies that bovines were an integral part of the Noen U-Loke society. Cattle were kept until a very old age, perhaps indicating the importance placed on these individuals. As cattle age, the value of the meat resource decreases, the meat is fibrous and coarser. Only 6% of specimens are recorded as being stage 6 or below (30 months or younger). The quantity and quality of an individual's herd may have been important for reasons other than consumption.

Bubalus bubalis appear to be a stable resource exploited, the recovery of very large specimens arguing for the presence of wild individuals. Of the specimens aged, over 80% were adult. This follows the trend of very old bovines at the site. The reason water buffalo were kept until old age could be explained by its use for traction.

SUIDAE

Pig remains contribute over a third of the total fauna. Measurements of the bones revealed that the suid population is most likely to have been domestic. The age of the suid population at Noen U-Loke was wide and varied. It is noticeable though that newly-born pigs were preferred for mortuary rituals. An analysis of remains outside the mortuary context shows very few pigs of that age. There is a concentration of mortality among sub-adults in features, whereas the occupation layers yield a large proportion less than five months old. It is therefore concluded that juveniles and sub-adults were preferred.

The recovery of several butchered pig crania indicates

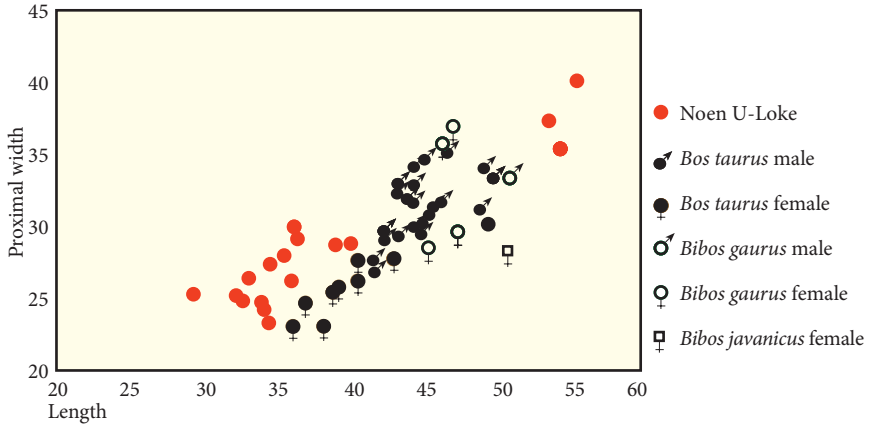


FIG. 29:2 Dimensions (mm) of *Bos* and *Bibos* second fore phalanges

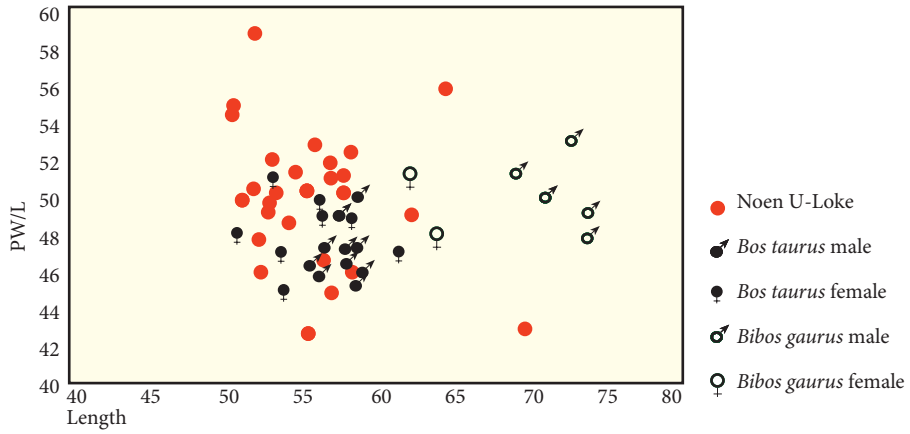


Fig. 29:3. The dimensions (mm) of *Bos* and *Bibos* first fore phalanges

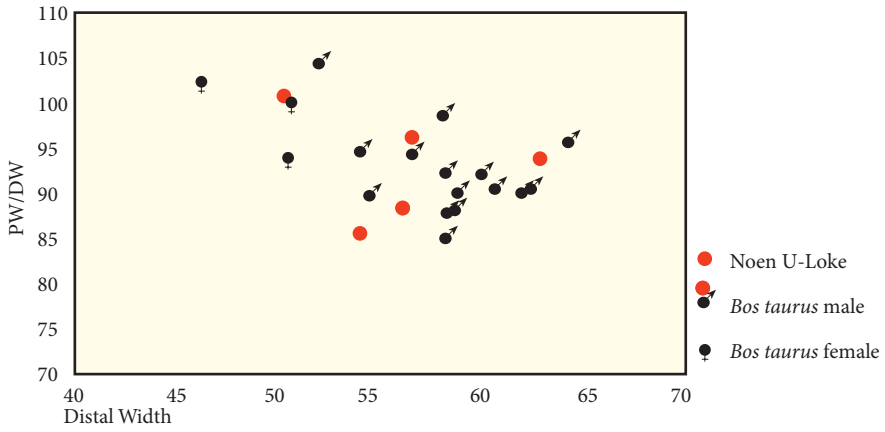


FIG. 29:4 The dimensions (mm) of *Bos* metacarpals

the type of technique used to procure the animal. Striking the animal with a sharp heavy object to the skull may have been the method used for killing. The large proportion of fractured distal mandibles gives rise to the idea that the animals were also struck on the snout.

Pigs were an important part of the mortuary phases 2-3 ritual, clearly dominating faunal remains in this context. Initially forelimbs were preferred, but this changed in Mortuary Phase 3A when the complete skeletons of very young pigs were sacrificed. This may indicate that the occupants had a wealth of pigs and could afford to sacrifice animals at a young age.

CERVIDAE

The deer population of Noen U-Loke consists of three species, *Cervus eldi*, *Cervus unicolor* and the *Muntiacus muntjak*. All major limb bones of the species were present, though little charring and few cut marks were encountered. An examination of MNI frequency tables indicates all three species were present during the sequence. *Cervus eldi* and *Cervus unicolor* were particularly abundant in the early stages of features, while they remained stable in occupation layers until Layer 3 where they taper off. Tooth wear and eruption patterns identify the population of *Cervus eldi* as being mainly sub-adult and adult specimens, making up 75% of the species. Of the aged sambar specimens, none were considered to be from young deer, all were sub-adult or adult. The *Muntiacus muntjak* specimens also appear to be from adult individuals.

Of all the deer species, *Cervus eldi* is the most common. This species would normally prefer swampy terrain, but heavy predation may have forced it further back into the reaches of the forest. Deer antler from both the sambar and Eld's deer were found in features, these were cut rather than shed. An explanation of this may be found in the technique used to process the carcass. A worked deer antler was interred with Burial 115. The surface was shaped and polished indicating a large amount of time and care had been invested in the fashioning of the ornament.

MOLLUSCAN REMAINS

A review of the inventory reveals the characteristics of the Noen U-Loke shellfish assemblage. The material from the occupation layers and features were combined, as there was no evidence indicating a difference in the composition of the two entities. The list reveals a high percentage of

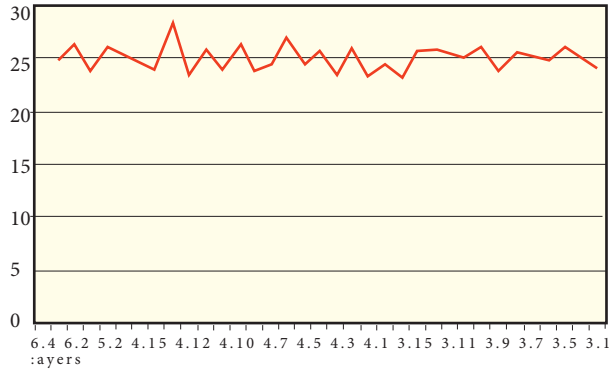


FIG. 29:5 The average length (mm) of *Pila ampullacea*

species which are primarily consumed. The food group is dominated by *Pila ampullacea* and *Filopaludina* sp., which comprise 93% of the spectrum (15% and 78% respectively). *Idiopoma* (3%), *Adamietta* (1.3%), and *Scabies* (1%) largely make up the rest of the assemblage.

During the early phases, Layers 5 and 6, shellfish frequencies are stable around 5000 MNIs. In Layer 4 the MNIs increase by 149%, more than Layers 5 and 6 combined. Frequencies from Layer 3 decrease from Layer 4, but are still 58% higher than the earlier levels. From this evidence it is possible to concede that shellfish gathering constituted an important part of the Noen U-Loke diet, but may have decreased slightly in the later layers.

The hypothesis that *Pila ampullacea* was over exploited was considered through shell size over time (Fig. 29:5). The size of the shells do not decrease, as would be expected if over predation had occurred. No pressure or stress appears to have been placed on the species, as the shells consistently remain the same size.

PALAEOENVIRONMENTAL INTERPRETATIONS

While of a preliminary nature, initial conclusions indicate an environment with permanent bodies of water during Layers 5 and 6. This is identified by the dominance of *Filopaludina* during this sequence (Fig. 29:6). This situation stayed the same in the early layers of 4, but changed slightly, noted by the slight decrease in frequency of *Filopaludina*, in the middle to late stages of Layer 4. At the beginning of Layer 3 the situation changed, indicated by *Pila ampullacea* as the dominant shellfish. As noted earlier *Pila ampullacea* is adapted and suited to the conditions of rice fields and is, therefore, indicative of an environment without consistent water supply.

The change in the frequency of these two species may well indicate a change in environment. As *Pila ampullacea* is adapted to conditions suitable for rice fields, this may indicate an expansion of rice fields at or around this time. If this is possible, then the increase in rice production may have initiated an agricultural surplus, by which the richness of the generation prospered. The change in shellfish species, and the apparent surplus of rice, indicated by rice bed burials, correlates with the introduction of very wealthy individuals. Mortuary phase four, dating to 250 AD, saw the variety and frequency of burial goods

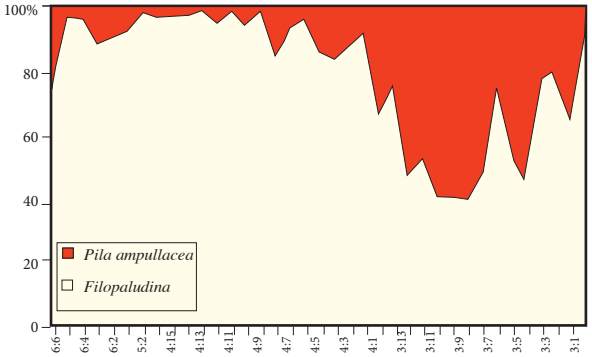


FIG. 29:6 The relative frequencies of *Filopaludina* and *Pila ampullacea* (based on the MNI)

increase. Burial 14 was the richest Iron Age burial found at Noen U-Loke, containing large amounts of bronze, glass beads and an iron knife. Burials 113 and 69 were also of particular wealth, with the former containing bronze earcoils, silver bangles and gold beads and the latter interred with bronze grave goods, including four bronze belts.

If we concede that the change in shellfish exploited indicates a change in the environment, we are then obliged to probe the question as to what caused this change and why. We can assume that the occupants of Noen U-Loke were developing in social complexity at this juncture. Common to this, is the increase in population size and perhaps a greater interaction with outside traders. An economic base with the ability to support and stabilise a growing population is much sought after and can be achieved through increased agricultural activities.

APPENDIX: THE DIMENSIONS OF THE ANIMAL BONES

M. M^{C}CAW

Bos Phalanx 1 Rear					Phalanx 3	
Context	L	PW	DW	MW	Context	DLS
5:2	66.5		33.5	29.5	C3 3:S8 F1	53.2
5:1	63.3	30.3	27.8	26.9	6:5	65.2
4:14		28.2	27.8	26.6	4:13	75
4:5	56.2	30	25.1	23.9	4:13	63*
3:14	63.1	28.2	25.5	24.5	4:8	51.5
3:13		27.4		24.7	3:9	55.5
3:11	53.1	21.8	21.3	19.3	3:7	59
3:7	56.4	25.1		22.3	3:5	65.8
3:6	52.7	25.5	24.2	23.3	3:4	62.6
3:6	60.1	26.5	24.8	23.2	3:4	56.2
3:5	65*	27.3	24.8	23.3	3:3	54
3:4	58.3	25.8	22.8	22.6	3:2	61.5
3:4	55*	25.8			3:1	55.9
3:4		26.2			3:1	50.1
3:3	58.8	30.3	25.1	24.9	2:6	54.4
3:3	55*	23	21.5	20.2	X1/C1 3: S5 F1	55*
3:3		26.8			A1 3:2 F2	52.3
3:3		24.6			B1 2:S6 F2	56.5
3:2	57*	23.5	21.1	20.7		
3:2			24			
3:2	53.3	22.9	21.3	19.4		
3:2		23.3				
3:1	58.3	27.9	24.7	23		
3:1	56.6	28.2	25.7	22.8		
3:1	52.3	24.6	23.4	22.3		
2:7	63.5	35.8	32.5	30.2		
2:7	61	25.9	24.1	23.8		
2:6	67	34.6	29.9	28.7		
2:3	54.1	22.5	21.0	18.7		
2:3		31.5				
2:2	52.4*	27.4	24.1	24		
2:1	56.9	27.1	23.8	23.4		
2:1	62.7	31.7	29.6	27.4		
A2 6:2 F3	72.4	28.8	28	28.1		
A2 6:1	69	29.8	27.4	27.4		
C3 3:10 F3	62.4	27.9	27.5	24.7		
C3 3:S8: F1	53.7	22.3	22.0	19.9		
C3 3:S8: F1	72.2	32.2	35.2	31.2		
C3 3:S8: F1	72.1	35.2	34.0	30.5		
C3 3:S8: F1		37.2		33.8		
X1 3:S6 F1	55.5	24.4	22.3	20.6		
B1 3:S4 F3	60.1	26.3	27.7	23.9		
Bur.72 (GF)	55.9	23.2	21.0	20.4		

All dimensions are in cm. * An estimated dimension

Bos Phalanx 2 Rear				
Context	L	PW	DW	MW
C3 3:S8 F1		35.5	27.5	29.0
6:3	39.3	26.9	24	22.4
4:14	31.4	26.9	25.3	
4:10	43.3	32.9		25.4
3:13	38.9	27.5	23.9	22.7
3:12	33.4	22.4	18.8	17.5
3:6	26.8		21.2	
3:5	41.3	27.8	24.6	22.9
3:5	33.7	24.6	19.2	19.5
3:4	35.4	20.4	20.1	19.5
3:4	34.8	25.3	21.4	21.1
3:3	34.1	22.5	17.9	17.3
3:3	22.4			
3:1	36.8	27.9	23	22.8
3:1	35.7	29.1	23.9	23.7
3:1	34.1	24.8	19.7	19.1
2:6	39.3	28.3	23.1	33.1
2:6	41.6	28.9	22.1	22.2
2:4	32.4	25.3	21.4	21.2
2:4	34.9	24	19	19.7
2:2	39.2	28.9	24.6	23.1
2:1	34.2	28*	23.3	22.9
B1 4:S1 F1	25.8	22.1	20.1	
C3 3:S1 F3	28.4	23.8	22.6	
C3 3:S10 F3	27.6	23.7	22.6	
X1 3:8 F1	30.1	26.8	25	

Bos Metacarpal				
Context	L	PW	DW	MW
C3 3:S8 F1		53.3		
5:1		64.6		42.6
4:14				52.0
4:12			55.7	
3:14				56.2
3:11	188.8	46.0	54.0	29.8
3:11			52.2	
3:8		51.4		
3:7		50.1		
3:7		47.0		
3:5		45.0*		
3:3	187.0	59.2	63.0	34.8
3:2		57.0		

Bos Humerus			Scapula		Patella	
Context	BT	DW	Context	NW	Context	GL
C 3 S8 F1	76.8		4:7	42.6	C3 3:S8 F1	73.7
6:2	58.9		2:6	54.3	2:7	56.4
4:1	70.1	78.8	A3 5:2 F1	52.1	2:7	75.2
3:13	68.1		C3 3:S8 F1	60.4	C1 3:9 F1	57.2
3:6	78.4	82.5	3:10	47.7	C3 3:S8 F1	54.0
3:3	68.2	77				
3:3	71.4	78.3				
3:1	60.1					
2:7	64.8					
2:7	65.4					
2:6	69.0	87.9				
A1 6:4 F1	110.5					
X1 5:2 F1	76.9					
B1 4:1 F2	71.5	81				
X1 3:12 F1	63.5					
X1 3:8 F1	67.8	72.6				
C3 3:8 F1	71.1	74.0				
B1 2:S6 F1	69.8	75.7				

Bos Femur			Ulna			
Context	DW	Bp	Context	BPC	DPA	SDO
3:1	85.5		C3 3:S8 F1	42.2	59.7	48.9
C3 3:S8 F1		47.2	C3 3:S8 F1		51.5	42.4
B3 3:6 F2		33	C3 3:S8 F1	32.0	48.6	41.2
B1 3:S5 F1		42.4				
X1/C1 3:S5	41.9					
A1 2:S6 F3		38.6				
A1 2:S6 F3		42.9				
B.72 G.F		35.6				

Bos Radius			Tibia		
Context	PW	DW	Context	DW	PW
C3 3:S8 F1	67.8		C3 3:S8 F1	59.6	
4:14	69		C3 3:S8 F1		90.4
4:11	69.5		C3 3:S8 F1	54.3	
4:8			C3 3:S8 F1	51	
4:7	72.4		6:2	68.7	
3:8	75.9		4:14	59.1	
3:8	60		4:12	77*	
3:7	72.5		4:8	68.4	
3:7	74.4		3:14	53.3	
3:6		63	3:5	58.9	
3:6		64*	3:5		94.3
3:6	76.9		3:4	61.1	
3:5	62.9		3:2	53.5	
3:2		59	3:2	53.7	
3:1		69.3	3:1	50.1	
3:1		69.6	3:1	51.3	
3:1	69.8		3:1	54.8	
3:1	65		2:6	62.4	
2:5		64.1	2:2		75*
2:4		63	2:1	66.3	
2:4	75.6		X1 6:4 F1	51.5	
2:2	78.7		A1 3:3 F2	76.9	
2:2	76.6		C3 3:S8 F1	58.9	
A1 3:3 F2		71.4	B3 3:6 F2	66.7	
C3 3:10 F3	68.3		B1 3:S5 F1	54	
C3 3:S8 F1		67.4	A1 2:6 F3		79
C3 3:S8 F1	76.7		A1 2:6 F3	53	
C3 3:S8 F1	88		A1 2:S6 F3	54.4	
B1 3:S4 F3		69.8			
A1 2:6 F3	70.2				
B1 2:S6 F1	75.5				

Bos Metatarsal				
Context	L	PW	DW	MW
C3 3:S8 F1		42.2		
C3 3:S8 F1			54.4	
C3 3:S8 F1			48.3	
4:8		42.4	48	25.8
4:5		42.5		
4:3			48.6*	
4:3		38		
3:9			58.6	
3:6	196	37.7	43.4	22.6
3:6		41.3		
3:5			50.7	
3:5			51*	
3:2		44.5		
3:2		49.3		
3:2		40.1		
3:2			52.5	
3:2			60.1	
3:2			48	
3:1		46.3		
3:1		45		
3:1		41.4		
3:1		45*		
3:1			48.4*	
2:7			51	
2:6			55*	
2:4		42.2		
2:4		45.9		
2:4			51.8	
2:4			54.5	
2:4			51.8	
X1 4:2 F2			58.9	
C1 4:S9 F6			54.1	
B2/B3 3:3 F1			42.7	
A1 4:1 F1			56*	
A1 3:3 F2		42.6		
A2 3:11 F1	211	51.8	53.2	25.2
C3 3:10 F3		46.8	51.6	
B3 3:S3 F4		37.0		22.6
C3 3:S8 F1		43.5		
C3 3:S8 F1		45.4		
B3 3:6 F2			52*	
A2 3:6 F3			51*	
A1 2:6 F3		45.4		
A1 2:6 F3		41.4		
A1 2:6 F3			51.6	
A1 2:6 F3			50.0	
A1 2:S6 F3			54.3	
A1 2:S6 F3		48.1		
3:10				22.8

Bos Cuboid Navicular		Astragalus		Calcaneum	
Context	GB	Context	GBI	Context	GL
C3 3:S8 F1	50.6	C3 3:S8 F1	58.9	C3 3:S8 F1	121.9
4:3	59.8	C3 3:S8 F1	62	4:10	132.9
4:1	64.8	C3 3:S8 F1	67	4:9	110*
3:8	52.9	5:1	57.8	4:8	123.4
3:6	44.8	4:13	64	3:10	117.9
3:6	54.5	4:1	59.9	3:6	134
3:3	48.2	3:14	57.2	3:4	110
3:2	49.6	3:14	56.5	3:1	120.8
3:2	50.5	3:13	60.1	3:1	123.3
3:2	45.7	3:7	61.1	3:1	112.2
3:1	52.1	3:7	60.4	3:1	116.2
3:1	48*	3:6	59.9	2:6	131
2:4	47.9	3:6	55	2:4	121
2:3	53.3	3:6	65*	2:3	116.5
2:3	47.7	3:4	54	2:3	115.3
B2/B3 3:3 F1	51.7	3.3	55.7	2.3	132.0
A1 3:3 F2	50.2	3:2	60.6	C1 4:2 F12	130.2
C1 3:10 F1	51.6	3:2	58.6	A1 3:3 F2	114
C3 3:8 F1	52.7	3:2	62.3	A2 3:3 F6	112
B1 3:S5 F1	55	3:1	65	X1 3:8 F1	118.3
C1 3:S4 F8	47.8	3:1	65.7	C3 3:8 F1	133.4
A1 2:S6 F3	55.7	3:1	62		
		3:1	62.8		
		2:3	66.2		
		2:2	58.7		
		2:1	64.7		
		B2/B3 3:3 F1			
		C1 3:12 F1	61.9		
		C3 3:8 F1	61.2		
		C1 3:S4 F8	59		
		A2 3:1 F2	59.9		
		A1 2:6 F3	63.5		
		A1 2:6 F3	67.7		
		B1 2:S6 F1	62		

Bos Phalanx 1 Rear					Phalanx 3	
Context	L	PW	DW	MW	Context	DLS
5:2	66.5		33.5	29.5	C3 3:S8 F1	53.2
5:1	63.3	30.3	27.8	26.9	6:5	65.2
4:14		28.2	27.8	26.6	4:13	75
4:5	56.2	30	25.1	23.9	4:13	63*
3:14	63.1	28.2	25.5	24.5	4:8	51.5
3:13		27.4		24.7	3:9	55.5
3:11	53.1	21.8	21.3	19.3	3:7	59
3:7	56.4	25.1		22.3	3:5	65.8
3:6	52.7	25.5	24.2	23.3	3:4	62.6
3:6	60.1	26.5	24.8	23.2	3:4	56.2
3:5	65*	27.3	24.8	23.3	3:3	54
3:4	58.3	25.8	22.8	22.6	3:2	61.5
3:4	55*	25.8			3:1	55.9
3:4		26.2			3:1	50.1
3:3	58.8	30.3	25.1	24.9	2:6	54.4
3:3	55*	23	21.5	20.2	X1/C1 3: S5 F1	55.0
3:3		26.8			A1 3:2 F2	52.3
3:3		24.6			B1 2:S6 F2	56.5
3:2	57*	23.5	21.1	20.7		
3:2			24			
3:2	53.3	22.9	21.3	19.4		
3:2		23.3				
3:1	58.3	27.9	24.7	23		
3:1	56.6	28.2	25.7	22.8		
3:1	52.3	24.6	23.4	22.3		
2:7	63.5	35.8	32.5	30.2		
2:7	61	25.9	24.1	23.8		
2:6	67	34.6	29.9	28.7		
2:3	54.1	22.5	21	18.7		
2:3		31.5				
2:2	52.4*	27.4	24.1	24		
2:1	56.9	27.1	23.8	23.4		
2:1	62.7	31.7	29.6	27.4		
A2 6:2 F3	28.8	28	28.1			
A2 6:1	69	29.8	27.4	27.4		
C3 3:10 F3	27.9	27.5	24.7			
C3 3:S8: F1	22.3	22	19.9			
C3 3:S8: F1	32.2	35.2	31.2			
C3 3:S8: F1	35.2	34	30.5			
C3 3:S8: F1	37.2		33.8			
X1 3:S6 F1	24.4	22.3	20.6			
B1 3:S4 F3	26.3	27.7	23.9			
Bur.72 (GF)	23.2	21	20.4			

Bovid Mandible							
Context	L. tooth row	L. PM row	L. M row	L. M1`	L. M2	L. M3	Comment
C3 3:S8 F1						36.7	
C3 3:S8 F1						44.5	
C3 3:S8 F1				25.3			
C3 3:S8 F1				21.4			
C3 3:S8 F1				22.8			
C3 3:S8 F1				23.5			
C3 3:S8 F1					29.1		
6:5						35.2	
6:4						36.5	w.worn old
6:2					30.8		
6:1		56.3	96.5	25.1	28.6	39	y.adult
6:1					35		worn adult
6:1				25.9			
6:1				20.3			
5:2					30.4		
4:15			86.2	20.5	24.2	38.3	w.worn old
4:14					27.6	37.8	w.worn old
4:14					29		w.worn old
4:14					27		w.worn old
4:14					27.5		w.worn old
4:14				21.5			young
4:13				25	30.8	41.8	adult
4:13		74**		29	31.1		young
4:12				24.5			
4:11					26	36.1	worn adult
4:10						39.3	w.worn old
4:10						37.6	w.worn old
4:10				25.2			w.worn old
4:9						44.8	w.worn old
4:9						38.4	just worn
4:9						40.1	worn adult
4:8						38.9	w.worn old
4:8						38	w.worn old
4:8					31.2		w.worn old
4:7						38.9	v.worn v.old
4:7					27.4		v.worn v.old
4:6						40.1	w.worn old
4:6						40.6	worn adult
4:6						39.3	worn adult
4:6		54					w.worn old
4:5						46.8	w.worn old
4:5				25.4			w.worn old
4:4						38.5	w.worn old
4:3				26	30.1		v.worn v.old
4:1				26.2			w.worn old

Bovid Mandible							
Context	L tooth row	L PM row	L M row	L M1	L M2	L 3	Comment
4:1				25.6			w.worn old
4:1			51				w.worn old
3:14				23.7			worn adult
3:13					29*		w.worn old
3:9				23.9			w.worn old
3:9				23.6			w.worn old
3:9				25.2			w.worn old
3:8			96.7	24.5	29.5	40.1	w.worn old
3:8						35.2	w.worn old
3:8		51.6					w.worn old
3:8		50.1		20.5			w.worn old
3:8				20.9			w.worn old
3:8		47.7					w.worn old
3:8				19.3	22.5		w.worn old
3:8				24			w.worn old
3:8						36	w.worn old
3:8						40	w.worn old
3:8					23.1		w.worn old
3:8					22.5		w.worn old
3:8						35.5	w.worn old
3:8				23.9	28.1		w.worn old
3:8				22.5	23.4		w.worn old
3:8					24.5		w.worn old
3:8						35.3	broken surface
3:7						35.1	w.worn old
3:7						36.5	w.worn old
3:7						37.6	w.worn old
3:7					25.2		w.worn old
3:7					24		w.worn old
3:7		48.8					w.worn old
3:7				18.6	20.4		w.worn old
3:7					28.2		w.worn old
3:7					24.7		w.worn old
3:6						34.7	w.worn old
3:6						36.8	w.worn old
3:6						32	w.worn old
3:6				19.8	23.3		w.worn old
3:6					25.6		w.worn old
3:6					25.1		w.worn old
3:6				22.5			w.worn old
3:6				22.8			w.worn old
3:5	131	50.1	82.9	20.5	24.4	34	w.worn old
3:5		50.2		23			w.worn old
3:5				20.4	22.5		w.worn old
3:5					20.8	32.2	w.worn old
3:5				21.6	21.8		w.worn old
3:5						35.7	w.worn old
3:5					26.9		w.worn old
3:5				18.7	25.1		w.worn old
3:5		44.2					w.worn old

Bovid Mandible							
Context	L tooth row	L PM row	L M row	L M1	L M2	L M3	Comment
3:5						34.6	w.worn old
3:5					23.4	34.1	w.worn old
3:5						34.3	w.worn old
3:4						37.8	w.worn old
3:4						35.7	w.worn old
3:4				20.3			w.worn old
3:4						35	w.worn old
3:4						39.8	w.worn old
3:4						34.7	v.worn v.old
3:4					29.2		w.worn old
3:4				21.1			w.worn old
3:4				23.6			w.worn old
3:3					24.5	38.5	w.worn old
3:3				20.6			w.worn old
3:3						35.6	w.worn old
3:3				20.3			w.worn old
3:3						33.4	w.worn old
3:3						31.6	w.worn old
3:3				21.1			w.worn old
3:3					25.8		w.worn old
3:3					25		w.worn old
3:3				19			w.worn old
3:3				21.5			w.worn old
3:3				19.3			w.worn old
3:3				22.8			w.worn old
3:2						31.2	w.worn old
3:2						37.3	w.worn old
3:2						38.5	w.worn old
3:2						33.5	w.worn old
3:2						35.7	w.worn old
3:2						38	w.worn old
3:2						38	w.worn old
3:2						35.3	w.worn old
3:2						33.5	w.worn old
3:2						36.6	w.worn old
3:2						36.8	w.worn old
3:2						36.6	w.worn old
3:2						38.2	w.worn old
3:2						35.4	w.worn old
3:2						37.9	w.worn old
3:2				23.7			w.worn old
3:2				21.3	25.6		w.worn old
3:2		50.2		20.6			w.worn old
3:2				21.3			w.worn old
3:2			46.7	19.8	22.5		w.worn old
3:2				22			w.worn old
3:2				22.7			w.worn old
3:2		46.8					w.worn old
3:2				22.1			w.worn old
3:2				19.8			w.worn old

Bovid Mandible							
Context	L tooth row	L PM row	L M row	L M1	L M2	L M3	Comment
3:2					26.6		w.worn old
3:2		48					w.worn old
3:2				19.5			w.worn old
3:2					24.7		w.worn old
3:2				21.5			w.worn old
3:2					23.4		w.worn old
3:2				21.3			w.worn old
3:2					24.3		w.worn old
3:2					27.9		w.worn old
3:2					26.6		w.worn old
3:2					28.3		w.worn old
3:1						31.7	w.worn old
3:1						34.3	w.worn old
3:1				22.1	25.3	40.1	w.worn old
3:1				20*	27.2	39.3	w.worn old
3:1						33.8	w.worn old
3:1				21.9	24	38	w.worn old
3:1				22.8	27.7	38.2	w.worn old
3:1						34.8	w.worn old
3:1						38.5	w.worn old
3:1						34.7	w.worn old
3:1						36.2	w.worn old
3:1						37.9	w.worn old
3:1						37.4	w.worn old
3:1					25.4		w.worn old
3:1					27.3		w.worn old
3:1					25		w.worn old
3:1					24.7		w.worn old
3:1				22			w.worn old
3:1				22.2			w.worn old
3:1				22.5			w.worn old
3:1				22.7			w.worn old
3:1				20.7			w.worn old
3:1						33.5	w.worn old
3:1				21.2			w.worn old
3:1				22			w.worn old
2:7			84.5	21.6	22.7	35.5	w.worn old
2:7						32.9	w.worn old
2:7						35.4	w.worn old
2:7						37	j.worn subadult
2:7						35.4	w.worn old
2:7						35.3	w.worn old
2:7				20.4	25.7		w.worn old
2:7				23.9	28.3		w.worn old
2:7				22.3			w.worn old
2:7					25.5		w.worn old
2:6			79.8	20.6	23.8	34.4	w.worn old
2:6				19.4	24.8		w.worn old
2:6				20	22.5		w.worn old
2:6		74.8					pM3 erupting: y.adult

Bovid Mandible							
Context	L tooth row	L PM row	L M row	L M1	L M2	L M3	Comment
2:6						31.9	v.worn v.old
2:6						36.6	w.worn old
2:6						31.4	w.worn old
2:6				21.5	23.1		w.worn old
2:6				20.8			v.worn v.old
2:5					24.7		w.worn old
2:4						43.8	unworn subadult
2:4						38.2	w.worn old
2:4						35	e.wear subadult
2:4						40.1	w.worn old
2:4						33.2	w.worn old
2:4						39.1	w.worn old
2:4				19.7			w.worn old
2:4				23.2			w.worn old
2:3						31.4	j.worn subadult
2:3						34.8	w.worn old
2:3						38.6	w.worn old
2:3				22			
2:3				21.5			w.worn old
2:3				24.1			w.worn old
2:3					22.6		w.worn old
2:3					23.5		w.worn old
2:2						36.4	w.worn old
2:2						36.2	w.worn old
2:2					25.6		w.worn old
2:2					25.9		w.worn old
2:2				19.5			w.worn old
2:1						40.4	w.worn old
2:1						33.1	w.worn old
2:1					27		w.worn old
C2 6:3 F1				20.3			w.worn old
C3 4:10 F1						40.6	w.worn old
C3 4:10 F1			83.4	21.2	25.2	33.9	v.worn v.old
X1 4:10 F1						44.8	w.worn old
X1 4:10 F1						38.9	w.worn old
C2 4:8 F1						41.2	w.worn old
C2 4:8 F1					30.6		w.worn old
C2 4:8 F1						41.2	w.worn old
C2 4:8 F1					31		w.worn old
X1 4:2 F2				23			w.worn old
C1 4:2 F12					29.1		w.worn old
C1 4:2 F12				24			w.worn old
A3 4:1 F4			89.3	23.5	29.2	36.4	w.worn old
A1 3:3 F2						34.5	w.worn old
A1 3:3 F2					23.5	35.3	w.worn old

Bovid Mandible							
Context	L tooth row	L PM row	L M row	L M1	L M2	L M3	Comment
A1 3:3 F2					24.4	36.6	w.worn old
A1 3:3 F2				20.2	24.5		v.worn v.old
A1 3:3 F2						40.3	w.worn old
A1 3:3 F2					19.6	31.2	w.worn old
A1 3:3 F2					25.1	37.6	w.worn old
A1 3:3 F2						35.6	w.worn old
B1 4:1 F1						33.9	w.worn old
A2 3:3 F6						36.5	w.worn old
A2 3:3 F6				20.9	23.6	35.8	w.worn old
A2 3:3 F6				18.4	24.7	34.1	w.worn old
C1 3:10 F1					23.5	38.5	w.worn old
A2 3:3 F6		47.1					w.worn old
A2 3:3 F6					21.6	35.7	w.worn old
C1 3:10 F1				21.7	25.9		w.worn old
X1 3:8 F1			86.7	21.3	25.3	36.6	w.worn old
X1 3:8 F1				24.3			w.worn old
X1 3:8 F1		42.3					w.worn old
X1 3:8 F1		41.6					w.worn old
A1 3:9 F2				23.1	26.8		w.worn old
C3 3:S8 F1				20.6			w.worn old
C3 3:S8 F1					26.6		w.worn old
C3 3:S8 F1						34.8	w.worn old
X1 3:S8 F1						37.8	w.worn old
C1 3:S5 F1						34.9	w.worn old
C1 3:S5 F1			91	19.6	25	35.7	w.worn old
C1 3:S5 F1			85.4	19.2	22.2	35.8	w.worn old
C1 3:S5 F1			75.3	19.3	20	31.8	w.worn old
C1 3:S5 F1					24.2	36.2	w.worn old
C1 3:S5 F1						40.1	w.worn old
A2 3:6 F3			98.1	25.9	30.4	40.5	w.worn old
B3 3:6 F2			80.6	20	21.1	34.1	w.worn old
B1 3:S5 F1				23.4	25.5		pm erupting subadult
B1 3:S5 F1		56.8		20	23.2		w.worn old
B1 3:S5 F1		48	78.2	18.8	23.3	34	w.worn old
X1/C1 3:S5 F1				22.6			w.worn old
C1 3:S4 F8						34.6	w.worn old
A2 3:4 F1				19.3	22.2		w.worn old
A2 3:1 F2				22.5			w.worn old
A1 2:6 F3			78.1	19.6	21.3	36	w.worn old
A1 2:6 F3					22.2	34	w.worn old
A1 2:6 F3		49.7		21.7			w.worn old
Bovid Mandible							
Context	L tooth row	L PM row	L M row	L M1	L M2	L M3	Comment
A1 2:6 F3		51.1		21.8			w.worn old
A1 2:6 F3						33	e.wear subadult
A1 2:6 F3					21.7	34.4	w.worn old
A1 2:6 F3				18.8			w.worn old
A1 2:S6 F3						36.9	w.worn old
B1 2:S6 F1			83.8	21.3	23.3	36.9	w.worn old
B1 2:S6 F1		62.6					w.worn old
A1/B1 2:5 F2						39.5	w.worn old
A3 2:2 F1						37.9	w.worn old
B1 2:S6 F2		45*		21.7			v.worn v.old
B1 2:S6 F1						35.5	w.worn old
3:10			88.5	21.1	26.7	39.6	w.worn old

Bovid									
Scapula			Radius		Ulna		Femur		
Context	SLC	LG	Context	BFd	Context	BPC	Context	DC	BP
C3 3:S8 F1	60.3	57.5	5:2	67.4	3:5	30.2	5:1	53.0	
B1 4:1 F2	60.1						3:8	57.3	
							C3 3:S8 F1	52.9	141
							C3 3:S8 F1	37.0	

Bubalus bubalis						
Cuboid Navicular		Calcaneum		Magnum		
Context	GB	Context	L	Context	MW	ML
C3 3:S8 F1	74.4	4.7	152.4	4:13	37.6	41.1
4:11	72	4:6	135.5	4:10	45.9	45.7
4:6	71.6	4:6	141.0	3:8		41.3
3:14	71.7	4:6	149.6	3:1	37.8	39.0
C1 4:2 F12	68.6	4.3	146*	3:1	36.7	36.9
		3:7	150.0	2:4	36.7	37.9
		3:6	154.2	2:3	34.0	38.9
		C1 3:10 F1	138.6	2:2	46.7	47.3
		3:10	139.7	A2 6:2 F3	39.4	38.6

Bubalus bubalis							
Astragalus		Tibia			Femur		
Con-text	GLI	Context	DW	PW	Context	DC	DW
5:1	85*	C3 3:S8 F1	77.6		2:4	67	
4:14	79.2	3:11		72	C1 4:5 F3		114.6
4:9	98*	3:10		79.8	C1 3:10 F1	53	
4:8	80	C2 4:8 F1	79.8				
4:7	81	C2 4:8 F1		100.1			
4:7	82.4	B3 4:11 F2	74				
4:6	85.8						
3:10	80.4						
3:1	84.0						
C2 4:8 F1	81.6						
C3 3:S8 F1	77.2						
C1 3:5 F1	75.0						

Bubalus bubalis						
Ulna		Humerus		Radius		
Context	BPC	Context	BT	Context	DW	PW
6:5	54	C3 3:S8 F1	92.7	2:1		86.1
3:1	54.9	C2 4:8 F1	87.5	B1 4:12 F2		99.9
C3 4:10 F1	48.3	C2 4:8 F1	92.0	C2 4:8 F1	87.9	
				B1 2:6 F1		77.7

Bubalus bubalis Phalanx 1 Rear				
Context	L	PW	DW	MW
4:8	72.0	36.9	34.5	32.8
4:7		36*		
4:5	67.6	37.6	33.7	28.3
4:1	72.2	33.5*	34.5	32.6
3:14	79*	37.8	31*	31
3:7	70*	34.9	32.1	31.1
3:6	69	34	32.7	29.4
3:4	72.6	36.7	33.7	30.9
3:2	63.8	34.8	34.1	32
3:2		37.7		
3:1	88.0	420	39.0	38.5
C2 4:8 F1	77.2	37.9	36.2	33.4
C2 4:8 F1	69*	37.6		
X1 4:8 F1		39.1		
C1 4:2 F12	70.1	39.2	33.6	31.6
C3 3:S8 F1	72.6	39.9	38.5	36.7
C3 3:S8 F1	72.7	40.1	39.7	31.8
A1 3:3 F2			36	36.2

Bubalus bubalis Phalanx 1 Fore				
Context	L	PW	DW	MW
4:14		51*	51.1	51.8
4:10	68*	38*	37.9	37.5
4:3		37		
3:8		37.3		
3:7		37.5		
3:4	66.7*	35.8	35.3	32.5
3:3		39.3		
3:2	77.3	42.3	38.8	35.2
3:2	66	39	36.8	37.3
3:2	41.5			
3:2			38	
3:1	71	40.1	36.9	34.4
3:1			36	
2:7	65.4	40.1	37.6	35.8
2:1	67.5	40.3	38.9	38
2:1	68*	41*	36.9	36.9
A2 6:2 F3	88.3	49	47	43.6
C3 3:S8 F1	68	39.7	37.9	37.3
B.28	64	37.5	36.9	33.7

Bubalus bubalis Phalanx 2 Fore				
Context	L	PW	DW	MW
5:2	47.5	39.8	32.4	32.2
4:12	49.5	36.6	31	28
4:11	47	37.2	29	28.6
4:10	48.4	39.5	29.2	29.9
4:10		37.9		
4:9	44.4	37.7	27.9	29
4:8	63.5*	47.3	37.3*	38.3
4:6	48.1	44.5	37.8	35.8
4:6		42*		
3:12	52*	42*		
3:11	40.2	32.7	28	27
3:10	45	38.2		
3:6	47.3	36.2	27.6	27.1
3:6	44.9	39.4	29.8	29.4
3:5	48*	38.4		29.2
3:4	44.9	34.6	28.8	25.3
3:4	45.3	35*	27.2	26.5
3:2	44.9	36.9	29.5	28.9
3:2		37.8		
2:4	49.7	38.4	30	31.4
2:2	44.1	37.9	33.3	28.9
B3 3:S3 F4	51.7	36.8	29.2	28.3
3:1		38.1		
2:7	51.3	38.4	31.4	27.9
A1 3:2 F2	44.8	39.9	32.3	31.2
B3 3:6 F2	60*	46.6	36	32.9
C1 3:S5 F1	57.3	45.2	36.7	35.3

Bubalus bubalis Phalanx 2 Rear				
Context	L	PW	DW	MW
C3 3:S8 F1	45.4	38.7	30.9	30.2
C3 3:S8 F1	54.3	45.9	32.1	33.4
5:2	62	42.4	36.5	34
4:7	50.5	39.6	29.8	29
4:6	46.8	35.9	28.2	27.1
3:11	46	35.5	28.5	25.2
3:6		34.5*		
3:1	46.5	35.5	26.4	24.4
3:1	45.1	34.6	27.3	27.7
2:2	50.3	33.7	27.3	26.9
2:1	48.7	36.9	28.3	29.5

Bubalus bubalis Phalanx 3					
Context	DLS	Context	DLS	Context	DLS
4:10	83.3	3:2	88.6	4.6	84.4
4:8	73	2:6	77.9	C3 3:S8 F1	82.0

Bubalus bubalis Metatarsal			
Context	PW	DW	MW
4:14		90	
4:7		72.4*	
4:7	59		
4:5	62.6		
3:14		60.9	
3:10	52.2		
3:4		60*	
2:3	55.9		
2:1		70.1	
B3 4:11 F2		77.0	
C3 3:S8 F1		61.6	
C3 3:S8 F1		56.0	
C3 3:S8 F1		46.9	28.6

Bubalus bubalis Metacarpal				
Context	L	PW	DW	MW
C3 3:S8 F1		77.1		
5:1			70*	
4:13			79.5	
4:13		72.3		
4:11			79*	
4:9		80.7		
4:7			83*	
4:7		63		
4:5			83.4	
4:3	71.7			
4:3		76*		
4:1		74.6		
3:14		72.8		
3:13		77.2		
3:7			73.8	
3:7		71.6		
3:6	171	66.8	70	41.7
3:6	192*	78.5	82.5*	52.6
3:5		75.4		
3:1			73.8	
X1 5:1 F1			86.4	
C2 4:8 F1		78.1		
A3 4:5 F1			70.8	
C1 4:2 F12		72.3		
A1 4:1 F1			79.3	
C1 3:10 F1	200.0	73.2	76.0	50.7
C3 3:S8 F1	182.0	68.2	76.5	42.7
A2 3:6 F3		68.2		
A1 2:S6 F3			80.0	

Sus scrofa Mandible					
Context	L PM 2-4	L M1	L M2	LM3	Comment
C3 3:S8 F1		18.8			w.worn adult
C3 3:S8 F1		15.2			e.wear
C3 3:S8 F1		17.3			j.worn
6:3	44.5	16.9	20.8		M2 e.wear
6:2		13.2			worn
6:2		15.2			unworn
6:1		14.9	18.7		y.adult
6:1		16.3			M1 e.wear juvenile
6:1		16.3			j.worn
5:1		15.9			e.wear
5:1		21.4			unerupted
4:14		14	16.8		y.adult
4:14		15.2			y.adult
4:13			20.1		
4:9		14			M1 j.worn juvenile
4:8		14.7			M1 j.worn juvenile
4:8		14.5			j.worn juvenile
4:7		13.3			j.worn juvenile
4:6		14.5	18.3		M2 j.worn: M3 unerupted sub-adult**
4:6		14.8	18.2		M2 j.worn: M3 unerupted sub-adult**
4:6		15.1			M1 j.worn: M2 unerupted young
4:6		16.4			w.worn adult
4:6		16			j.worn juvenile
4:6		14.4			j.worn juvenile
4:4		15			M2 unerupted young
4:4			18.8	33.2	M3 worn adult
4:4			17.9		burnt all over
4:3		14.8			e.wear juvenile
4:3		17.2			e.wear juvenile
4:3		15.2			e.wear juvenile
4:3		14.5			
4:1				32.3	w.worn adult
4:1		15.3			w.worn adult
4:1			18.8		unworn subadult
4:1		13.5*			premolars unerupted young
4:1		15.4			unworn young
3:14				36.5	w.worn adult
3:14			22.8		erupting subadult
3:13		14.1			e.wear subadult
3:11		15.5	19.2		M2 e.wear y.adult

Sus scrofa Mandible					
Context	L PM 2-4	L M1	L M2	LM3	Comment
3:9		14.6			pm4 decidous young
3:9		14.9	19.1		M2 unworn young
3:9		13.9	17.8		M2 e.wear y.adult
3:9		14.9	19.5		M2 j.worn subadult
3:9			19.1		e.wear subadult
3:8		15.4			young
3:8		15.5	19.6		subadult
3:8		15.9			subadult
3:8		15.1	19		adult
3:8			18.5		y.adult
3:8		15.2			young
3:8		15.2			
3:7		14.2	16.3		M3 unerupted subadult
3:7		14.3	19.1		M3 unerupted subadult
3:7		15.3			premolars erupting juvenile
3:7		13.5	19.4		M2 erupting young
3:7				38.5*	j.worn subadult
3:7		14.9			
3:7			19.2		j.worn subadult
3:7			18.3		w.worn adult
3:7		14.9			w.worn adult
3:6		15.4			y.adult
3:6		15.4			M2 erupting
3:6		14.2	15.9		M3 unerupted
3:6		15.1			M2 erupting unworn
3:6		18.2			e.wear subadult
3:6		15.2			M2 unerupted
3:6		15.7			M2 late erupting subadult
3:5		13.7			j.worn young
3:5			16.5		j.worn young
3:5		14.6	18.7		M3 unerupted juvenile
3:5		15.2			premolars erupting young
3:5		14.1			slightly worn juvenile
3:5		15			unworn unerupted
3:5		15.2			M2 unerupted young
3:4		15.4	18		M3 unerupted
3:4		15.1			j.worn
3:4		14.3			PM4 e.wear

Sus scrofa Mandible					
Context	L PM row	LM1	LM2	LM3	Comment
3:3	37.7	14.5	16.4		M3 erupting
3:3			19.2		unworn
3:3			18.3		
3:3		15.1	17.9		
3:3		15.3			
3:3			18.9		M3 unerupted
3:3			18.6		unworn
3:3			18.9		j.worn
3:3			18.1		unworn
3:3		15.1			j.worn
3:3		14			worn
3:3		14.3			j.worn
3:2		16.3	18.9		M3 unerupted
3:2		14.7	17.5	29.6	M3 j.worn
3:2		15.4	18.1		pm4 deciduous j.worn
3:2		15.8	18.3		heavily burnt: M2 j.worn
3:2		15.9	18.3		M2 j:worn
3:2		14.3	18.6		M2 w.worn
3:2		20.9			early wear
3:2		15.6	18		M2 j:worn
3:2			17.9		M3 unerupted
3:2			20.9		j.worn
3:2		15.2			e.wear
3:1			18.3	36.6	w.worn old
3:1		14	16.9		M3 unerupted: pm erupting
3:1		14.5	18.2		M3 unerupted
3:1		14.8	17.5		M3 unerupted
3:1		14.7			M2 unerupted
3:1		14.5			M2 unerupted
3:1		15.4			M2 unerupted
3:1		14.4			j.worn
3:1			17.8		
2:6		15.6	18.5		pm4 permanent unworn
2:6		15.2			M2 unerupted
2:6		15.6			M2 unerupted
2:6		13.5			M2 unerupted
2:6		15			erupting
2:6		15			pM3 erupting
2:6		14.7			M2 erupting
2:5		16.2			M2 erupted
2:4		15.2	17		M2 j.worn
2:4				38.2	worn adult
2:4		14.9			pm4 permanent erupting

Sus scrofa Mandible					
Context	L PM row	L M1	L M2	L M3	Comment
2:4			16.7		M3 unerupted
2:4		14.2			e.wear
2:3		15.3	19.4		M3 unerupted
2:3		14.8			e.wear
2:3				28.4	M3 unerupted
2:2		15.3			M3 unerupted
2:2			16.6		j.worn
2:1		14.5			M2 unerupted
2:1		15.7			unworn
2:1		14			unworn young
X1 5:2 F1				38.6	unworn young
A3 5:2 F1		15.8			
X1 5:1 F1				34.7	j.worn
B2 4:15 F1		16	19.9		M2 erupting
C3 4:14 F2		14.6			
C2 4:8 F1		16.6	19.8		M3 unerupted
C1 4:9 F5			19.6	33.9	M3 j.worn
C2 4:8 F1			20.4		
B2 4:6 F1			19	36.7	
B2 4:6 F1			19.1	36.5	worn old
B2 4:6 F1			17.6		worn old
X1 4:2 F2		14.3	19		M3 unerupted
B1 4:1 F2		15.7			decid. pm worn
B2/B3 3:3 F1		14.5			M2 just erupted
A1 3:3 F2		14.2	18.3		M2 erupting
A1 3:3 F2		15.6			M2 erupting
A2 3:3 F6		15.7			pm4 erupting
C1 3:10 F1		15.7			M2 unerupted
C1 3:10 F1		16.9	22.2	44.8	w.worn
A2 3:11 F1		14.9	17.6		M2 unworn
A1 3:9 F2		15.1	17.5		pM2 erupting subadult
C1 3:9 F1		13.7			
C3 3:S8 F1		14.5			
C3 3:8 F1		15.5			
C3 3:8 F1		15.6			
C3 3:8 F1			19.9		M2 j.worn
C3 3:8 F1			17.8		M2 j.worn
C3 3:8 F1			16.8		M3 unerupted
X1/C1 3: S5 F1			18.5		M2 erupted unworn
A1 3:S6 F3		14.6			M3 unerupted
B1 3:S4 F3			18.2		M3 unerupted
B1 3:S4 F3			20.7		M3 unerupted
B1 2:S6 F1		14.8	20.3		M3 unerupted
B1 2:S6 F1		13	16.8		M3 unerupted

Sus scrofa Mandible					
Context	L PM 2-4	L M1	L M2	L M3	Comment
B1 2:LS6 F1		14.8	18.0		M3 unerupted
B1 2:S6 F1		14.7			M3 unerupted
3:10		14.4			j.worn M2 unerupted
3:10		15.2			

Sus scrofa Maxilla						
Context	L PM Row	L M Row	L M1	L M2	L M3	Comment
C3 3:S8 F1		66.3	12.8	17.3	30	M3 erupting
C3 3:S8 F1			14.5	18.7		pm4 late eruption
C3 3:S8 F1			13.2	16.7		M2 unworn young
C3 3:S8 F1					33.4	cusp 1 early wear
C3 3:S8 F1				15.4		
4:14					31.2	worn adult
4:14			14.2	19		young adult
4:14				16		young adult
4:13					29.5	young adult
4:13				19.8		young adult
4:13			16.8			j.worn young
4:13			15			adult
4:13			15.8			e.wear
4:11			16.4			e.wear
4:11				16.2		unworn
4:8			14.2			M2 erupting young
4:8			15			M1 erupting: unworn young
4:8				18.3		j.worn subadult
4:8			15.2			e.wear
4:8			14.9			e.wear
4:7					32	j.worn
4:7			14.9			M2 just worn subadult
4:7			14.8	15.6		w.worn adult
4:6					35.5	worn adult
4:6			14.8			worn adult
4:5		70.4	16.5	19.9	32.8	M3 w.worn adult
4:5	46.2					w.worn adult
4:3			12.9	17.3		M2 just worn subadult
4:3			15.9	18.4		M1 worn subadult

Sus scrofa Maxilla						
Context	L PM row	LM row	LM1	LM2	LM3	Comment
4:3			13.5			M1 j.worn young**
4:3			13.7	19.8		M2 unworn young**
3:14				17.3	31.1	w.worn adult
3:14				19.3		unworn subadult
3:14				19.1		e.wear subadult
3:12					34	unworn young
3:12				16.6		worn M3 unerupted subadult
3:12			15.2			pm4 decidous w.worn young
3:11			15.1			pm4 unerupted juvenile
3:11			14	18.3		M2 erupting young
3:10			14.1			e.wear immature
3:9			12.5			e.wear: M2 unerupted young
3:9				16.5		j.worn subadult
3:8			14.7			y.adult
3:8				18.1		y.adult
3:8				16.5		subadult
3:7			12.1			M2 erupting young
3:7				15.3		j.worn
3:6		64.6		17.2	33.4	M3 j.worn
3:6			14.3			M1 e.wear subadult
3:6			14.6			M1 e.wear subadult
3:6			14.7			M1 e.wear subadult
3:5			14.9	18.2		v.worn adult
3:5			15.6	19.8		M3 unerupted subadult
3:5			15.4			young
3:5			11.6	15.1		M3 unerupted subadult
3:5				15.6		j.worn
3:4			13.6			M2 unerupted
3:4			13.8	17.7		M2 just worn
3:4				20		worn
3:4			16			
3:3			13.6	17.5	38	M3 late eruption
3:2			13.1			
3:2			15.1			
3:2			13.4	14		

Sus scrofa Maxilla						
Context	L PM row	L M row	LM1	LM2	LM3	Comment
3:2			13.1	14.2		
3:2			13.9	14.7		
3:2			13.8			
3:2			13.4	149		
3:1			12.9	14.2		
3:1			13	16.8		
3:1			13.9			
3:1			13.4			
3:1				16.9	30.6	
2:6			15.8	19.6		M2 w.worn
2:6			15.1			M2 erupting
2:6			15.4	17.2		M2 j.worn
2:6	46.2					pm j.worn
2:6			15.5			M2 heavily worn
2:4			13.6			M2 j.worn
2:4			15			M2 j.worn
2:4			14.7			j.worn
2:2			13.9			
2:2				16.2		unworn
2:2			14			worn
2:2				16.8		unerupted
2:1			15.2			j.worn
2:1			15			w.worn
2:1			13.9			worn
2:1				17.8		
B1 5:2 F2				16.8		
C3 4:10 F1					30.9	
B1 4:10 F1					36.8	j.worn
C2 4:8 F1			13.9			
X1 4:2 F2				17.9		unworn
B2/B3 3:3 F1			14	17.8		M2 early wear
B2/B3 3:3 F1			13.6	16.9		M3 unerupted
A1 4:1 F1				17.1		M3 unerupted: M2 j.worn
B3 3:3 F2			14.9	18.6		M2 w.worn wdult
A3 4:1 F4			14.7			
A3 4:1 F4				16.7		

Sus scrofa							
Scapula			Tibia			Ulna	
Context	LG	SLC	Context	DW	PW	Context	BPC
4:10	31.7	23.2	4:15	30*		4:15	21
4:1		24.5	4:14		49.8	3:14	19.7
3:2		24.8	4:8	32.9*		3:6	19.8
3:2		20.5	4:1	32.2		3:5	18.5
3:1		21.1	3:8	29.4		3:4	18.4
3:1		18.2	3:2	29.3		3:2	20.1
3:1		20.4	2:6	34.6		2:7	18.4
3:1		20	C2 4:8 F1	27.9		C1 3:S5 F1	19.8
2:7		25.5	C2 4:8 F1	29.8			
2:3		21.2	X1 3:8 F1	30.1			
3:6		31.4					

Sus scrofa							
Calcaneus		Radius		Humerus			
Context	L	Context	PW	Context	TW	MW	DW
C1 3:S5 F1	75.5	4:13	31.5	C3 3:S8 F1	33.6	19.1	
		4:11	29.2	4:8			46.3
		3:14	25.9	3:8			41
		3:13	29	3:7			39.6
		3:7	31.1	3:6			37.7
Astragalus		3:5	26.3	3:2	28.3		36.4
Context	GLI	3:3	37.6	2:3			39.1
		3:3	27.3	2:3			36.1
6:1	48.1	3:2	27.5	B1 3:S4 F3		35.4	
4:15	46.3	2:2	27.2				

Sus scrofa						
Metacarpal IV					Metacarpal III	
Context	L	PW	DW	MW	Context	PW
4:1		13.5			4:9	17.8
3:7		16.1			4:3	15.6
3:4	61.4	14.1	16	12.7		

Sus scrofa									
Metatarsal IV					Metatarsal III				
Context	L	PW	DW	MW	Context	L	PW	DW	MW
4:13	91.8	20	25	18.9	5:1	87.3	18.8	19.9	14.9
					5:1		16.7		
					4:10		19.9		
					3:6		15.8		

Sus scrofa								
Phalanx 1					Phalanx 2			
Context	L	PW	DW	MW	Context	L	PW	DW
4:13			14		4:8			14.9
4:4		16.8			4:3	21	15.8	14.2
4:3	31.9	17.2	14.6	14.4	B. 27		16.4	
3:11			16.3					
A1 4:14 F1		16.8						

Cervus eldi					
Metacarpal			Metatarsal		
Context	DW	MW	Context	PW	MW
4:14		16	5:1	26.6	
4:10	30*		4:11		28.6
3:13	27.3		4:9	26.6	
2:3	31.5*		3:13		37.5
			2:1		30.3*
			B3 4:12 F4	27.5	
			B1 4:10 F1		30
			B1 4:7 F3	28.3	

Cervus eldi					
Cuboid Navicular		Calcanium		Astragalus	
Context	GB	Context	L	Context	L
B3 4:12 F4	31.7	3:1	85.9	4:9	42
		A1 6:4 F1	81.1	3:7	39.7
				3:4	40.3
				2:2	40.2
				2:1	41
				A3 5:2 F2	45

Cervus eldi	Phalanx 1				Phalanx 3	
Context	L	PW	DW	MW	Context	DLS
5:2	46.8	12.6	12.1	11.1	4:14	32
4:12	49	14	13.2	10.6		
4:11	39.1	14	11.9	9.5		
4:11		13.1				
4:11		14				
4:10			14.1			
4:10			14.1			
4:10			13.7			
4:9	55.4	16.2	14.2	12.9		
4:2	43.3	14.2	12.3	10.1		
3:9		14.1				
3:6	55.3	16.4	13.5	12.3		
A3 5:2 F1	54.8	19.9	18.5	16.8		
C2 4:8 F1	54	15.8	14.8	12.9		

Cervus eldi						
Pelvis		Tibia			Phalanx 3	
Context	LA	Context	DW	PW	Context	DLS
3:4	29.8	4:15	30*		4:13	25.6
3:3	57.9	4:14		49.8		
3:1	29.5	4:8	32.9*			
2:2	30.8	4:1	32.2			
		3:8	29.4			
		3:2	29.3			
		2:6	34.6			
		C2 4:8 F1	27.9			
		C2 4:8 F1	29.8			
		X1 3:8 F1	30.1			

Cervus eldi							
Phalanx 2					Magnum		
Context	L	PW	DW	MW	Cont ext	MW	ML
4:12			9.9		X1 4:10 F1	19	19.9
4:11			14				
4:1	31.1	14.7	10.5	10.4			

Cervus eldi						
Humerus		Scapula		Radius		
Context	DW	Context	LG	Context	DW	PW
4:14	39*	4:14	25.1	5:1	31.7	
4:6	41.5	X1 6:2 F1	29.9	4:10	34	
				2:5		26.5
				C3 3:S8 F1	39	

Cervus eldi				
Tibia			Ulna	
Context	DW	PW	Context	BPC
C3 3:S8 F1	36.9		3:12	19.9
4:12	35.5			
4:12	37.5			
4:8	33			
3:2	36.5			
3:1		60.1		
2:3	33.4			
2:1	34.4			
A3 5:2 F1	37.6			
C3 3:10 F3	34.8			

Cervus eldi Maxilla						
Context	PM3	M Row	L M1	L M2	L M3	Comment
C3 3:S8 F1			13.4			adult
5:1	18.2					e.wear subadult
4:14				16.9		y.adult
4:13			13.8			
4:11				18		y.adult
4:9		47.4	12*	16.2	18.2	M3 unworn subadult
3:12		51.6	14.8	17.9	18.3	e.wear subadult
3:11		50.9	14.1	18.1	18.3	M3 worn y.adult
3:11			16.9			M1 worn y.adult

Cervus eldi Mandible						
Context	L.PM Row	L.M Row	L M1	L M2	L M3	Comment
C3 3:S8 F1		43.8	10.3	11.6	20.7	adult
4:12				17.8		e.wear y.adult
4:9			10.2			w.worn adult
4:7	34.4	54.2	12.7	18	22.4	y.adult
4:7			13.7			adult
4:6		52.8		16.3	23.5	j.worn sub-adult
2:2					21.2	worn adult
C2 6:3 F1		55*				y.adult
A3 4:2 F9		49				worn adult
A3 3:12 F10					26.9	

Cervus unicolor					
Calcanous		Pelvis		Ulna	
Context	L	Context	LA	Context	SDO
4:13	88*	3:8	47.6	5:1	36.9*
Astragalus					
Context	L				
4:1	55.2				

Cervus unicolor						
Metatarsal			Mandible			
Context	PW	DW	Context	L M1	L M2	L M3
4:13	36.8		4:14			
4:5	28.9		4:3	18.8		
3:14		43.2	3:8	19.9	27	
X1 6:4 F1		41.4	3:8			19

Cervus unicolor						
Phalanx 3		Femur		Tibia		
Context	DLS	Context	DC	Context	PW	DW
A3 5:2 F1	49	3:8	40.6	3:2		49.8
		3:1	36.3	B2 5:2 F1	7.1 (?)	
				A1 3:9 F1		52.7

Muntiacus muntjak					
Calcaneous		Cuboid Navicular		Astragalus	
Context	L	Context	W	Context	L
4:9	43.8	4:9	19.7	4:9	32.2

Muntiacus muntjak						
Radius			Femur			
Context	PW	DW	Context	DW	DC	BP
4:9	22.4		3:8	31.5		
3:8		27	2:3		17.9	36.8
A2 3:3 F2	24					

Muntiacus muntjak						
Tibia		Phalanx 1		Phalanx 2		
Context	DW	Context	DW	Context	L	PW
4:13	28	3:12	11.7	2:3	26.3	12.9
4:9	21.2					
4:8	32.6					
3:6	19.8					
C1 4:4 F6	25.1					
A1 3:3 F2	22.5					

Muntiacus muntjak							
Metatarsal		Metacarpal			Humerus		
Context	DW	Context	PW	DW	Context	PW	DW
4:13	23*	4:11		20.8	4:12	33	
		4:10	23.2		3:2		27
		4:7		23.2	X1 4:14 F1		29.1
					A3 3:S8 F2	27.8	
Scapula							
Context	NW						
4:8	21.1						
3:2	17.1						
A2 3:3 F6	15.7						

Canis familiaris Mandible									
Context	Tooth Row	M Row	PM Row	L M1	11	12	13	20	Comment
5:1			31.3					19.6	
4:12				19.6					
3:10					33.4	23		16	
3:9	64.7	31.5	33.7					18.4	j.worn (YA)
3:7		32							
3:4						27.9	19.8		y.adult
3:2							19.5		
2:4		36.2				27.7	20		y.adult
2:1				19*					
B1 4:14 F3								16.1	
C3 4:10 F1							20.9		
X1 4:10 F1								19.9	
C1 3:S9 F1				21.3					
C3 3:S8 F1			36.3			29.9		16.8	
X1/C1 3: S5 F1		32	36.5			31	19.5	15.9	
B1 3:S2 F1						28.8	19.2	20.9	
B.26		28.8		20.3	29.2	25.5		17.1	

Canis familiaris						
Femur		Metacarpal			Humerus	
Context	DW	Context	L	DW	Context	DW
4:11	25.8	4:14	55.6	8.2	C3 4:10 F1	32.3
		4:14	53	8.2	B3 3:6 F2	30.1

Canis familiaris						
Calcaneous		Radius		Tibia		
Context	L	Context	PW	Context	PW	DW
4:12	46	3:2	16.5	4:5	27.2	
4:12	45.1			4:1		21.7
				3:2	21.5	

Canis familiaris					
Metatarsal			Ulna		
Context	L	DW	Context	DPA	SDO
4:15	69.2	9	4:10	23.3	21.8
			3:14	23	20.2
			3:7		20.4

Canis familiaris Maxilla			
Context	L M Row	L M1	L PM4
5:1		11.4	
4:13	20.5	16	19
3:9	26.5		
X1/C1 3: S5 F1	16.1		

Felis sp.				
Bone	Context	L	PW	DW
Calcanium	2:1	28.7		
Radius	2:1		11.6	
Tibia	2:1			14.4
Humerus	2:1			18.8

Felis sp.					
Mandible				Maxilla	
Con-text	Meas. 5	Meas. 10	Meas. 14	Con-text	Meas. 14
3:4	26.3	13.2		2:1	10.8
3:1			16.7		
2:1	20.8	9.7			

Gallus			
Femur		Humerus	
Context	DW	Context	DW
4:13	15	3:13	14.5

XXX. THE FISH REMAINS

RACHANIE THOSARAT

Despite the most stringent programme for the recovery of biological material, including the flotation procedure, very few fish bones were recovered when compared with Ban Lum Khao. Most fish remains, indeed, were recovered from inside early pottery vessels placed with the dead as mortuary offerings. Given the swampy nature of the environment, and the proximity of water courses in the immediate vicinity of the site, not to mention the many shellfish recovered, this paucity of fish bones is hard to explain. It might be that different cooking or preparing methods were involved, or that fish were processed at another part of the site. Further excavations might illuminate this issue.

INTRODUCTION

The excavation of Noen U-Loke followed the same procedure as at Ban Lum Khao, with flotation and fine screening being employed to ensure that all microfauna was recovered (Thosarat 2005). Although complete fish skeletons were found in early mortuary vessels, few fish bones were recovered from non-mortuary contexts. The habitats and distributions are in all cases derived from Smith (1945), Widthayanon *et al.* (1997) and Koranantakul *et al.* 2000.

The same comparative sample was used in the identification of the bones to genus and species. The following were identified:

ANABANTIDAE

Anabas testudineus
This species is best known for its ability to traverse dry land and climb steep slopes or even trees. However, it is also one of the main food fishes of Thailand, adapted to fresh water rivers, streams, canals and marshes. A mature specimen will measure 10-15 cm and unusually large adults may attain a length of over 20 cm. It is known in Thai as *pla mor* (doctor fish).

BAGRIDAE

Mystus sp.
There are many species of this widely-consumed catfish in Thailand.

Mystus nemurus
The fish is widespread in Thailand, including the tributaries of the Mun River. It grows to a length in excess of 35 cm. The Thai name is *pla kot*.

CLARIIDAE

Clarias sp.
These catfish breathe air and without access to it they perish. Members of this family are widespread and important in Thailand for food. It is known as *pla duk* (wriggling fish).

SYMBRANCHIDAE

Monopterus albus
The swamp eel is prolific and widely consumed. It lives in a wide range of fresh water habitats, and is commonly found in wet rice fields during the rainy season. During the dry season, the eels survive in damp hollows with no surface water. They can be caught by hook in the wet season and by digging during the dry, and can survive for a long period out of water if kept moist. Large specimens can attain a length of 70 cm. They are known as *pla lai.*

NOTOPTERIDAE

Notopterus notopterus
These widely consumed fish may reach a length of 35 cm. They enter swamps to spawn then return to rivers. Many are smoked and marketed. Despite their name *pla chalat*, or clever fish, they are taken in nets and traps in considerable numbers.

CHANNIDAE

Channa lucius
The blotched snake-headed fish or *pla kasong* is found in streams and lakes in Northeast Thailand. It reaches a length of 35-40 cm but is normally half that size.

Channa micropeltes
The giant snake-headed fish or *pla chado*, is the largest species of *Channa*, reaching a maximum weight of 20 kg and a length of nearly a metre. It is a voracious feeder, and is widely consumed. In Surin Province, Khmer speaking villagers regard this fish with reverence. It is commonly to be seen in Cambodian fish markets, and many are taken in the Tonle Sap.

Channa striatus
Known as *pla chon*, this fish is probably the most popular and widely consumed in Thailand. It has been known to reach a length in the vicinity of a metre. It can be secured by trap or line, and can survive for long periods without access to water. During the dry season it can be cut out

of the mud in which is takes refuge in dry lake beds. It is often dried and marketed.

SILURIDAE

Wallago sp.
A voracious and determined feeder, this catfish, known as *pla khao* or the great white sheatfish, can reach nearly a metre in length. They live in larger streams or rivers.

Ompok bimaculatus
The sheatfish, or *pla nua on*, is widespread in Thailand, and reaches a maximum size of 40 cm but is usually much smaller. It is present in large numbers and often found in markets.

THE FISH BONES FROM BURIALS

The following fish bones were found in association with burials:

Burial 26
Four complete skeletons of *Channa striatus* (cat. 538) were found in pottery vessel cat. 512. Three small specimens and one large were identified.

Burial 27
Eleven fish were found within the pottery vessel cat. 476, which was found with this burial of an adult male. There were eight individual *Channa striatus*, one *Anabas testudineus*, one *Mystus* sp. and one *Notopterus notopterus*.

The number of anatomical bones are as follows:
Channa striatus. Articular, 7L, 8R; basioccipital, 7; ceratohyal, 5L, 7R; cleithrum, 3L, 5R; dentary, 5L, 2R; epihyal, 5L, 4R; hyomandibular, 2L, 3R; lacrymal, 1L, 2R; lower pharyngeal, 5L, 7R; nasal, 2R; opercular, 5L, 4R; palatine, 6L, 6R; parasphenoid, 7; post-temporal, 3L, 4R; premaxilla, 5L, 3R; preopercular, 5L, 3R; prevomer, 2; pterotic, 2R; quadrate, 5L, 2R; scale bone, 2L, 1R; subopercular, 2L, 1R; sphenotic, 2L, 5R; supracleithrum, 1L, 1R; supraoccipital, 5.
Anabas testudineus. One individual, identified bones being 1 basioccipital, 1L dentary, 1L lacrymal, 1L and 1R lower pharyngeal and 1 parasphenoid.
Mystus sp. One individual, represented by 1R cleithrum and 1R pectoral spine.
Notopterus notopterus. One individual, represented by 1L and 1R cleithrum and 1L preopercular.

Fifteen individual fish (cat. 569) were found in a second pottery vessel: ten individual *Channa striatus*, two *Anabas testudineus*, two *Mystus* sp. and one *Notopterus notopterus*. The identified bones are as follows.

Articular, 8L, 5R; basioccipital, 8; ceratohyal, 9L, 9R; cleithrum, 1L, 6R; dentary, 8L, 9R; epihyal, 10L, 5R; frontal, 3L, 4R; interopercular, 1R; lacrymal, 1L, 1R; lower pharyngeal, 4L, 2R; maxilla, 2L, 5R; nasal, 2L, 1R; oper-

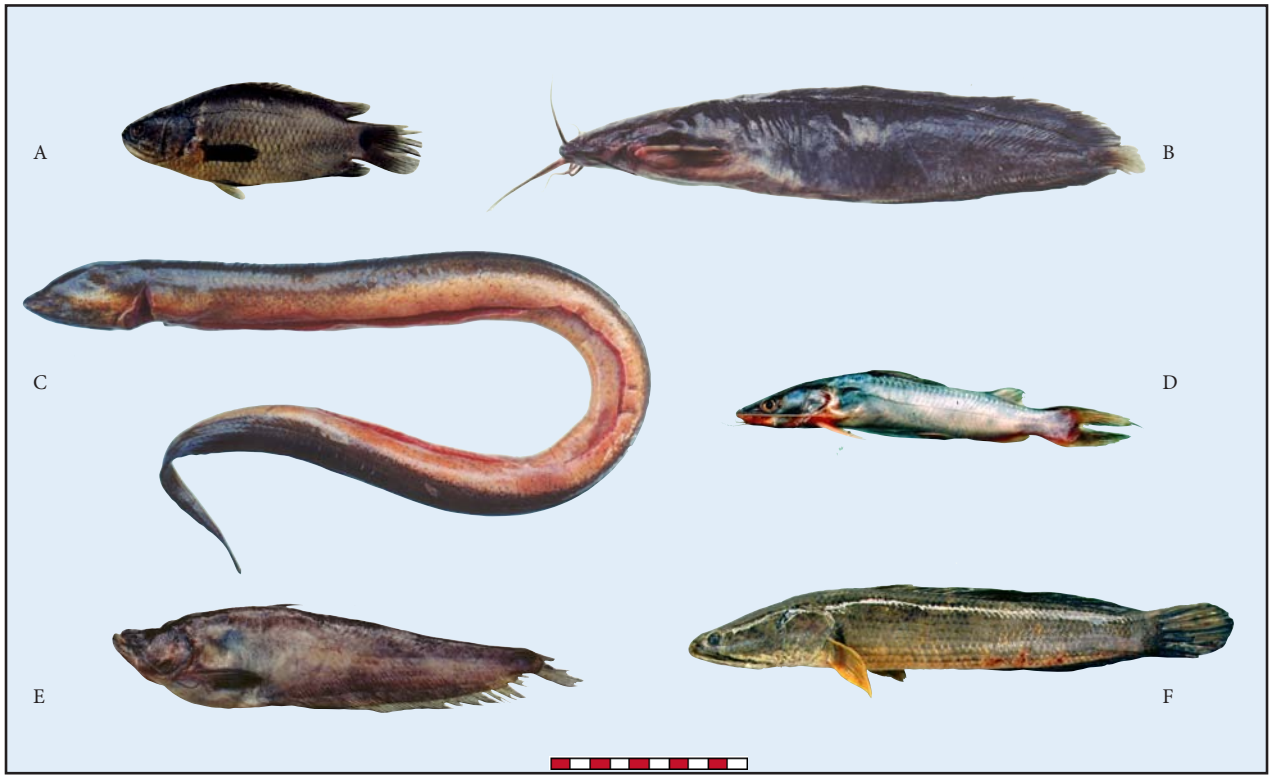


FIG. 30:1 Some of the fish represented at Noen U-Loke. A. *Pristolepis fasciatus*, B. *Clarias macrocephalus*, C. *Monopterus albus*, D. *Mystus nemurus*, E. *Ophicephalus striatus*, F. *Channa striatus*. Scale 10 cm

cular, 1L; palatine, 3L, 5R; parasphenoid, 3; post-temporal, 3L, 2R; premaxilla, 4L, 6R; preopercular, 2L, 3R; prevomer, 5; pterotic, 4L, 3R; quadrate, 4L, 2R; scale bone, 1L, 1R; subopercular, 1R; sphenotic, 3L, 4R; supracleithrum, 1L, 1R; supraoccipital, 4; upper pharyngeal, 4L, 4R.
Anabas testudineus. Two individuals are represented by 1L and 2R lower pharyngeal bones.
Mystus sp. Two individual fish are represented by 1L cleithrum, 2L and 1R pectoral fin spines and 1 supraoccipital.
Notopterus notopterus. One individual is represented by 1L and 1R dentary, 1 glossohyal, 1R maxilla, 1R premaxilla and 1R preopercular.

Burial 38 Cat. 774. One individual *Anabas testudineus* is represented by an articular, dentary, lower pharyngeal and several vertebrae.

Burial 100. The pottery vessel cat. 1452 contained the bones of two fish. One individual *Channa striatus* was represented by a ceratohyal and lower pharyngeal. A specimen of *Clarias* sp. was represented by a pectoral fin spine.
Burial 107 . Cat. 1557 is the entire skeleton of *Channa striatus*.
Cat. 752. This whole pot was found in B2, layer 6:2 feature 1. It almost certainly comprises a mortuary offering, although no human remains were found. The pot included the skeletons of three individual *Channa striatus*, one glossohyal of *Notopterus chitala* and a whole skeleton of *Notopterus notopterus*.

FISH REMAINS FROM GRAVE FILL

Burial 4. One left cleithrum of *Clarias* sp.
Burial 8. One fragment of the cranium of *Clarias* sp. and 1L ceratohyal and 1R dentary of *Channa striatus*.
Burial 19. A single R pectoral fin spine of *Clarias* sp.
Burial 36. 1R dentary and 1R ceratohyal of *Channa striatus*.
Burial 43. 1R pectoral spine of *Mystus* sp.; 1R pectoral fin spine of either *Ompok bimaculatus* or *Wallago* sp.; 1 basioccipital, 1R dentary, 1R frontal, 1R ceratohyal and 1R supraoccipital of *Channa striatus* representing one individual.
Burial 41 or 44. 2R supraoccipital bones of *Channa striatus*, two individuals.
Burial 50. 1R articular of *Channa striatus*, one individual.

FISH REMAINS FROM FEATURES

A1 6:2 feature 3. *Anabas testudineus*, 2R lacrymal bones, representing two individuals. *Channa striatus*, 1R frontal, 1R preopercular, one individual.
A1 5:1 feature 2. *Anabas testudineus*, 1L lower pharyngeal, 1R articular, one individual.
A1 5:1 feature 4. *Anabas testudineus*, 1L lacrimal, 1R pharyngeal, one individual. *Clarias* sp. 1 fragment of cranium. *Channa striatus*, 1L cleithrum, 1R dentary, one individual.
A1 4:14 feature 1. *Clarias* sp. 1L opercular. *Channa striatus*, 1R ceratohyal, 1L epihyal, 1L lower pharyngeal, 1L pterotic, two individuals.
B1 4:14 feature 3. *Anabas testudineus*, 1L lacrymal, 1R lower pharyngeal, one individual. *Clarias* sp. 1L cleithrum, 2R pectoral spines, two individuals. *Monopterus albus*, 1L and 1R cleithrum, two individuals. *Mystus* sp. 1R pectoral spine. *Channa lucius*, 1R quadrate. *Channa striatus*, 1 basioccipital, 1L cleithrum, 1L post-temporal, 1R supracleithrum, two individuals.
B2 4:13 feature 1. *Channa striatus*, 1L cleithrum.
A1 4:5 feature 1. *Anabas testudineus*, 1R cleithrum, 2R lower pharyngeals, two individuals. *Clarias* sp., 1 fragment of cranium. *Channa striatus*, 1 cleithrum.
A1 4:6 feature 7. *Channa striatus*, 1 basioccipital, 1L ceratohyal, one individual.
B2 4:6 feature 10. *Clarias* sp. 1R pectoral fin spine.
B1 4:9 feature 2. *Anabas testudineus*, 1R cleithrum. *Monopterus albus*, 1L dentary. *Channa striatus*, 1R cera-

TABLE 30:1 *The distribution of fish bones by species from the occupation layers*

	4:15	4:14	4:13	4:12	4:11	4:10	4:9	4:8	4:7	4:6	4:1	3:7	3:1	2:6	N
Anabas testudineus	1	-	2	-	-	-	-	-	1	1	-	-	-	-	3
Clarias sp.	-	1	1	2	1	-	1	-	-	-	-	1	-	-	7
Monopterus albus	-	1	-	-	-	-	-	-	-	1	1	-	-	-	3
Mystus nemurus	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Mystus sp.	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-
Ompok bimaculatus	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Channa micropeltes	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Channa striatus	2	-	1	2	1	-	2	-	1	1	-	1	-	-	11
Pangasius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Total	3	2	6	4	2	1	4	-	3	3	1	2	1	1	33

tohyal.
B1 4:6 feature 5. *Mystus* sp. 1R pectoral fin spine. *Channa striatus*, 1L premaxilla.
B2 3:5 feature 1. *Anabas testudineus*. 1L and 1R lacrymal, 1R lower pharyngeal. One individual.
A1 3:5 lens 1. *Channa striatus*. 1L cleithrum, 1L dentary. One individual.

FISH REMAINS FROM OCCUPATION LAYERS

Anabas testudineus
Layer
- 4:15 1L lacrymal, 1R opercular, 1 individual
- 4:13 1L supracleithrum, 1r supracleithrum, 2 indi -viduals.
- 4:7 1R supracleithrum
- 4:6 1L lacrymal

Clarias sp.
- 4:14 1R pectoral fin spine
- 4:13 1L pectoral fin spine
- 4:12 2R pectoral fin spines, two individuals
- 4:11 1L pectoral fin spine
- 4:9 1R articular
- 3:7 1L pectoral fin spine

Monopterus albus
- 4:14 1L palatopterygoid
- 4:6 1L dentary, 1L articular
- 4:1 1 cranium

Mystus nemurus
- 4:10 1L pectoral fin spine

Mystus sp.
- 4:13 1L pectoral fin spine
- 4:9 1R pectoral fin spine
- 4:7 1R pectoral fin spine

Ompok bimaculatus
- 4:13 1 fragment of R articular

Channa micropeltes
- 3:1 1R post temporal

Channa striatus
- 4:15 1R ceratohyal, 1R maxilla
- 4:13 1L ceratohyal, 1L quadrate, 1R lower pharyn- geal
- 4:12 1L lower pharyngeal, 1 fragment of lower right pharyngeal, 1R cleithrum
- 4:11 1L preopercular
- 4:9 1R articular, 1R ceratohyal, 1L dentary, 1R dentary, 1R lower pharyngeal, 1R supracleithrum, representing two individuals.
- 4:7 1L ceratohyal
- 4:6 1R cleithrum, 1L dentary, 1 parasphenoid, 1R supracleithrum
- 3:7 1L maxilla

Pangasius sp.
- 2:6 1R pectoral fin spine

CONCLUSIONS

Fish played an important part in early mortuary rituals, with many being placed in pottery vessels as offerings to the dead. This follows the same practice in the Bronze Age burials at Ban Lum Khao. The range of fish, species, with the exception of *Pangasius* sp., is the same as at Ban Lum Khao, indicating an environment which included ponds and streams or rivers. To judge from the abundance of fresh water shellfish in all layers, fresh water habitats continued throughout the occupation, but the number of fish represented in the faunal assemblage is unexpectedly low. There is some evidence for intensified rice agriculture during the accumulation of layer 3, and this might have affected the number of fish available.

PART THREE. NON MUANG KAO
XXXI. NON MUANG KAO: RESEARCH PROBLEM AND OBJECTIVES

D. J.W. O'REILLY

Perceptions of Southeast Asian prehistory have changed radically since the inception of scientific investigation during the late 20th century. Once considered a cultural *tabula rasa*, our understanding of the region has grown substantially. Early scholarly research tended to focus on the influence of foreign cultures such as China and India on the development of complex society (Cœdès 1968). The influence of these external factors, although significant, is not sufficient to explain the development of the complex and powerful societies that dominated Southeast Asia from the early centuries of this era. The roots of these later polities must be sought in the role played by the indigenous inhabitants.

The excavation and analysis of material from Bronze and Iron Age sites in Southeast Asia will make possible an assessment of the social, technological and economic life of both an early and a late prehistoric community. The present research will test the hypothesis that the processes leading to social and political complexity were underway as early as the Bronze Age and were well developed by the Iron Age. It will also contribute an essential foundation to our understanding of regional development and cultural evolution in Northeast Thailand. The research will clarify the nature of the societies which were prepared to incorporate certain Indian traits into their own culture, while continuing such long-established practices as rice cultivation, exchange in exotic goods and the maintenance of ancestral cemeteries.

GEOGRAPHY

The Khorat Plateau of Northeastern Thailand is an uplifted basin, covering approximately 112,000 km^2, bounded by the Petchabun mountain range to the west, the Dangraek and San Kamphaeng ranges to the south and the Mekong River to the north and east. The majority of the plateau lies between 101 m AMSL and 200 m AMSL, while the remaining 28% lies between 201 m AMSL and 500 m AMSL (MacDonald 1980).

The Phu Phan hills divide the plateau into two drainage basins, the Songkhram and Khorat. The former is drained by the Songkhram River, the latter by the Mun and Chi rivers, all of which flow from west to east to join the Mekong River. The flood plains of the Mun and Chi rivers are generally narrow, a trait accentuated near the confluence with the Mekong.

There are two geomorphological models for the region, the first explains the geomorphology in terms of river ter-



FIG. 31:1 The site of Non Muang Kao comprises twin mounds ringed by banks and moats. The roof of the excavation can be seen on the horizon



FIG. 31:2 Laying out the excavation square at Non Muang Kao. The site chosen was the highest point of the larger of the two mounds

races, of which there are believed to be three; lower, middle and upper (Moormann, *et al.* 1964; Arbhabhirama, *et al.* 1988). According to this model, the landscape was, to a large extent, formed as a result of river action with episodes of deposition and erosion during the Quaternary leading to the formation of terraces. Lower river terraces dominate in the Mun basin while the northern part of the plateau is mainly middle terrace. Remnants of the high terrace are found in many areas of the Khorat plateau. This model has been employed extensively in attempts to understand prehistoric settlement patterns (MacDonald 1980, Welch 1985, Moore 1988, Higham 1989, Bayard 1992). It has been noted in many of these studies that the lower terraces were favoured for early habitation, presumably for their superior agricultural properties, while the more marginal middle and upper terraces were settled later (Moore 1988). This trend is particularly apparent in the southwestern portion of the Plateau where the poor water retention of the middle and upper terraces is exacerbated by decreasing annual rainfall.

More recently an alternative model has been advanced which views the geography of the region as resulting not solely from fluvial action but also tectonic events. Michael (1982) presents a model which views the formation of the landscape as resulting from "mass movement, surface wash and small stream activity" (Boyd 1998:32). McGowan International (1983) also question the terrace model, claiming that the landscape is best explained as an erosional one that developed over the horizontal and gently warped bedrock (Nutalaya and Sophonsakularat 1988). As this new model gains favour, explanations of settlement patterns based upon the terrace model may have to be reassessed.

Pedology

The Khorat Plateau has been divided into four sub-regions, Sakhon Nakhon, Roi Et, Khon Kaen and Phimai, based on pedological factors. The Phimai region, where the current research was undertaken, is located in the Mun River valley above the confluence of the Plai Mat and Mun rivers. The predominant crop in Northeast Thailand is transplanted rice which is grown on the flood plains and low terraces (Arbhabhirama *et al.* 1988). The soils in each subregion, combined with the local climate, are believed to be the major determinant of rice yields (MacDonald 1980). Fertility is moderate to low, as are the moisture holding capabilities of the soil.

In the Phimai region, 33 different soil series have been recorded (Welch 1985). Most are Khorat and Roi Et series soils which are viewed as unsuitable for rice cultivation or marginal at best (MacDonald 1980). The most common soil types are entisols, inceptisols, altisols and ultisols (Arbhabhirama, *et al.* 1988). The Phimai region is noted, however, for higher agricultural productivity than the rest of the plateau, due perhaps to the presence of Bangkok clays, which are well suited to rice agriculture (MacDonald 1980).

Environment

The Phimai region incorporates a number of useful resources. Salt is one of the most abundant and has been exploited since prehistoric times (Higham 1989). Salt

deposits, known as the Mahasarakham formation, exist between the Boribun and Chiang Krai rivers and north of the Lam Sa Thaet River. The large Talat Kae salt deposit also lies close to Phimai and is commercially exploited to this day.

Although ore deposits are not plentiful on the Khorat Plateau, copper deposits exist in the Petchabun Mountain range and laterite iron ore is abundant.

Metamorphic rock, suitable for the production of stone tools, is available from the Daeng Raek mountains, and a once abundant supply of wood and associated forest products previously covered large areas of the Plateau.

Climate

The Phimai region is subject to the annual monsoon which brings alternate dry and wet seasons. The former lasts from November to April when northeasterly winds bring dry air across the country. From May to October the southwesterly winds predominate, bringing moisture-laden air from the Bay of Bengal. Locally the Phimai region receives between 1130 and 1180 mm of rain annually, sufficient for the harvesting of one crop of wet rice (Welch 1985). It is not likely that this could be exceeded as Phien and Sunchindah (1981 in Welch 1985) have shown that even if intensive irrigation were undertaken the result would be insufficient to meet the demand of a second rice crop. Rainfall, although relatively stable in the region, may be absent in the early and later months of the rainy season. Alternatively, there is a possibility of flooding during the late wet season which is equally detrimental to the cultivation of rice. Fortunately the area enjoys favourable temperatures which remain well above freezing.

The rainfall patterns of the area are of particular concern when considering human settlement. The long dry season presents problems regarding water supply for human and animal use. It is common practice in the region to store rain water for use during the dry season. Ground wells offer an alternative source of fresh water but the scarcity of this resource is still a major concern.

Objectives

The Origins of Angkor Archaeological Project has the clear objective of examining the development of social complexity in Northeast Thailand. To this end Non Muang Kao was excavated in conjunction with a number of other sites including Ban Lum Khao (Higham and Thosarat 2005), Noen U-Loke, Ban Non Wat (Higham and Thosarat 2006) and an area within the precinct of the Khmer temple at Phimai (Talbot and Janthed 2001). These sites were excavated in the hope that they would provide some insight into the hitherto uninvestigated area of prehistoric social development in the Mun River basin.

Ban Lum Khao and Noen U-Loke have provided a large number of human interments and other data which have proven extremely useful in the delineation of the social milieu. Non Muang Kao was not so generous. Difficult conditions at the site rendered a large exposure untenable and so the data recovered were regrettably small, in fact no complete burials were revealed. Nevertheless the site has proved to be of immense importance in our understanding of regional prehistory. It has been possible to draw inferences regarding the socio-political environment of the Iron Age based upon the evidence from Non Muang Kao as well as from the contemporaneous site of Noen U-Loke.

It has, therefore, been possible, using the evidence from these two sites, partially to reconstruct the social and political foundations on which later developments in Southeast Asia were based.

OUTLINE

This section of the monograph, devoted to the site of Non Muang Kao, is part of a series the purpose of which is to present the complete findings of the Origins of Angkor Archaeological Project. The present work begins with an overview of the methodology employed in the excavation and analyses of Non Muang Kao as well as a presentation of the results of the excavation.

Chapter 32 describes the excavation of this site. The material culture recovered and the results of the archaeological analysis are presented in Chapter 33. Chapter 34 describes the mortuary remains recovered at Non Muang Kao. The mortuary population from Non Muang Kao is too small for statistically viable inferences, but the data recovered are described.

In Chapter 35 the results of the analysis are presented followed by a discussion of their implications for an understanding of the regional prehistory.

XXXII. THE EXCAVATION OF NON MUANG KAO

D. J.W. O'REILLY

INTRODUCTION

Non Muang Kao (latitude: 102˚.17', longitude: 15˚.13'), 'Mound of the Ancient City', is a 50 ha prehistoric mound, ringed by several wide moats or channels (Fig. 32:1). These channels are up to 33 m in width and separated by banks up to 3 m high. The mound itself is approximately 700 m (E-W) by 300 m in plan and rises 7 m from the surrounding rice fields. The only evident disturbance of the site has been the construction of a railway and a road which destroyed the channels to the west and east. The site is bounded by a rectangular feature, the date of which is unknown. Non Muang Kao today is surrounded by extensive rice fields. Isolation has probably contributed to its preservation, clearly enhancing its archaeological value. Based on the recovered ceramics, Non Muang Kao appears to have been unoccupied since at least the Early Historic period, around 600 AD.

Non Muang Kao is situated in a former river channel complex (Fig. 32:2), which represents a major meander belt flowing in an easterly direction (Boyd, Chapter 2). Most of the moats around the site are irregular and there are several points where they appear to merge with the former meander belt. Examination of the sedimentation by Boyd (Chapter 2) indicates an inflow to the northwest of the site, with flow around the north and east, exiting on the south (Fig. 32:2). There are other sites located on the same meander in close proximity to Non Muang Kao, including Non Sung and an unnamed site 2 km further to the east.

Boyd has concluded that the moats which surround many of the Iron Age sites in the Mun River were created by the construction of banks that ringed the settlements and served to constrain and control the flow of water from the rivers which then flowed nearby, but which have, in many cases, now moved courses.

At Non Muang Kao, a section was excavated through two of the moats and an embankment separating them (Fig. 32:1). A layer of white clay, located *c.* 1 m below ground, was visible under the bank

I propose that the banks at Non Muang Kao were created during the Iron Age occupation of the site. There is evidence of this in the form of a 'Phimai black' pot which was found *in situ*, sealed by run-off from the embankment

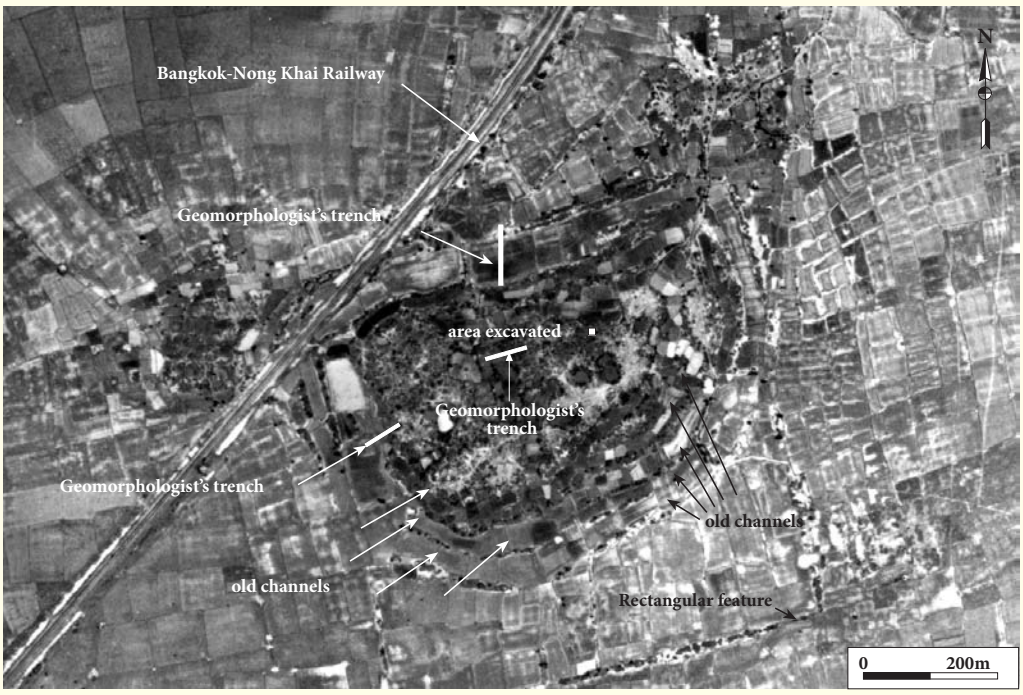


FIG. 32:1 Aerial photograph of Non Muang Kao showing the area excavated, geomorphologist's trenches and archaeological features

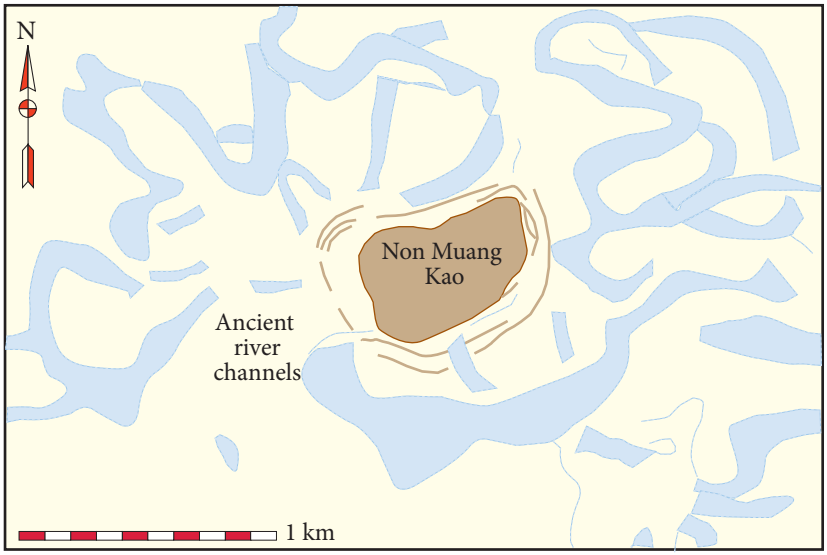


FIG. 32:2 Diagram of Non Muang Kao showing its location in a complex river channel.

(Fig. 32:5). It is possible that these earthworks represent attempts by the inhabitants of Non Muang Kao to off-set the effects of flooding by channelling the water which surrounded the site.



FIG. 32:3 The section cut through the northern moats. The excavation roof can be seen in the distance

THE EXCAVATION

Excavations at Non Muang Kao were undertaken by the author coincidental to those at Ban Lum Khao by Higham and Thosarat. A 5 x 5 m area was excavated on the top of the mound. The excavation procedure, as at Ban Lum Khao, involved the removal of cultural layers within 10 cm spits. The cultural sequence was divided into three broad periods based upon the nature of the matrix (Figs. 32:12-15). Layer 1 comprised the surface layer and was found to be a dark reddish brown to reddish brown colour (Munsell: 5 YR 3/3 to 2.5 YR 5/4). Layer 2 was a mottled reddish yellow to light brown colour (7.5 YR 7/6 to 7.5 YR 6/4). The third layer was pinkish grey (5 YR 6/2). The basal layer was light brown (7.5 YR 6/4). The datum was located 17 cm above the surface of the mound (Figs. 32:6-8, 10).

The colouring of the different strata at Non Muang Kao probably reflect the original sediment colours before their arrival at the site. Some weathering may have occurred on the mound in the form of oxidation (reddening) associated with exposure and drying or oxidation associated with localised burning (Boyd pers. comm.).

Initial impressions from the field suggest that the uppermost horizons at Non Muang Kao are rich in weathered bedrock, whereas the lower layers predominantly comprise weathered alluvium (both bedrock and alluvium were transported to the site naturally). This suggests that sources for the material changed at some point during the occupation (Boyd pers. comm.).

Based upon the ceramics recovered and the radiocarbon dates the entire sequence excavated at Non Muang Kao was found to date to the Iron Age (Table 32:1). The archaeological material rested upon a natural mound which, in antiquity, would have been situated beside a major river (Boyd pers. comm.). The top of this natural mound is 4

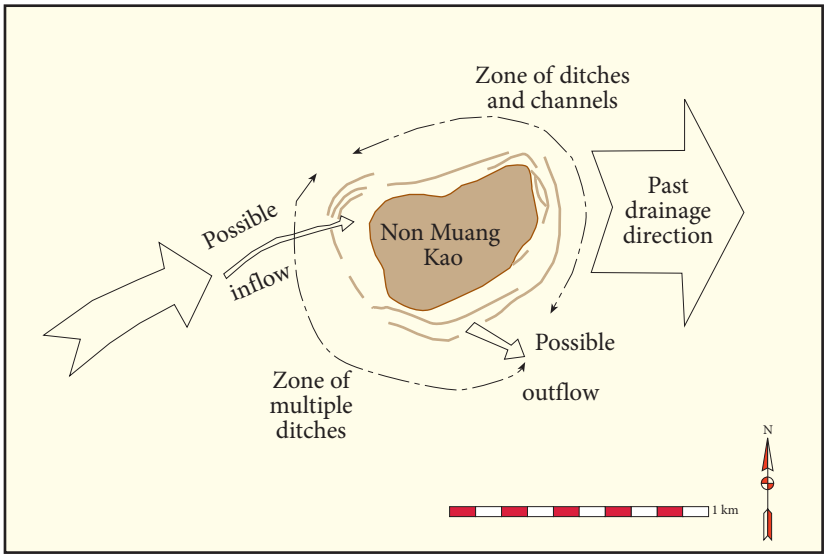


FIG. 32:4 Schematic diagram of Non Muang Kao showing probable direction of water flow. After Boyd (1997)

m above the present fields with just over 3 m of cultural material on top of it.

RADIOCARBON DETERMINATIONS

Several samples from the two field seasons at Non Muang Kao were submitted to the University of Waikato's radiocarbon laboratory. All were taken from secure contexts. The resulting dates are listed in table 32:1.

NMK 32 - (Wk 4512) - Charcoal sample from within a pot in Layer 2:1 Feature 1. This feature was sealed by a clay floor (Transition L1-2 Feature 4). This sample dates the use of the pot as a possible hearth base. 1.44 m bd.

NMK 81 - (Wk 4513) - Charcoal from the fill over a clay floor (Layer 2:5 Feature 15). The sample therefore postdates this floor and predates another clay floor (2:3 Feature 5). 1.54 m bd.

NMK 66 - (Wk 4514) - Charcoal from fill over a clay floor (Layer 2:5 Feature 15) therefore post-dating the floor and contemporary with pot scatters 2:3 Feature 7 and 2:3 Feature 8. 1.53 m bd.

NMK 32 - (Wk 4515) - Charcoal from Layer 2:1 Feature 1. The sample lay below a 'Phimai black' pot which contained sample Wk 4512. It should date the use of the hearth and predate the clay floor (Transition L1-2 Feature 4). 1.45 m bd.

NMK 10 - (Wk 5872) - Wood charcoal from a hearth (feature 1) located in Layer 3:11. This hearth was located 2.8 m bd.

NMK 15 - (Wk 5873) - Wood charcoal recovered from Layer 3:surface of spit 13 feature 1. This feature was a hearth found at a depth of 3.0 m bd.

NMK 16 - (Wk 5870) - Charcoal from feature 1 in Layer 4:surface of spit 3. This layer was the lowest and the sample dates the initial occupation of the site. The charcoal was located beside the remains of a ceramic vessel at a depth of 3.42 m bd.

A further set of AMS dates were obtained from samples

TABLE 32:1 *The radiocarbon dates from Non Muang Kao.*

Code	δC13	% modern	Result BP	2 σ calibration
NMK 32 WK-4512	-26.9 ± 0.2	80.4 ± 1.6	1750 ± 160	3 BC-AD 639
NMK 81 WK-4513	-24.0 ± 0.2	NA	1640 ± 70	AD 315-584
NMK 66 WK-4514	-25.3 ± 0.2	80.9 ± 0.9	1700 ± 90	AD 129-545
NMK 32 WK-4515	-26.2 ± 0.2	81.9 ± 0.6	1610 ± 60	AD 336-600
NMK 10 WK-5872	-27.1 ± 0.2	79.8 ± 0.5	1810 ± 60	AD 79-391
NMK 15 WK-5873	-27.3 ± 0.2	80.3 ± 0.7	1760 ± 70	AD 118-428
NMK 16 WK-5870	-24.2 ± 0.2	79.6 ± 1.0	1840 ± 110	45 BC-AD 428

taken from a large trench adjacent to the excavated area. This trench, which reached a depth of over 4 m, was excavated by Boyd, the project geomorphologist. Non Muang Kao is comprised of two discrete mounds with a 'valley' running between them. Boyd excavated a trench across this depression as well as two further trenches through the moats (Fig. 32:1). These large trenches were excavated in an attempt to assess the geomorphology of the site and investigate formation processes. The charcoal samples obtained were from the lowest cultural deposits in the trench and date the initial archaeological deposition. The samples rendered dates of (OZC 911) 2,120±210 BP and (OZC 912) 2,000±60 BP. At 2 σ OZC 911 calculates to BC 772 - AD 382 and at 1 σ, BC 393 - AD 88. Sample OZC 912 calculates to BC 158 - BC 134 at 2 σ and BC 127 - AD 130 at 1 σ (Stuiver and Reimer 1993).

STRATIGRAPHY

Layer 1

The surface and first 70 cm of the excavated area featured concentrations of pot sherds, antlers, animal bone and ash.

At this same level, the first of a series of unusual features was encountered. Two floors constructed of white (5Y 7/3 to 5Y 7/4) plaster or clay, one lying above the other, were uncovered (Fig. 32:12 A-B). At the same level, a circular feature, constructed of identical material to the floors was discovered. In section it was seen to be *c.* 50 cm across and 7-10 cm high. The top surface was dish shaped. At a slightly lower level there was a 2 m oblong extension of steel grey plaster from the circular feature. The function of the feature is unknown but may have served as a mortar in which rice was crushed.

The upper floor was rather degraded, the clay being thin and patchy, and covered an area of about 1 x 1.5 m. Below this lay another floor which covered a much larger area, nearly 3 x 2 m, before disappearing into the baulk. The lower floor was found to be only 3 mm thick in section. It is unlikely that these floors represent alluvial or other naturally deposited material. The presence of packed white clay around former posts, some of which still retained growth rings, negates this possibility.

The first burial was encountered at 1.26 m bd (Fig. 32:12 A). Burial 1 consisted of metatarsals and tibiae projecting out of the south baulk, with the head presumably orientated to the south. The burial appeared to rest on the lower of two clay floors. In section, however, it was apparent that the body had been encased in a clay-lined grave, structurally unrelated to the clay floors (Fig. 32:7). No grave goods were found in association with this interment.

Layer 2

Below the white clay floor described above, the remains of a large pot sitting on an area of burnt soil and ash were discovered (Fig. 32:12C). The feature clearly represents an *in situ* cooking hearth which was sealed by the construction of the clay floor. It was from this feature that the radiocarbon sample WK 4512 was taken.

A second burial was discovered *c.* 1.5 m bd (Fig. 32:12 E). It was partially within the excavated area, nearly everything except the skull remaining in the north baulk. Although it was difficult to ascertain, it appears that this burial was orientated with the head to the south.

Another burial was encountered along the middle of the west baulk and again it was only partially exposed (Fig. 32:12F). Although the bone was very poorly preserved, several infant teeth were recovered. The skeletal remains were surrounded by rice silica and rested on a white clay surface which was curved and bowl-like in section. The orientation of the burial was unclear, but probably ran east-west.

Burial 4 was discovered at a depth of 1.44 m bd along the south baulk (Fig. 32:12D). Only the cranium was protruding into the excavated area. The individual was interred with the head to the north, contrary to the orientation of the previous burials. Beneath the mandible, an area of green staining was noted and interpreted as the remnants of a rice bed. As the excavation progressed it became apparent that the prehistoric inhabitants of Non Muang Kao interred their dead with large quantities of rice, often in graves lined and sealed with white clay. A congruent burial practice was encountered during the 1997/98 excavation of Noen U-Loke, and again, some of the graves were clay lined.

At a depth of 1.45 m, another feature, which may be related to the lower of the two clay floors above, was discovered. It covered the same area as the lower clay platform

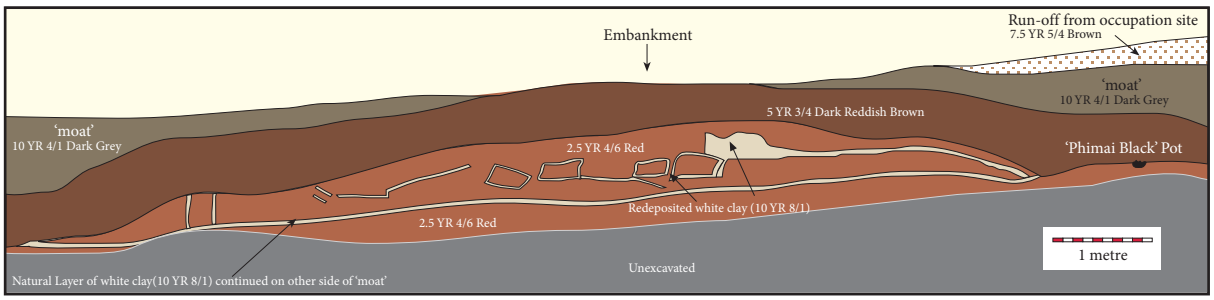
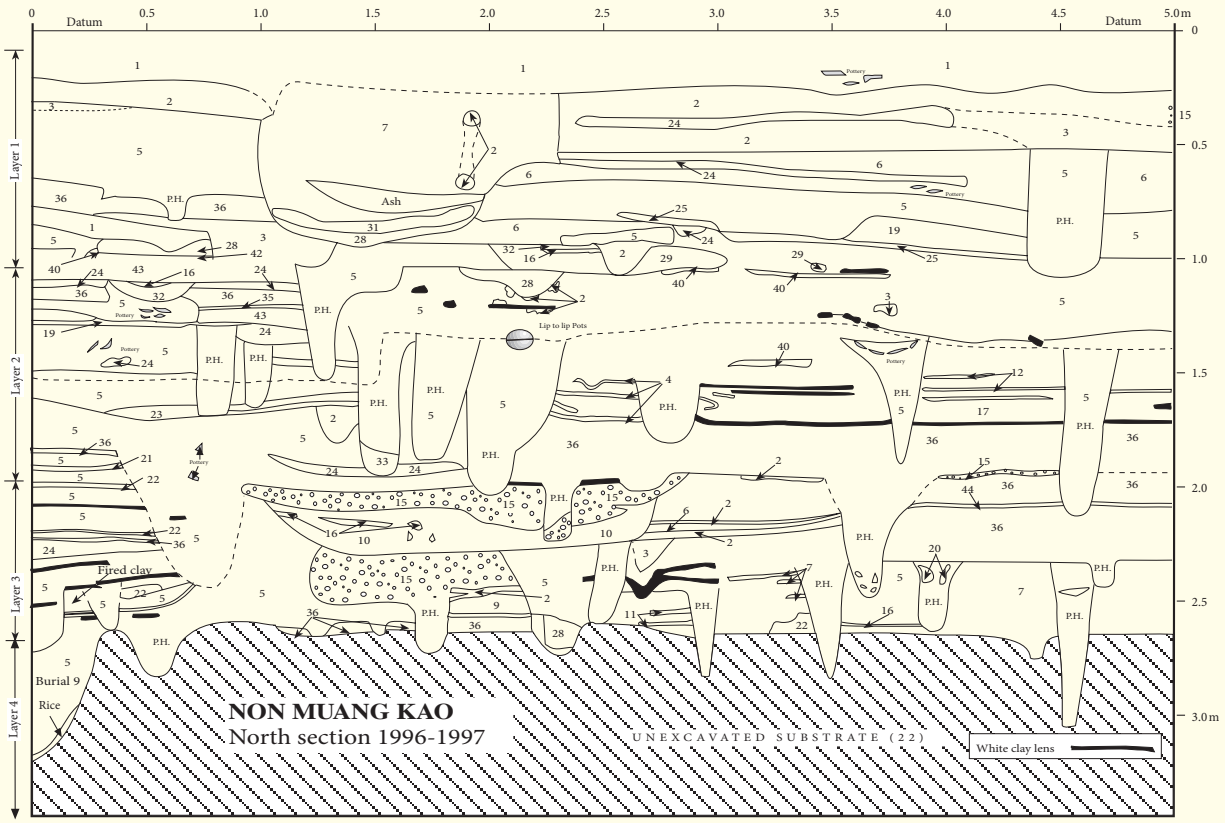


FIG. 32:5 North section of trench excavated by Boyd. Located to the west of the excavation near the railway tracks



1. 5YR 3/3 Dark Reddish Brown **2.** 10 R 4/6 Red **3**. 2.5 YR 5/8 Red **4.** 10 YR 8/6 Yellow **5.** Mottled **6.** 2.5 YR 4/6 Red **7.** 5 YR 5/4 Reddish Brown **8.** 2.5 YR 6/4 Light Yellowish Brown **9.** 2.5 YR 5/2 Weak Red **10.** 5 YR 6/3 Light Reddish Brown **11.** 7.5 YR 7/4 Pink **12.** 5 YR 7/3 Pink **13.** 10 R 6/3 Pale Red **14.** 10 R 6/8 Light Red **15.** Laterite **16.** 10 YR 8/1 White **17.** 10 YR 7/6 Yellow **18.** 2.5 YR 4/8 Red **19.** 10 YR 7/3 Very Pale Brown **20.** 10 R 4/6 Red **21.** 7.5 YR 7/6 Reddish Yellow **22.** 7.5 YR 5/6 Strong Brown **23.** 7.5 YR 6/4 Light Brown **24.** 5 YR 5/1 Grey **25.** 7 YR 3/6 Dark Red **26.** 5 Y 7/2 Light Grey **27.** 5 YR 6/2 Pinkish Grey **28.** 5 YR 6/4 Light Reddish Brown **29.** 10 YR 7/4 Very Pale Brown **30.** 5 YR 7/4 Pink **31.** 5 YR 5/2 Reddish Grey **32.** 10 YR 6/4 Light Yellowish Brown **33.** 2.5 YR 6/6 **34.** 2.5 YR 7/2 Light Grey **35.** 5 YR 6/8 Reddish Yellow **36.** 2.5 YR 5/6 Red **37.** 2.5 YR 3/4 **38.** 2.5 YR 3/2 **39.** 10 YR 5/8 Red **40.** 7.5 YR 2.5/1 Black **41.** 2.5 YR 3/6 Dark Red **42.** 2.5 YR 7/4 Pale Yellow **43.** 10 YR 6/3 Pale Brown **44.** 5 YR 4/2 Dark Reddish Grey **45.** 7.5 YR 5/4 Brown **46.** 10 YR 6/6 Brownish Yellow **47.** 7.5 YR 7/2 Pinkish Grey **48.** 7.5 YR 6/8 Reddish Yellow **49.** 10 YR 8/3 Very Pale Brown

FIG. 32:6 North section of Non Muang Kao

but consisted of reddish, burnt soil and charcoal which was *c.* 10 cm deep. There was a very clear edge running north-south from the south baulk, below which lay another clay floor. On the surface of this floor, a great deal of broken pottery and charcoal was found.

Ten cm below this clay floor, at *c.* 1.60 m bd in the southeast corner, lay the patchy remains of yet another floor which varied in thickness. Within this floor several linear features were found which may have been seatings for wooden wall structures, although this was not readily apparent in section. Post holes with clay packed around them were also noted. Two small pots were discovered, lip to lip, set into the clay floor in a precisely cut hole (Fig. 32:12F).

At 1.76 m bd a larger floor was revealed (Fig. 32:13A). It covered nearly the entire eastern half of the excavated unit. The morphology of this feature is identical to the others in that the floor is depressed *c.* 10 cm into the ground and plastered. The floor was covered with scatters of carbonised rice and bamboo.

Burial 5, located in the south-west corner of the unit, (Fig. 32:13B) was lined with a clay similar to that used to make the floors. The grave, which contained an infant mandible, was about 70 cm deep and was capped with a thin layer of white clay. The orientation was impossible to determine.

Another burial was encountered along the southern baulk and appeared to extend north-south (Fig. 32:13B-D). Burial 6 contained substantial quantities of rice silica and pieces of the clay floor, through which it was dug. The

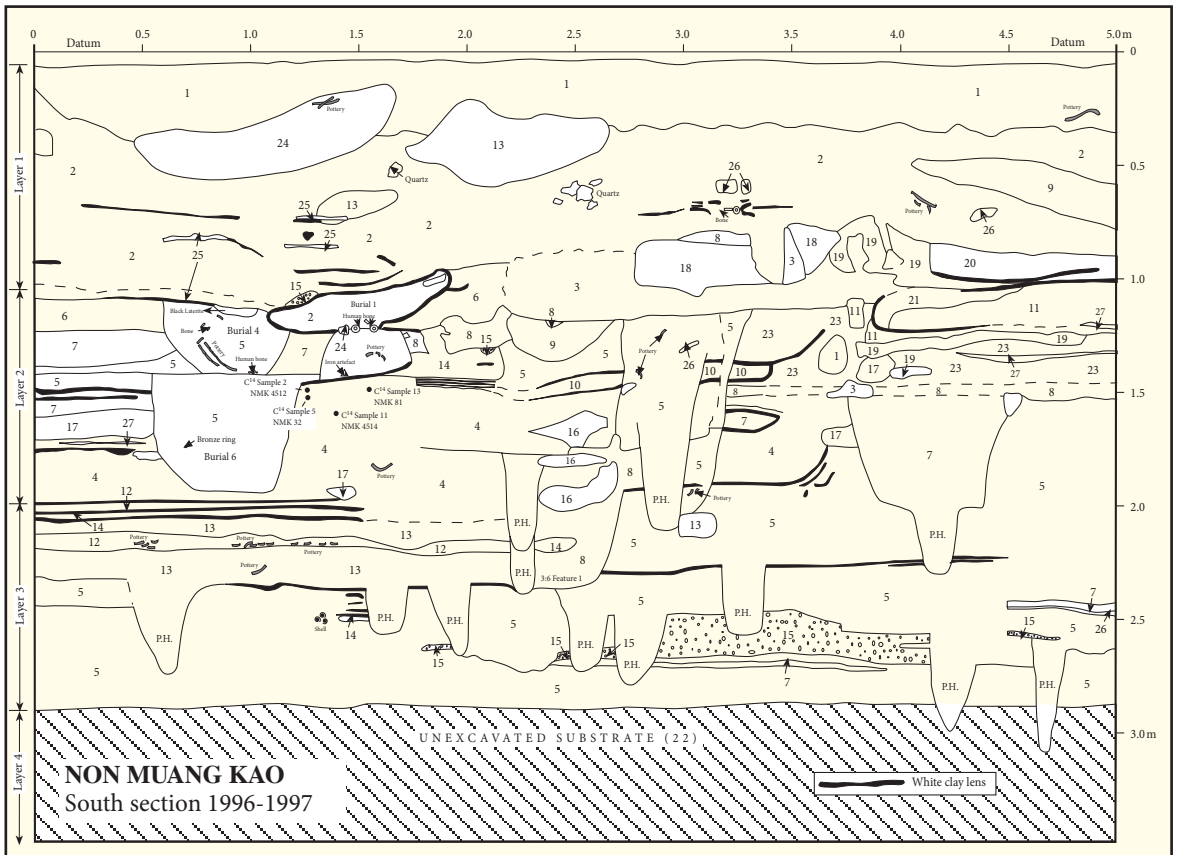


FIG. 32:7 South section of Non Muang Kao. For key, see Fig. 32:6

bone was very poorly preserved, only fragments of the skull, pelvis and parts of the tibiae were recovered. This was the richest of the burials encountered, containing 25 artefacts.

Along the south baulk, *c.* 1.80 m bd, a concentration of pottery was discovered which was associated with bronze ear rings, one bimetallic bangle and two concentrations of drawn Indo-Pacific glass beads. One group of beads was yellow and the other was of mixed colours which were found in the fill. Other artefacts included several broken pots and more beads all encased in a clay envelope. There was a notable amount of burnt bamboo and rice remains associated with the feature (Fig. 32:13D). Although no bone was recovered near the concentration of artefacts it is likely that this represents a burial which, based upon the cross section of the clay envelope, ran north-south. It was lined with the same white clay as the others. This burial was in very close proximity to one of the clay floors and it was difficult to distinguish where one began and the other ended. The burial had disturbed the white clay floor when it was dug. The clay bottom of the burial was thick and of a slightly different colour than the floor.

The remains of another white clay floor were found at a depth of 1.93 m bd on the east side of the unit. This surface was found to be patchy and discontinuous, the largest area covering 1 x 0.6 m . Below this lay another white clay floor (Fig. 32:13E) which covered approximately two thirds of the excavation unit. There were some fire-blackened areas (*c.* 40 cm in diameter) along the east baulk and the remains of an interior wall, which ran from east to west, was identified.

This floor, cut through by burial 6, lay atop yet another clay surface which had not been disturbed by the burial. It was difficult to determine the relationship between the clay floor and the bottom of the interment. The lower floor may represent a replastering of a third floor which is 2 cm below it. This appears in section as three separate episodes in the same location.

Layer 3

A distinct change in the matrix was noted at a depth of 2.16 m bd becoming varied from a mottled reddish brown (5 YR 5/3) to a very pale brown (10 YR 7/4).

The clay floor which sat atop this matrix, although not as well preserved as those above, was extensive. It covered the entire unit from north to south and nearly two thirds of the unit, east to west (Fig. 32:14A). The floor was lipped along its western edge and the remains of two more lipped edges could be discerned below it. Excavation demonstrated that these lips were the only remains of previous floors.

Several large areas of burning were identified below the intact white clay floor. Although there was extensive blackening of the soil, no charcoal was encountered. This

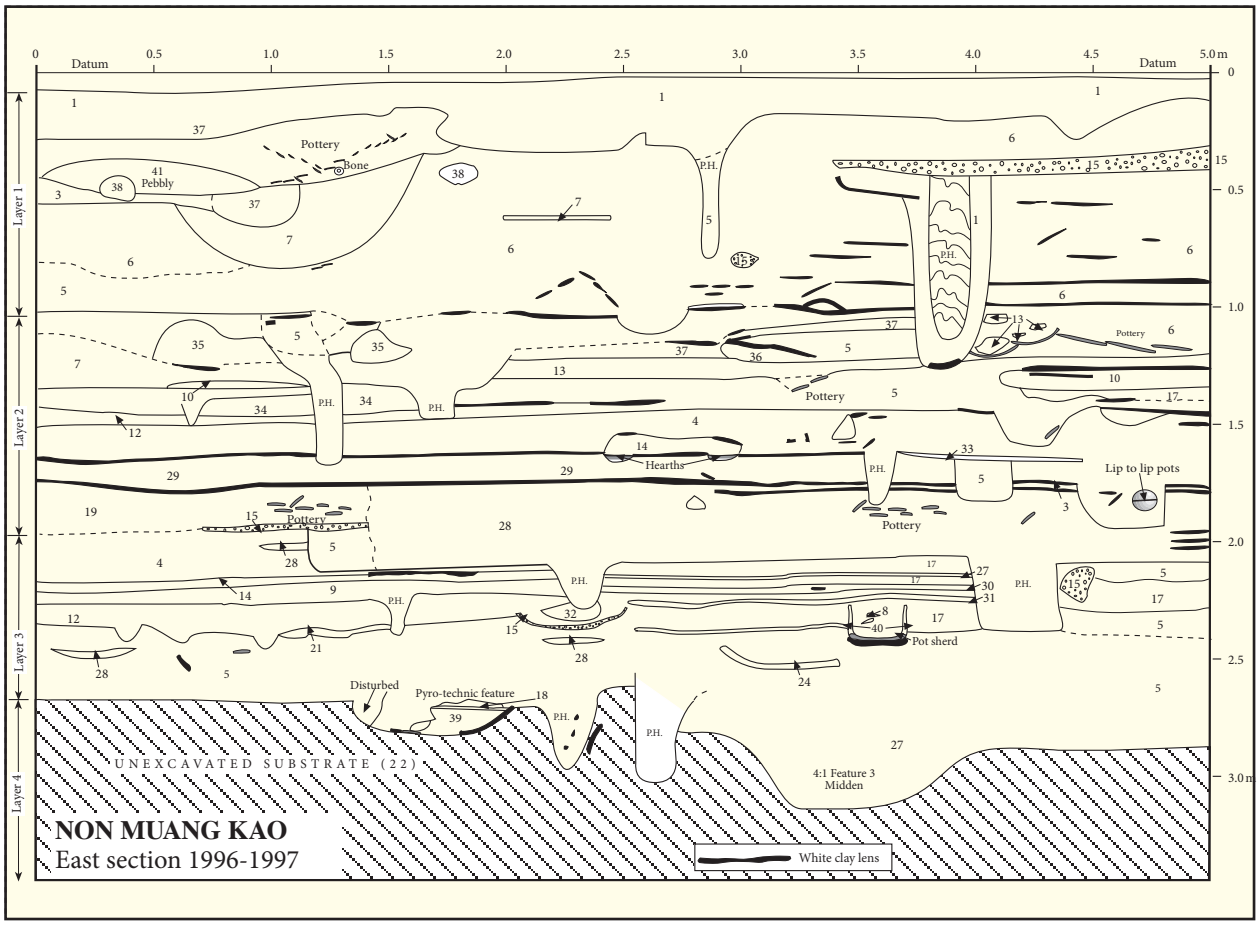


FIG. 32:8 East section of Non Muang Kao. For key, see Fig. 32:6

may represent the removal of debris after the destruction of the structure and subsequent reconstruction in the same location.

At 2.20 m bd, the edge of a new clay floor was uncovered (Fig. 32:14A). It was located in a different position than those above it, and had been disturbed by many posts and a grave cut (Fig. 32:14B). It contained carbonised rice, yellow glass beads and sherds of 'Phimai black' pottery. No bone remained, but the grave was orientated north-south. The clay floor measured 3.90 x 3.60 m (Fig. 32:14B). Its construction was the same as the others although it lacked evidence of interior walls. This floor was the best example encountered and was relatively undisturbed by later activity. There was some evidence of burning on the floor in the southwest corner. Near the southeast corner an iron artefact, which although corroded, resembles a chisel, was discovered encased in the lip of the clay floor.

A very large spread of ash and charcoal was found further to the east of this area, as well as what appeared to be the burnt remains of a white clay floor. This surface had a very fine powdery texture and was light brownish grey (10 YR 6/2) in colour with some areas burnt orange. There were many tiny fragments of pottery and it was apparent that the area had been subjected to considerable heat. In some areas, the clay floor had been left unaffected by the

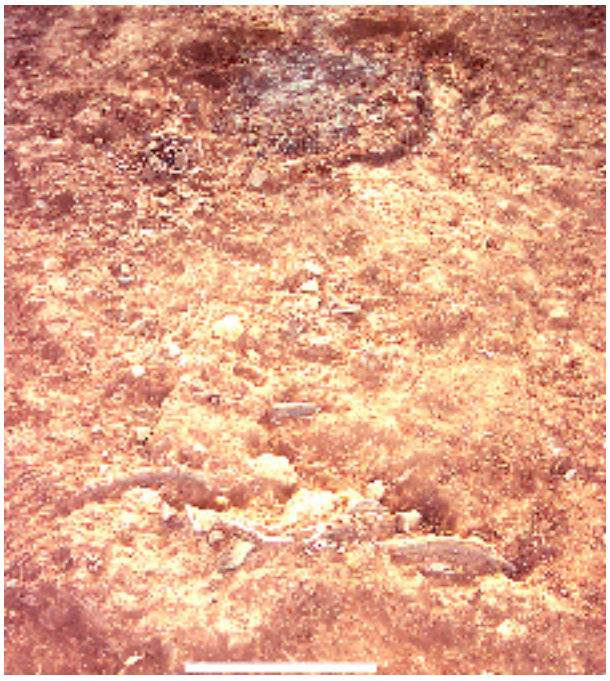


FIG. 32:9 Layer 1 included concentrations of animal bone and ash-filled hearths. Scale 20 cm

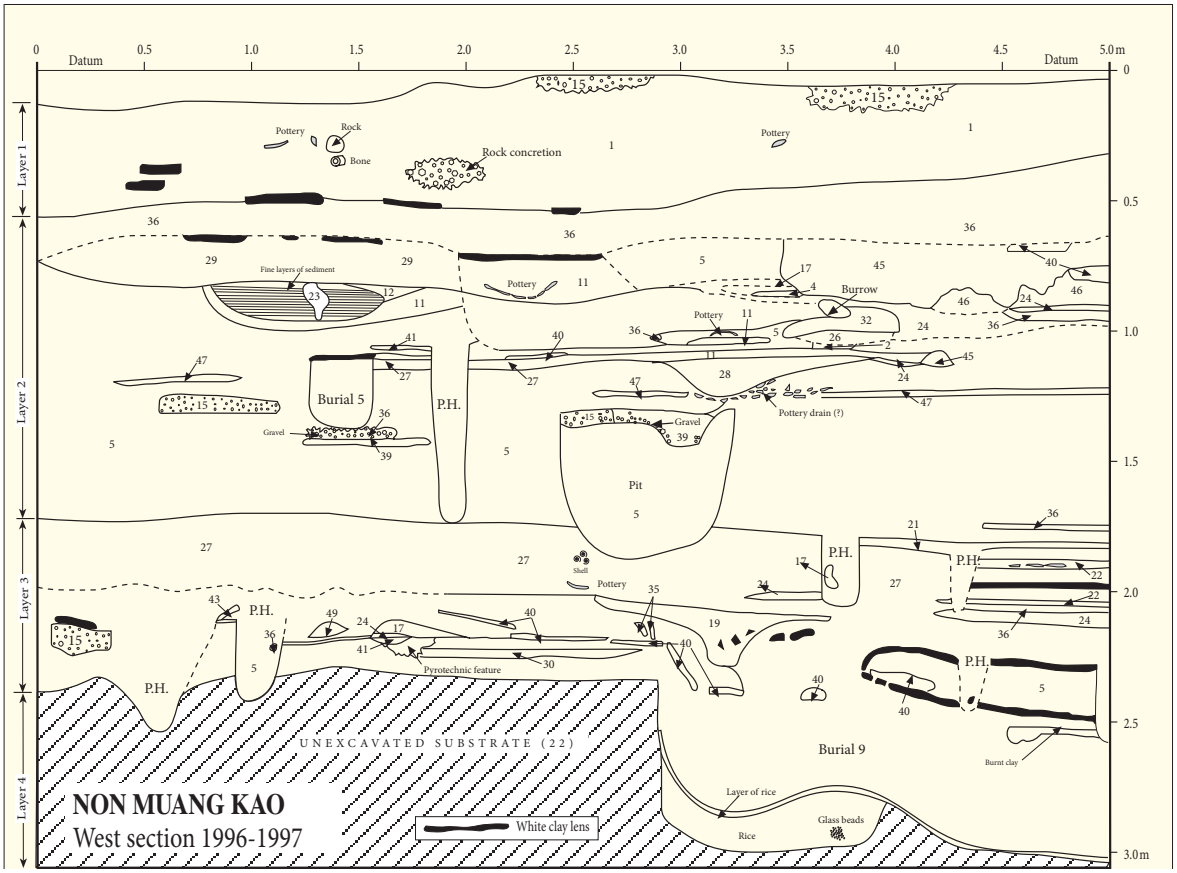


FIG. 32:10 West section of Non Muang Kao. For key, see Fig. 32:6



FIG. 32:11 Layer 1:6 feature 7 comprised a set of antlers and large cervid and bovid limb bones

burning. There were the partial remains of a lipped edge parallel with the east baulk. Ten cm deeper, to the west, a similar parallel line was discerned. The distance between these two 'walls' is exactly the same as the edges of the floor above. In the same spit, a line of posts were found along the edge of the clay floor, which may have been wall supports. Although there was very little charcoal, this feature has been interpreted as evidence of a conflagration which destroyed the original structure.

After removing the burnt floor and the spit below it, a concentration of rice remains was encountered at a depth of 2.50 m bd. The feature measured *c.* 50 cm long and 20 cm wide. Investigation revealed a grave cut, burial 7, which was full of rice silica to a depth of 2.88 m bd (37 cm deep). The grave contained two sets of copper alloy wires twisted into tiny spirals, similar to those excavated at Ban Prasat (Fine Arts Department Thailand 1992) and a complete 'Phimai black' bowl and pot sherds (Fig. 32:14E).

There was disturbed white clay all round the area of burial 7 and a white feature lay to the northwest of the grave cut. In section, this feature had a white powdery layer, 2 cm thick, beneath which lay a layer of fine soft yellowish-brown, clay-like material about 4 cm thick. A sample of the white clay was removed, revealing a layer of red soil beneath. There was also a great deal of pottery embedded in the white material. The absence of skeletal remains renders a precise determination of body orientation impossible but the grave appeared to run north-south.

At 2.53 m bd another burial (burial 8) was discovered in the western portion of the unit (Fig. 32:14F). A grave cut was clearly seen, due to the rice silica outlining it. A curious linear band of lateritic deposits was found in close association and there was a sharp division of soil types across the square running from north to south. The grave was situated in a matrix of light brown soil/sand (7.5 YR

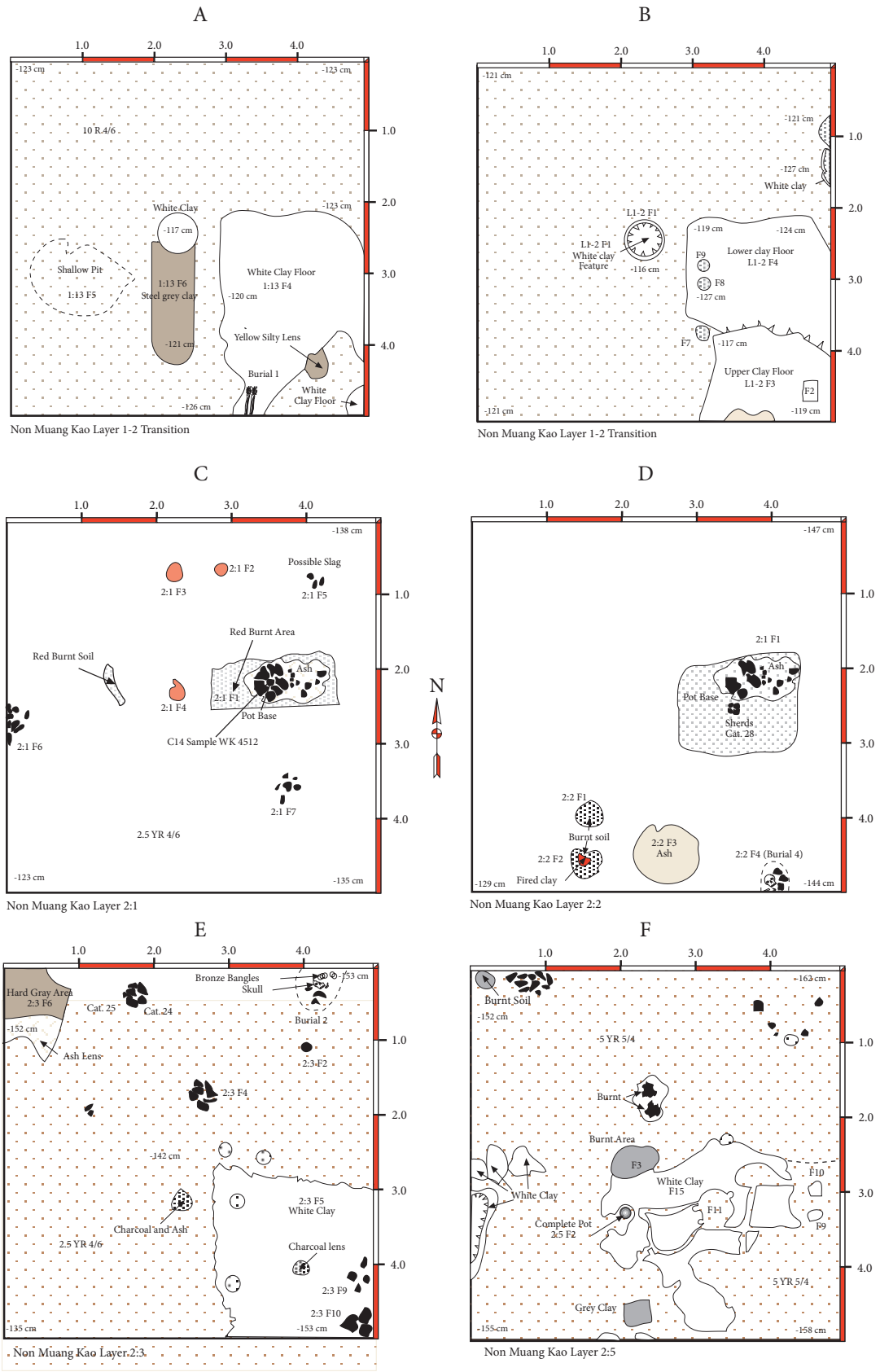


FIG. 32:12 Plan views of the excavation of Non Muang Kao

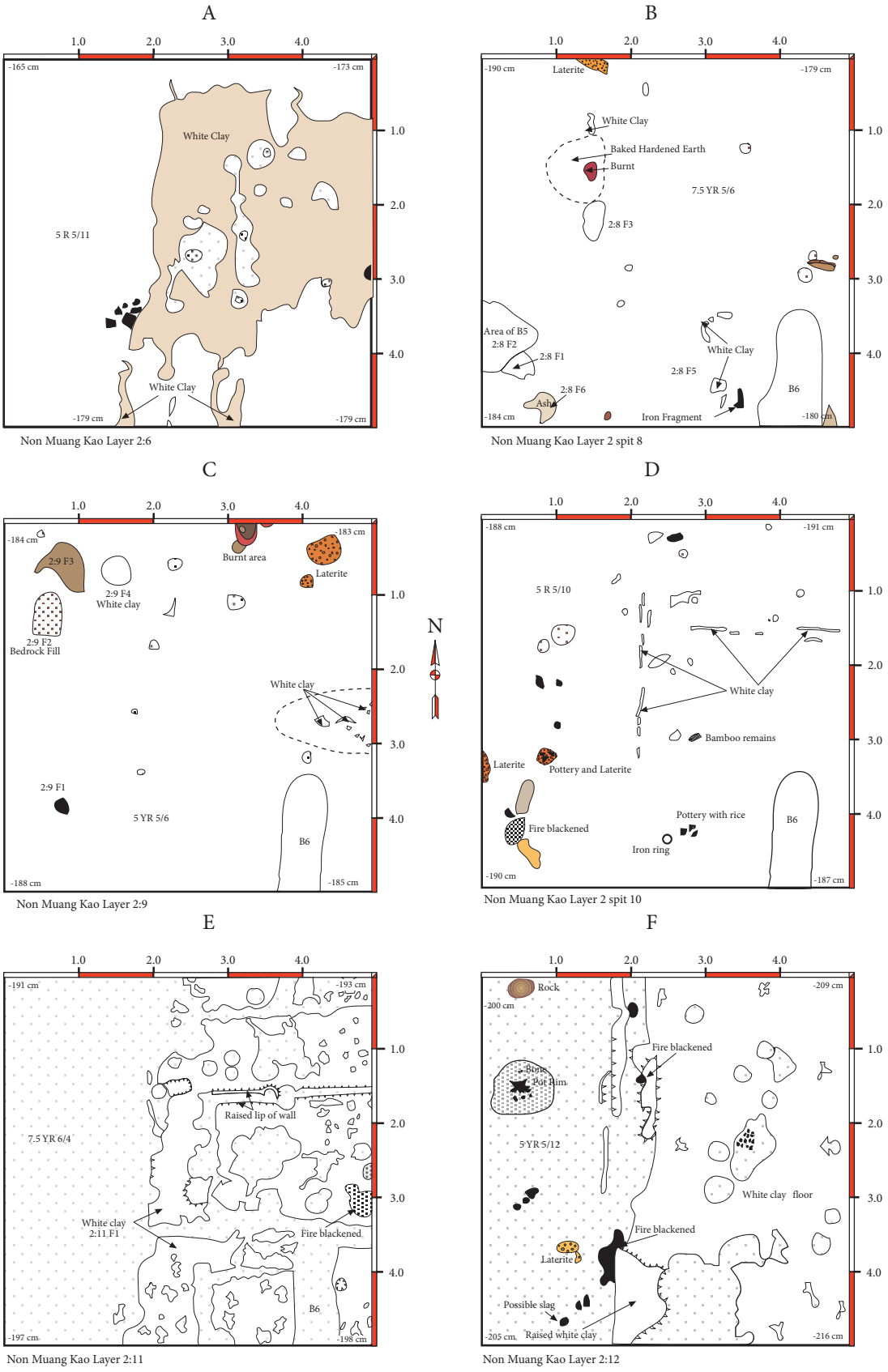


FIG. 32:13 Plan views of the excavation of Non Muang Kao

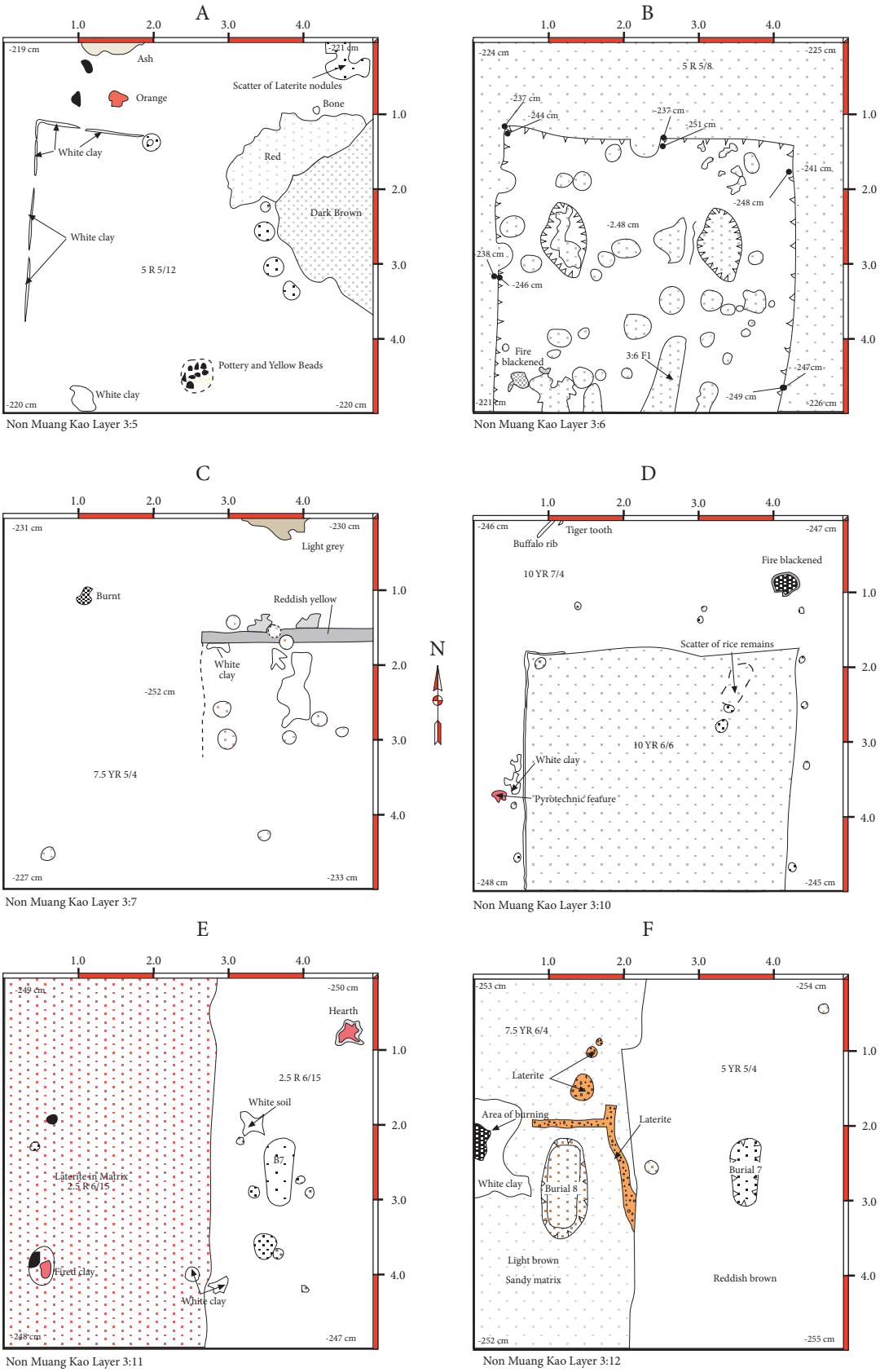


FIG. 32:14 Plan views of the excavation of Non Muang Kao



FIG. 32:15 Plan views of the excavation of Non Muang Kao

6/4), while the rest of the unit was of a reddish brown hue (5 YR 5/4) and much harder.

Burial 8 contained a 'Phimai black' bowl, some pot sherds and two small bangles. It would appear to be a child's burial, with a similar orientation to burial 7, although no bone was recovered. The interment was completely full of rice silica.

Layer 4

The nature of the matrix changed abruptly to a homogeneous brown (7.5 YR 6/4) at *c.* 2.60 m bd (Fig. 32:15B). Accordingly, the layer assignment was changed. There was a marked reduction in the amount of ceramic material recovered from this level, although a number of features were still apparent. The paucity of ceramic remains and the nature of the matrix suggested that the surface of the natural substrate had been reached. A test pit in the north east corner of the unit revealed no change in the homogeneity of the matrix down an additional 0.75 m. Layer 4 was naturally-deposited material with no evidence for cultural stratigraphy although it was apparent that the first inhabitants had excavated into the natural mound surface.

In Layer 4:1 several industrial features were encountered, interpreted as possible glass manufacturing hearths. Along the east baulk there was a large greyish brown area (10 YR 5/2), extending some 4 m, which was associated with what was thought to be another hearth associated with glass making to the north (Fig. 32:15B).

A dark stained area, similar to that along the east baulk, but much smaller, was also noted in Layer 4:1 in the north-west corner of the unit. As the area was excavated, a line of rice silica began to appear, identifying this as an interment (Fig. 32:15B-D). The grave cut of burial 9 was 2.10

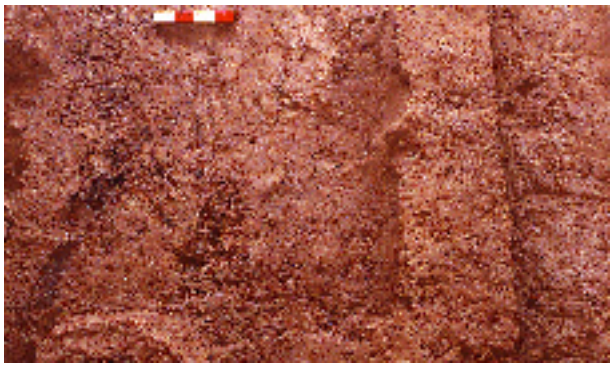


FIG. 32:16 Layer 2:3 feature 5. The surface of a clay floor can clearly be seen. Scale 20 cm

m long. As it was excavated, a significant amount of rice silica was revealed. The grave contained a 'Phimai black' shouldered pot, some pigs' teeth and several agate, drawn Indo-Pacific (Francis 1990) and brick-red glass beads, also referred to as *mutisalah* or "Indian reds" (Dubin 1987) as well as a carnelian bead. Human remains were observable in the section. Only 30 cm of the burial was exposed along the west baulk, although the orientation of the body could be determined, with the head to the south. The grave had been excavated into natural substrate to a depth of 1.40 m.

CONCLUSION

Based upon the available evidence, it appears that Non Muang Kao was continuously occupied for a period of 400-500 years. The site seems to have been abandoned sometime during the Early Historic period.

The initial occupation of the mound, at least in the area excavated, appears to have occurred during the Iron Age, based upon the ceramic styles found at the deepest levels, including 'Phimai black' wares in the earliest burials. It is, however, possible that other areas of Non Muang Kao contain evidence for Bronze Age occupation. A nearby site, Noen U-Loke contains Bronze Age burials.

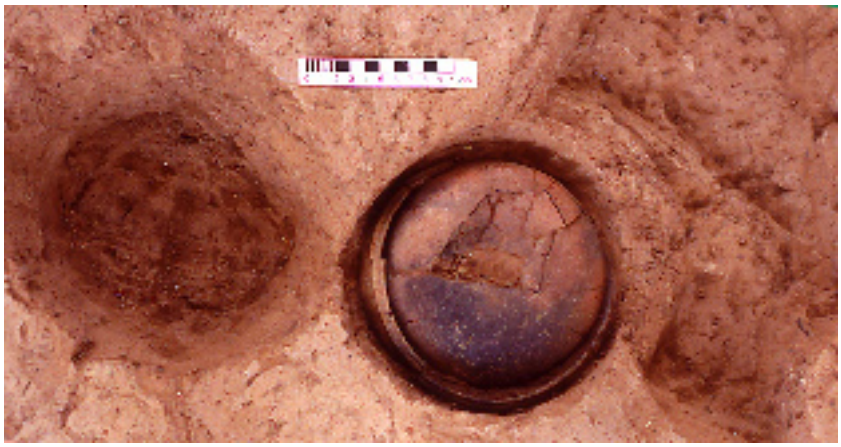


FIG. 32:17 Layer 2:5 feature 2. Lidded bowls, placed in the ground without reference to a burial, are commonly found in Iron Age sites in the upper Mun Valley

Non Muang Kao was probably selected for settlement based upon its strategic location next to a major waterway (Boyd pers. comm.), which partially surrounded it. The natural mound was an estimated 4 m higher than the surrounding flood plain which would have afforded the occupants some protection against flooding, as well as being an ideal defensive position.

The area excavated saw a variety of uses, including, habitation, industrial activity and disposal of the dead. Eleven burials and grave cuts were identified. The limited number of interments make it difficult to assess accurately the nature of the mortuary regime and the chronological sequence. The stratigraphic proximity is perhaps the best indicator of contemporanaeity, although the nature of the interment is also relevant. Five periods may be identified on the basis of stratigraphic location (Fig. 32:20) and interment type. Burials 1, 3-5, 6 and 2:6 Feature 20, were all lined and sealed with a layer of thin white clay, most containing evidence for rice. The burials found below 2.45 m bd were not clay lined, rather they were pits filled with rice. Rice is still used in mortuary ceremony in Southeast Asia where grains are thrown on funeral pyres. As Mabbett and Chandler (1995:119-20) note, "[d]eath is the birth of a new life for the transmigrating soul; rice grains, similarly, produce new plants, and the ritual action can be expected to hasten a good rebirth for the deceased." There is a recurring grave assemblage of whole pots, often shallow, streak burnished, 'Phimai black' bowls, pot sherds and copper alloy artefacts such as bangles. All but one of the burials and features interpreted as burials, were orientated in a north-south direction. This continuity would suggest a limited time span and is congruent with the mortuary behaviour at nearby Iron Age sites. Considering this, the variation in interment facility may indicate status differences within the mortuary population.

Perhaps the most interesting component of the site was the discovery of successive clay floors. The preservation of this type of feature in archaeological contexts is uncommon in Thailand and merits considerable attention.

Ten clay floors were uncovered. The first eight were constructed successively on top of one another while the earliest two floors were offset. The size of the structures is difficult to determine as they extended beyond the excavated area but the earlier floors (3:6 Feature 2 and 3:9 Feature 3) were approximately 3.80 x 3.70 m. Internal structural features were noted, including an interior wall running *c.* 2 m and several post holes with clay packed around them for support. The colour of the clay floors may be a result of weathering i.e. either they have undergone leaching and/or converted to a clay mineral, which is characteristi-



FIG. 32:18 The clay floor, layer 2:5 feature 15, is clearly visible

cally white in colour (Boyd pers. comm.). Alternatively, they may be made from the white clay found during the excavation of the moats.

The construction of these features varied little and involved the excavation of about 10 cm of earth to form a lipped edge. This was then plastered with a thin coating of white clay. The foundation trenches for the interior walls are substantial, over 0.5 m deep in one instance.

Comparable features were found at Non Yang, Amphoe Chumphonburi, Changwat Surin, Thailand (Nitta 1991). Nitta describes irregularly shaped clay floors, the north and south walls of which measure 2.3 m and 2.6 m respectively. At both Non Yang and Non Muang Kao, a shallow pit was excavated to facilitate construction of the floor. The walls in the structures at both sites are of a similar size in section, 12-16 cm across. Nitta found the remnants of half-split logs which he interpreted as a foundation for the structure, an aspect not encountered at Non Muang Kao. Other notable parallels between Non Yang and Non Muang Kao include the discovery of complete ceramic vessels, laid atop one another, lip to lip. This practice has been noted also at Noen U-Loke (Higham pers. comm.) and Ban Prasat (Fine Arts Department Thailand 1992). Three such features were encountered at Non Muang Kao, in which two 'Phimai black' bowls were placed in a close fitting hole. The purpose of these depositions remains enigmatic. It is possible they were ceremonial foundation offerings as suggested by Nitta (1991) or related to the mortuary ritual.

Ban Takhong had similar features to those described at Non Yang, including clay derived from walls or floor features (Higham 1996a). Although these features are similar, Ban Takhong contained a different artefact assemblage. No pattern burnished 'Phimai black' pottery was recovered from this site.

There are several possible explanations for the intriguing clay floors at Non Muang Kao. They may represent work areas, perhaps for rice threshing. In modern Thailand threshing floors are constructed by clearing a



FIG. 32:19 A plan view of the floor layer 2:5 feature 15, looking east

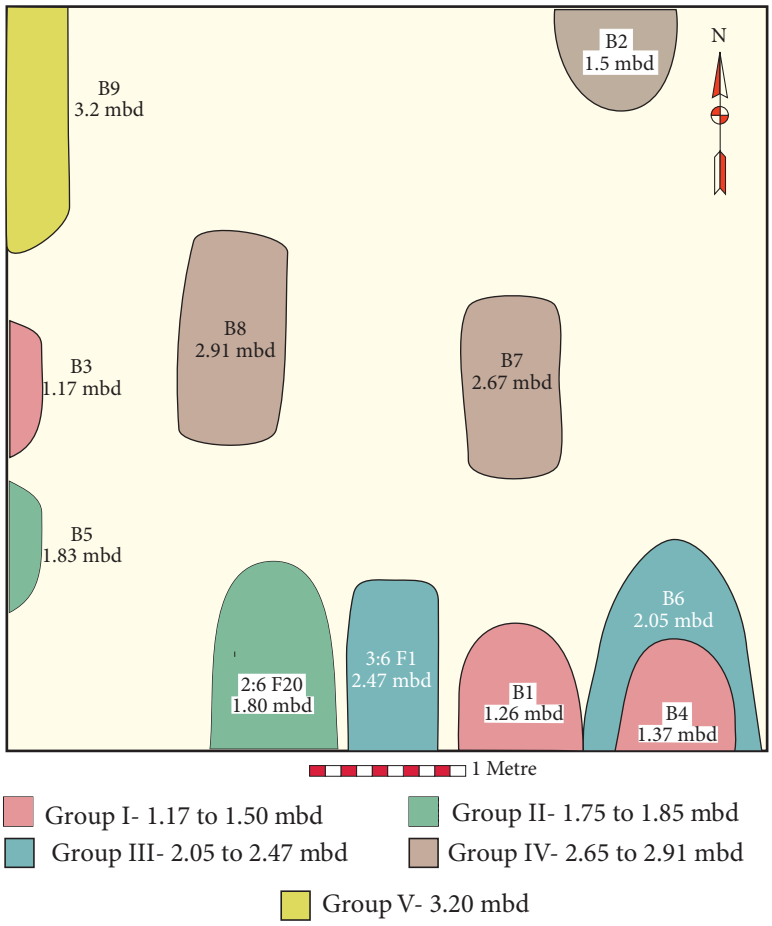


FIG. 32:20 Distribution of burials at Non Muang Kao

suitable area approximately 15 m in diameter, and coating it with a mixture of buffalo dung and water (Thompson 1996). In the past, threshing was conducted closer to the fields to minimise grain loss in transport and handling (Chung and Lee 1978, Kee n.d. in Thompson 1996). Grain loss may have been more apparent in antiquity because the rice was more prone to shatter (Thompson 1996). It seems unlikely that the prehistoric inhabitants would have brought the harvested rice to the top of the mound for threshing. There was also very little evidence of rice remains on the floors themselves although it was found in other contexts.

It is also possible that the clay floors represent domestic occupation. The presence of interior walls and repeated plastering of the floors in the same location could indicate that the floor was part of a successively occupied dwelling. A possible association with interments must be considered. Several of the graves were lined with white clay, similar to that of the floors. The clay floors were frequently found in close association with burials, a relationship being very difficult either to confirm or dismiss.

XXXIII. THE MATERIAL CULTURE

D.J.W. O'REILLY

INTRODUCTION

A wide range of grave goods was recovered at Non Muang Kao. These are categorised as ornaments, and utilitarian objects and possible symbolic items. It is acknowledged that there may be a degree of error in such a categorisation, some ornamental items may have held symbolic significance and vice versa. Rather than make spurious assumptions about the significance of artefacts, it is more prudent that the artefacts apparent function be used to categorise them.

ORNAMENTS

Ornamental items are those whose purpose is to adorn the body in a decorative manner. These include bangles, beads and rings, made from bone, bronze, shell, stone, glass, bronze and iron.

The variety of decorative jewellery found in the burials at Non Muang Kao was far greater than that found at Ban Lum Khao. The range of ornaments included glass and agate beads, copper alloy, iron and bimetallic jewellery, including finger, ear and toe rings as well as bangles and small bells.

Bangles

The bangles from Non Muang Kao differed from those of Ban Lum Khao in that they were made exclusively from a copper alloy which was not encountered at the latter site. The external diameter of these varied from 3.5 - 7.7 cm. Bangles were placed either over the arms or legs. Some individuals were interred with several bangles, the most being found in burial six, which contained 14 (Fig. 33:1).



Fig. 33:1 The bimetallic and copper-based rings from Non Muang Kao. A-D, cats. 106, 107, 108, 126, burial 6. E. cat. 129, burial 6. F. cat. 153, burial 4. G. cat 89, layer 2:6 feature 20. H. cat. 52, burial 4

Rings and Earrings

Rings were also made of bronze or iron, although some were bimetallic, having been fashioned from a combination of iron and copper alloy (MacDonnell pers. comm.). Such artefacts were often found in the vicinity of the cranium although many other similar but smaller rings were found on the fingers. The external diameter of rings varied from 1.9 - 2.3 cm. A number of iron rings were found in burial contexts which had an average diameter of 4.1 cm. In burial six these iron rings were found on either side of the torso and legs. The function is unknown, but they may have served a decorative purpose or may be related in some way to a shroud or container for the corpse.

Bronze coils were found in burial contexts (B7) which were very similar to those encountered during the excavation of Ban Prasat (Fine Arts Department Thailand 1992) and Noen U-Loke. These artefacts had an external diameter of 1.4 cm and comprised a single strand of copper alloy wound into a coil, resembling a spring.

Ornamental Bells and Balls

Two small artefacts which appear to have been ornamental bells were recovered. These are hollow spheres which at one time may have contained a ball. The spheres had a narrow slit through which the sound might escape. The bells were 2.4 cm and 2.9 cm in diameter. In burial six the bell was found near the right wrist.

An irregularly-shaped copper alloy ball was recovered from burial nine. This artefact was found in the vicinity of the cranium and may have been part of an earring. It measured 1.4 cm in width by 1.6 cm long.

Beads

A total of 1,356 beads were recovered during the excavation of Non Muang Kao. These were made from either glass or agate, and took a number of forms including barrel, seed, square and disc shapes. The square and barrel shaped beads were made of agate which was either a milky light brown and white colour or banded black, white and brown (Fig. 33:2). Average dimensions of barrel beads were 1.5 x 0.4 cm wide, while the square beads ranged from 1.5 to

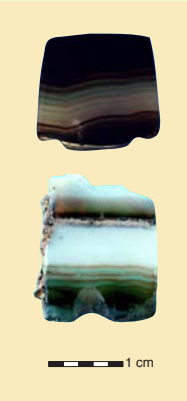


FIG. 33:2 Agate pendants from Non Muang Kao

2.1 cm long and 1.2 to 1.7 cm wide. The barrel and square beads had a hole drilled longitudinally through the centre.

The majority of glass beads were "monochrome drawn Indo-Pacific" beads, sometimes referred to as seed beads (Francis 1990). Colours included red, green, orange, light blue, and dark blue but the most common colour was yellow (Fig. 33:3). Each bead had a small hole through its centre and the average diameter of these beads was 0.5 cm. A distinct form of glass bead was discovered in the deepest burial at Non Muang Kao. These are similar in form to the shell disc beads found at Ban Lum Khao, being circular in shape with a hole in the middle. The beads are opaque, being orange in colour and resembling fired clay. Beads of this type ranged in diameter from 0.25 - 0.5 cm. It is believed that the technique of manufacture of the two types of glass bead is different. The Indo-Pacific seed beads appear to have been manufactured by stretching a rod of molten glass around an organic substance. The rod was then likely cut into beads when the glass was still plastic. The glass disc beads were probably created in a similar manner but it is probable that the beads were cut when the glass had cooled and hardened as evidence of cutting or sawing is often apparent.

CERAMICS

The entire ceramic assemblage from the OAAP will be analysed by the project ceramicist. In anticipation of this report some preliminary observations may be made regarding the ceramic assemblage from Non Muang Kao. A stratigraphic analysis of the assemblage reveals that the rim morphology and decorative styles were not static.

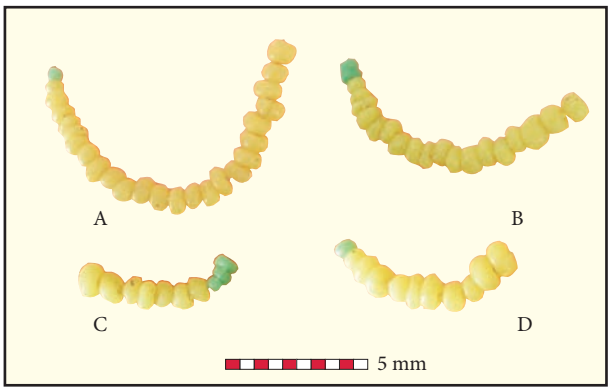


FIG. 33:3 The glass beads from Non Muang Kao
A. cat. 71A 2:6 feature 13, B. cat. 72 2:6 feature 8, C. cat. 77 2:6 feature 21, D. cat. 78 2:6 feature 20

The material was sorted by stratigraphic provenance and weighed. Rim and body sherds were separated. Each of these groups was then sorted based upon several morphological elements. The body sherds were divided based on the colour of the sherds, surface finish and decoration. The rim sherds were sorted using the same criteria as well as being sorted into varying forms using an attribute template.

A great deal of the ceramic material excavated at Non Muang Kao may be classified as 'Phimai black' ware. Wares of this type were first brought to light by Solheim in the 1960s (Solheim 1965, Solheim and Ayres 1979). Ceramics of the Phimai tradition were mainly tempered with rice chaff and sometimes, laterite nodules, grog or granule size rocks. They are often made of dark, highly organic clay (Welch 1985). Within the Phimai tradition exists 'Phimai black' ware. Vessels of this type are most readily identified by their distinctive colour denoted in the name. The surfaces of these pots were often burnished to a dull or bright lustre, often in geometric patterns. Other decorative elements include "the application of banded grooves and ridges, or impressing of small circles encircling the upper bodies of some jars" (Welch 1985). The Phimai black vessels were undoubtedly fired in a reducing atmosphere, which in conjunction with the type of clay employed contributed to the colour (Welch 1985).

In the interest of analytical continuity, Welch's (1985) attribute values were employed in the analysis of the body sherds. The surface finish of sherds may be defined as the method of smoothing or coating the surface of the ceramic vessel. The majority of the sherds from Non Muang Kao were found to be either, plain-unslipped-non-lustrous, cord-marked, burnished to a dull lustre, or burnished to a bright lustre. Very few were slipped or painted.

The rim sherds were sorted into various forms based upon a modified tripartite attribute system, originally developed by Irwin (1977). Rim direction, inverted, everted or direct, rim profile and the shape at the lip determine the form (Fig. 33:4, Table 33:1). There were 56 different rim forms represented at Non Muang Kao. Several of these forms were found to be of limited value in assessing diachronic variation. Rim forms which were represented by less than five different sherds were omitted in the stratigraphic analysis of distribution, leaving 30 different forms. Histograms were produced which display the proportion of various rim forms throughout the stratigraphy. It was hoped that variation in the material culture may shed light on the variation found in the archaeological features at Non Muang Kao.

Further analysis was undertaken based upon the colour and surface finish of the rim sherds. The colour of ceramic materials is often indicative of the manufacturing technique. Ceramics which are black may have been fired in a reducing atmosphere in which the supply of oxygen was limited (Orton *et al.* 1993), while sherds which are light coloured may have been fired in an oxygen rich at-

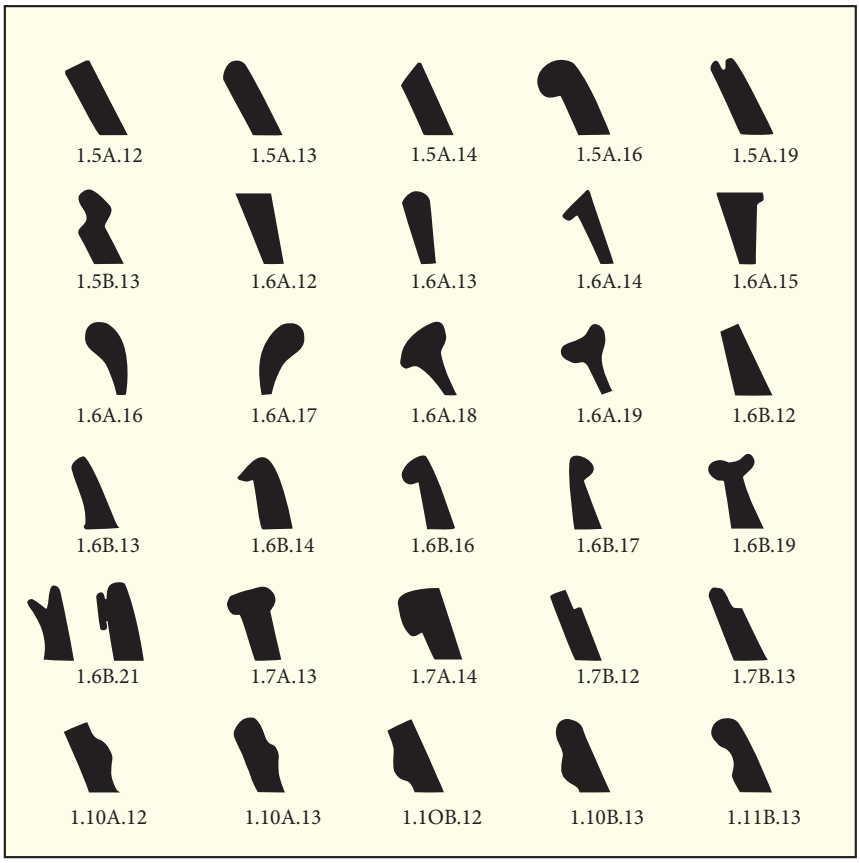


FIG. 33:4 Rim forms from Non Muang Kao

mosphere. There is a considerable difference in the two techniques, the production of black pottery requiring a carefully monitored hearth or kiln which will not allow the complete burning out of the carbon. The lighter coloured, mottled ceramics may be fired in an open hearth, and require slightly less care.

Body sherds were subjected to an analysis based upon the surface finish. Cord-marked sherds were those which demonstrated evidence of being produced using a cord-wrapped or carved paddle. Plain sherds were those which had either been produced with a cord wrapped paddle and later smoothed or simply made with a smooth paddle or made by hand. Polished body sherds are those which show evidence of having been polished, to such a degree that they reflected light. Vessels were usually polished using small quartz pebbles, which are often found in mortuary contexts associated with other ceramic production paraphernalia (Higham 1989). Decorated sherds are those which were found to have decorative patterns of applique, incision, impression as well as those which were burnished or painted. The number of decorated sherds in the sample from Non Muang Kao was limited. For this reason they were not categorised separately.

The distribution of rim sherds by weight (Fig. 33:5) suggests a change in the morphology of the ceramic vessels from Non Muang Kao. There is a notable increase in the weight of rims which indicates both an increase in the number of vessels and an increase in the robustity of the rims. This is evident in an examination of the various rim forms identified, based upon the measurement of the sherds at the lip and rim.

The distribution of sherds with other attributes through the stratigraphy is also notable. Plain sherds (Fig. 33:5) are especially prevalent in the upper layers of the stratigraphy. There is a correspondence between this increase and an increase in burnished sherds in the lower levels at the site (Fig. 33:11A). It would seem there was a major shift in

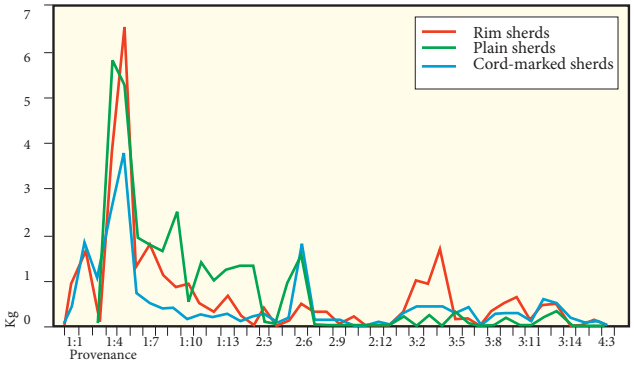


FIG. 33:5 The distribution of plain and cord-marked sherds, and rim sherds by layer, at Non Muang Kao

TABLE 33:1 *The attributes of rim form. A combination of one attribute from each field results in a specific rim form*

FIELD 1 - RIM DIRECTION

1. Everted
2. Inverted
3. Direct

FIELD 2 - RIM PROFILE

5. A) Simple parallel profile
   B) Simple parallel profile with directional change
6. A) Gradual thickening to lip
   B) Gradual reduction to lip
7. A) Abrupt thickening to lip
   B) Abrupt reduction to lip
8. A) Single fold
   B) Rolled fold
9. A) Bulging interior and exterior below lip
   B) Indented interior and exterior below lip
10. A) Bulge on rim interior
    B) Bulge on rim exterior
11. A) Indentation on rim interior
    B) Indentation on rim exterior

FIELD 3 - LIP SHAPE

12. Rim contour unchanged at lip - Flattened
13. Rim contour unchanged at lip - Rounded
14. Rim contour changed at lip - Flat flaring out
15. Rim contour changed at lip - Flat flaring in
16. Rim contour changed at lip - Round flaring out
17. Rim contour changed at lip - Round flaring in
18. Rim contour changed at lip - Flares in and out
19. Rim contour changed at lip - Diverging
20. Secondary interior lip
21. Secondary exterior lip

ceramic technique from the intensive production of burnished sherds to a less labour intensive plain sherd. There is a congruent rise in the production of cord-marked pottery in the upper eight spits of the site as well (Fig. 33:5). It was remarked above that very little decorated pottery other than that which was burnished was recovered from Non Muang Kao. The decorated pottery which was recovered was found, for the most part, in the lower levels of the matrix (Fig. 33:6A).

COLOUR AND DISTRIBUTION OF RIM SHERDS

The rim sherds from Non Muang Kao were analysed on the basis of their morphology, colour and surface finish. An examination of the distribution of the rim sherds reveals a similar pattern to that which was found among the body sherds.

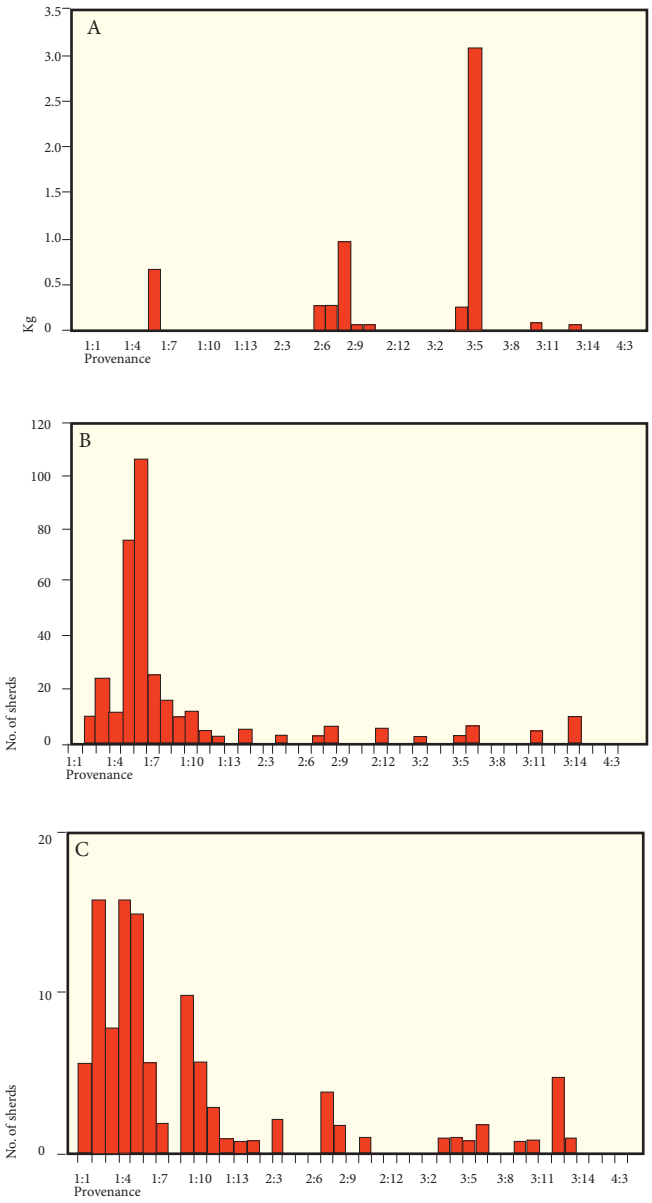


FIG. 33:6 The distribution of A: decorated sherds, B: mottled rim sherds and C: brown rim sherds at Non Muang Kao

The rim sherds were grouped into seven categories based upon Munsell colour determinations. Pink sherds correspond to Munsell values 5 YR 8/3- 5 YR 8/4, Grey sherds are classified as 5 Y 7/1- 5Y 3/1. Orange sherds may be defined as Munsell value 2.5 YR 7/3- 2.5 YR 7/8. Brown sherds encompass those which were both light and dark brown, Munsell values 7.5 YR 6/4- 7.5 YR 4/2. Black sherds were found to correspond to Munsell values 5 Y 2/1 and 5 YR 2/1. Sherds described as mottled were found to have several different colour on the rim sherd. These could not be assigned a Munsell determination but may be seen as varying combinations of all the above colours on a single sherd.

The distribution of the various colours reveals an

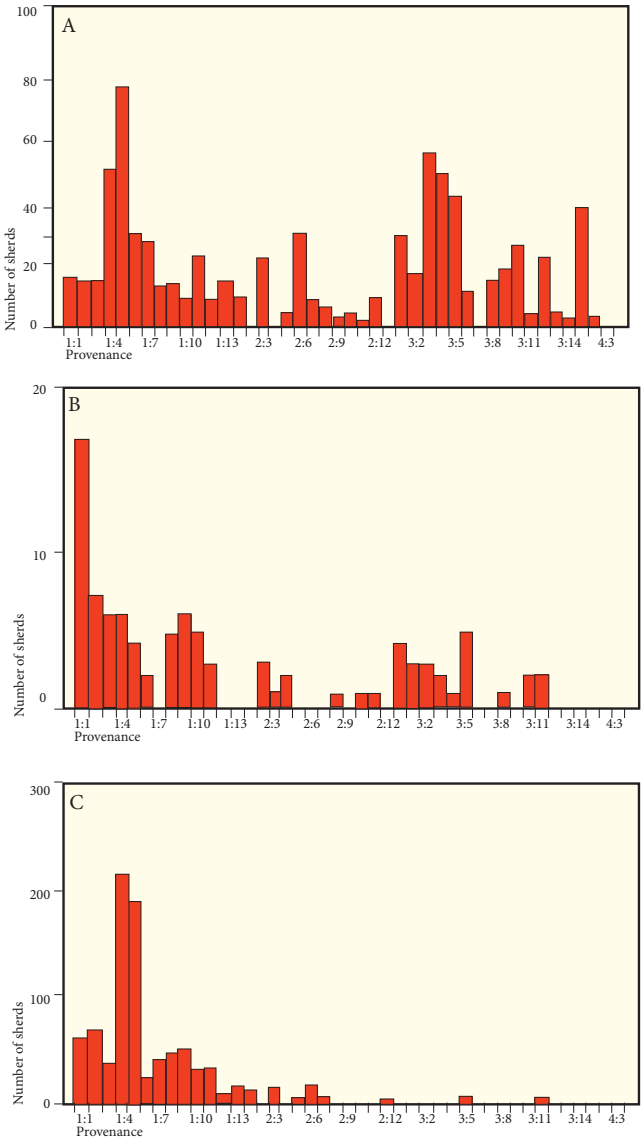


FIG. 33:7 The distribution of A: black rim sherds, B: grey rim sherds and C: unslipped, unburnished rim sherds at Non Muang Kao

interesting pattern. The mottled rim sherds are seen to become more prevalent in the upper layers, especially in Layer one (Fig. 33:6B). There are similar patterns evident among the brown, pink and orange rim sherds which also demonstrate a marked increase in the upper layers (Fig. 33:6C). This pattern would seem to indicate a shift in the production technology which first manifested itself in Layer 1:13.

An examination of the black and grey rim sherds (Figs. 33:7A-B) reveals that this type of ceramic was present throughout the stratigraphy. A careful examination of the chart also reveals several peaks and valleys, a major increase being apparent in Layer three.

A consideration of the patterns evident in the histograms illuminates variation in the proportion of different sherd colours. It is apparent that in the lower stratigraphic levels the pottery was almost exclusively black in colour, while in the upper layers there was a move away from this stylistic type to ceramics which were multi coloured. This is best explained as a reflection of a shift in the ceramic production technology being employed

SURFACE FINISH AND DISTRIBUTION OF RIM SHERDS

The surface finish of the rim sherds was also investigated to monitor diachronic change. There were found to be three main types of surface finish, namely, burnished, highly burnished and unslipped-unburnished sherds. A congruous pattern was evident among these sherds and the analysis based upon colour.

The distribution of unslipped and unburnished sherds (Fig. 33:7C) was found to congregate in the upper layers of the site, being prevalent in Layer one. There is a marked decrease in Layer two and the unburnished sherds are uncommon in the lowest layer.

The polished rim sherds have a more balanced distribution through the stratigraphy. Although it appears to be bimodal, lower numbers appear in Layer two. The polished sherds are most prevalent in the bottom layers, which is an interesting development when viewed in conjunction with the frequency of the unburnished sherds. It would seem that polishing was the exclusive form of surface finish in the lowest layers.

The distribution of the highly polished rim sherds is again most prevalent in the lower layers of the stratigraphy (Fig. 33:9B).

The pattern of sherd distribution reveals that the mottled, brown, pink and orange rim sherds are concentrated almost exclusively in Layer one, while the black sherds appear throughout all the layers. Unburnished sherds are found in the upper layers and the highly burnished sherds are exclusive to the third layer.

In summary, there is a clear and definite shift in the ceramic pattern at Non Muang Kao. In the lower strata the occupants were using pottery which was fired in a reducing atmosphere, and highly decorated by burnished surfaces. There was an apparent trend away from this style in the upper layers of the site, the occupants preferring plain ware, which was probably fired in an open hearth.

DISTRIBUTION OF RIM SHERDS

In examining the histograms of rim form distribution, four distinct patterns are apparent. Some of the rims appear only in the lowest layers, others appear throughout. There are also rim forms which appear exclusively in Layer one. Perhaps the most interesting pattern reveals rim forms which are absent from Layer two but present in Layers one and three.

Those rims appearing only in the lowest strata were of

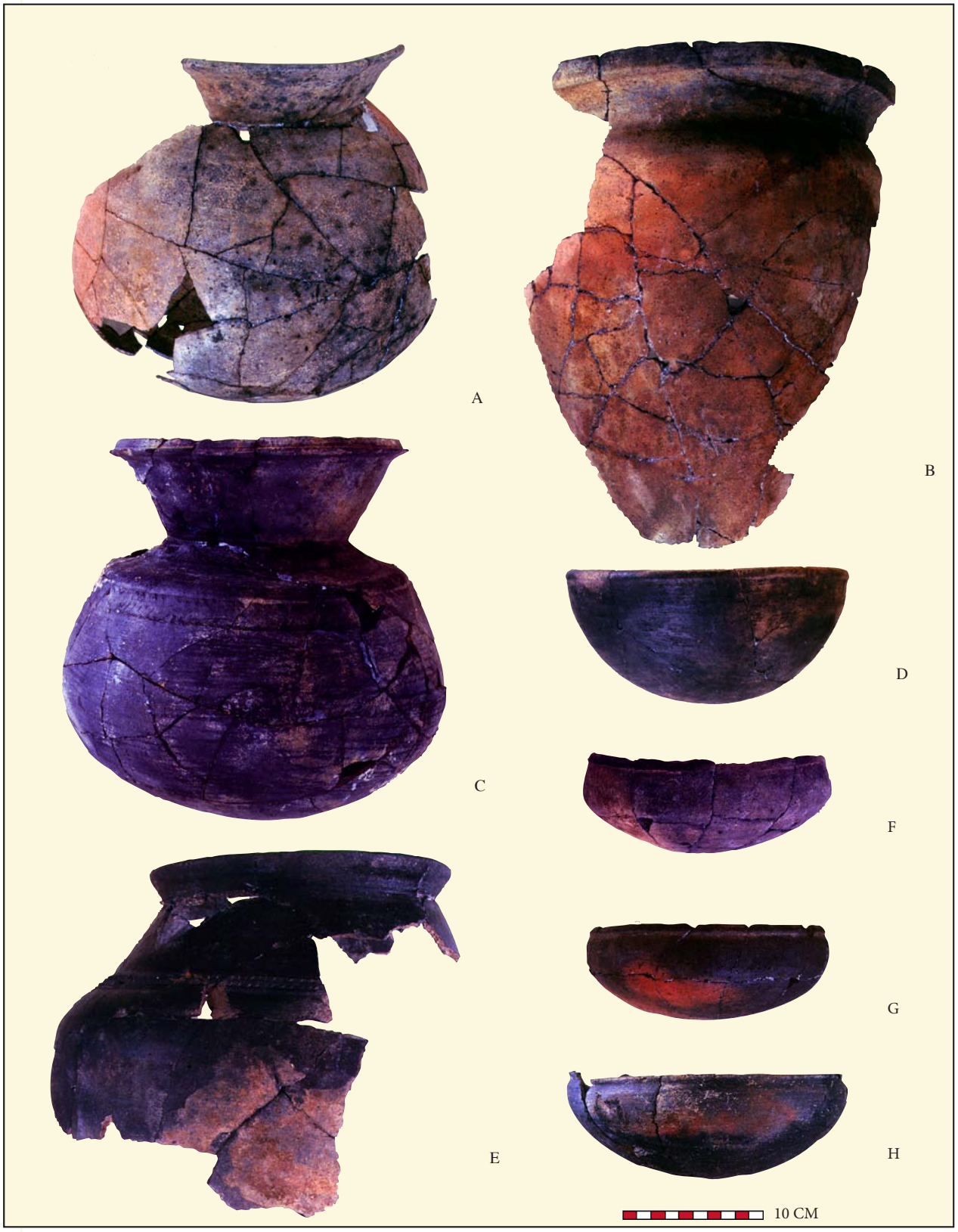


FIG. 33:8 The pottery vessels from Non Muang Kao. A. cat. 34, burial 3. B. cat. 58, layer 2:3 feature 8. C. cat. 157 burial 9, D. cat. 86, layer 2:6 feature 20, E. cat. 147, burial 7. F. cat. 146, burial 7. G. cat. 49A, layer 2:5 feature 2. H. cat. 55, burial 4

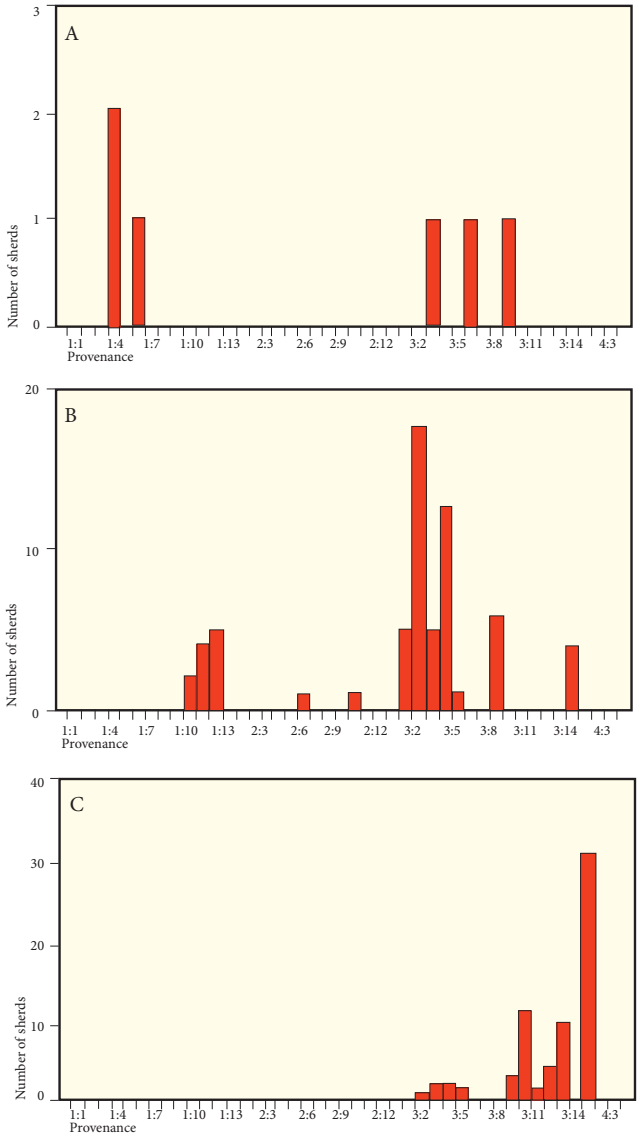


FIG. 33:9 The distribution of A: rims with impressed decoration, B: rim sherds polished to a bright lustre and C: rim form 1 6B 21 from Non Muang Kao

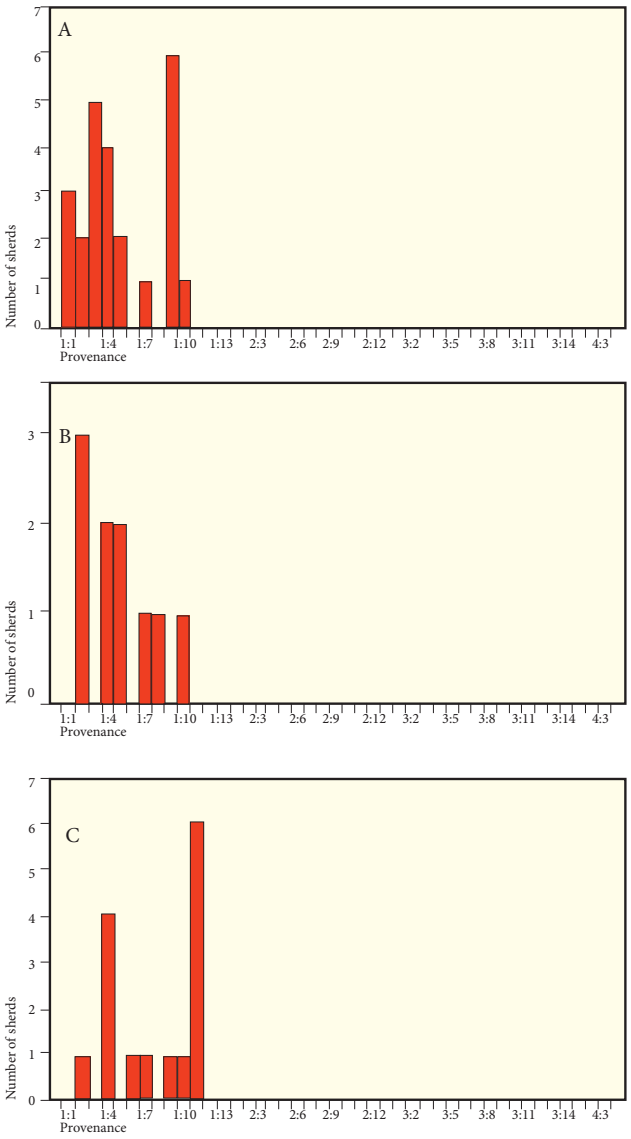


FIG. 33:10 The distribution of A: rim form 1 5B 13, B: rim form 1 5A 16 and C: rim form 1 10B 12 from Non Muang Kao

only one form, 1.6B.21 (Fig. 33:9C). This is a rather distinctive form, having a secondary exterior lip. The majority of these were streak burnished. The restricted presence of this rim form in the lowest strata may prove useful for future dating of Iron Age ceramic assemblages.

Rim forms found only in the upper stratigraphy included 1.5B.13, 1.5A.16 and 1.10B.12 (Fig. 33:10). The rim forms themselves are not remarkable but the restricted presence is. All of the rims appear to have been adopted simultaneously.

The bimodal aspect mentioned above is of great interest. Ten different rim forms appear in both Layer one and Layer three exclusively, none having been found in Layer two. To explain this phenomenon as the occupation of the site by a different group of people seems implausible, as other rim forms were found evenly distributed through nearly all of the layers of the stratigraphy. Twelve different forms exhibit this pattern (Figs. 33:12-15). The bimodal distribution is better explained as representing a change in the activities conducted by the prehistoric inhabitants in the excavated area. There is no evidence for sherds which are exclusive to Layer two alone.

It is clear from the distribution of the various rim forms that Layer two enjoys some exclusivity. It is necessary to consider which aspects of this cultural layer set it apart from the layers above and below it. The most obvious difference between them is the presence of clay floors, the majority of which were found in Layer two. It is difficult to explain an absence of rim forms if the clay floors are to be considered domestic features. If the floors do represent

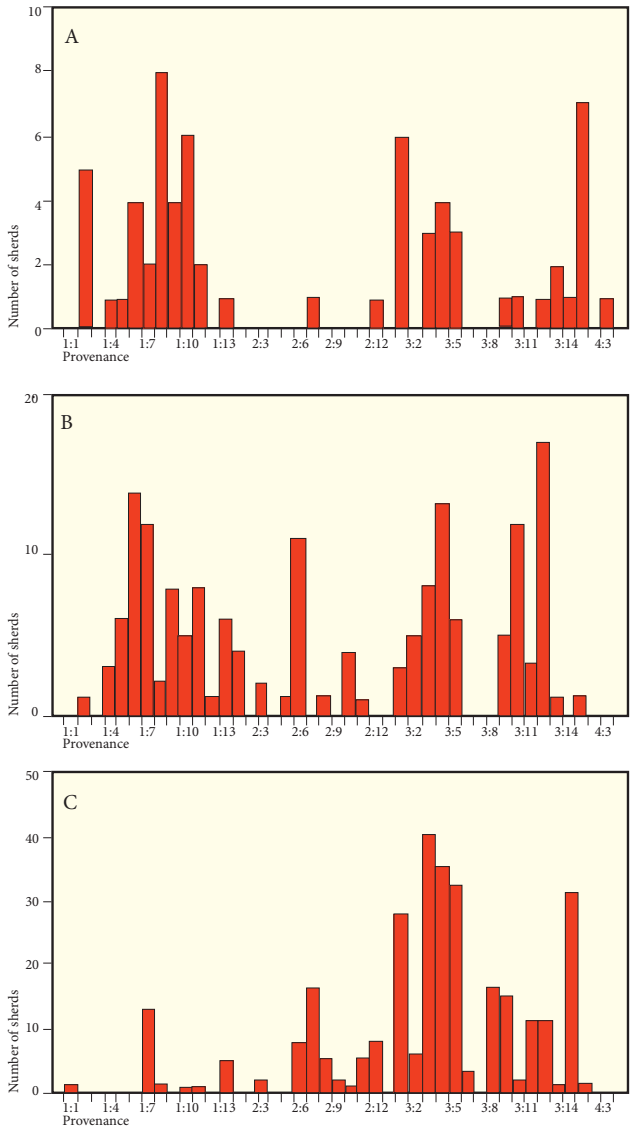


FIG. 33:11 Rim form distribution A: rims with high lustre streak burnishing, B: rims with dull streak burnishing and C: rims with incised decoration from Non Muang Kao

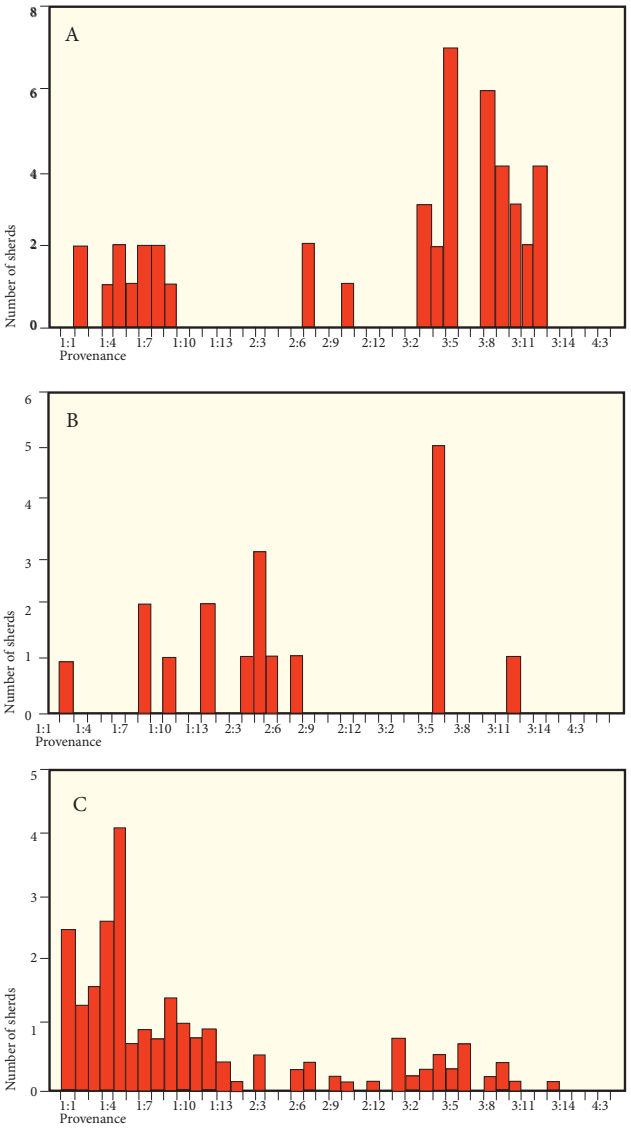


FIG. 33:12 The distribution of A: rim form 1 6B 19, B: rim form 1 6B 12 and C: rim form 1 6B 13 at Non Muang Kao

domestic occupation of the excavated area then one would assume there would be an exclusive set of rim forms found only in those layers. If we consider Layers one and three to represent domestic deposition then Layer two can not. If Layer two is considered to represent domestic deposition we must explain the absence of rims which appear above and below it.

There are several possible explanations for the presence of the clay floors. They may represent the interior area of a domestic dwelling and the exclusion of certain rim forms could be explained as a result of the missing forms representing pots which were used in exterior activities. This explanation would be plausible if the clay floors covered the entire excavated area and perhaps if the period under consideration were of short duration. Layer two is over one metre deep, representing a considerable period of time. It seems a dubious proposition that sherds from vessels used in exterior contexts would not appear in the Layer two deposits occasionally.

The exclusion of ten different rim forms from all of the contexts in Layer two strongly suggests that there was a shift in the activities which took place in the area, from a possible domestic use to some other function which was well removed from domestic occupation activity, and finally a return to a domestic context. What the function of the area was during the intermediate period was, is impossible to say. While it is true that the floors were found in close association with burials also lined with clay, it was determined during excavation that they were probably not related and that the burials cut through the clay floors.

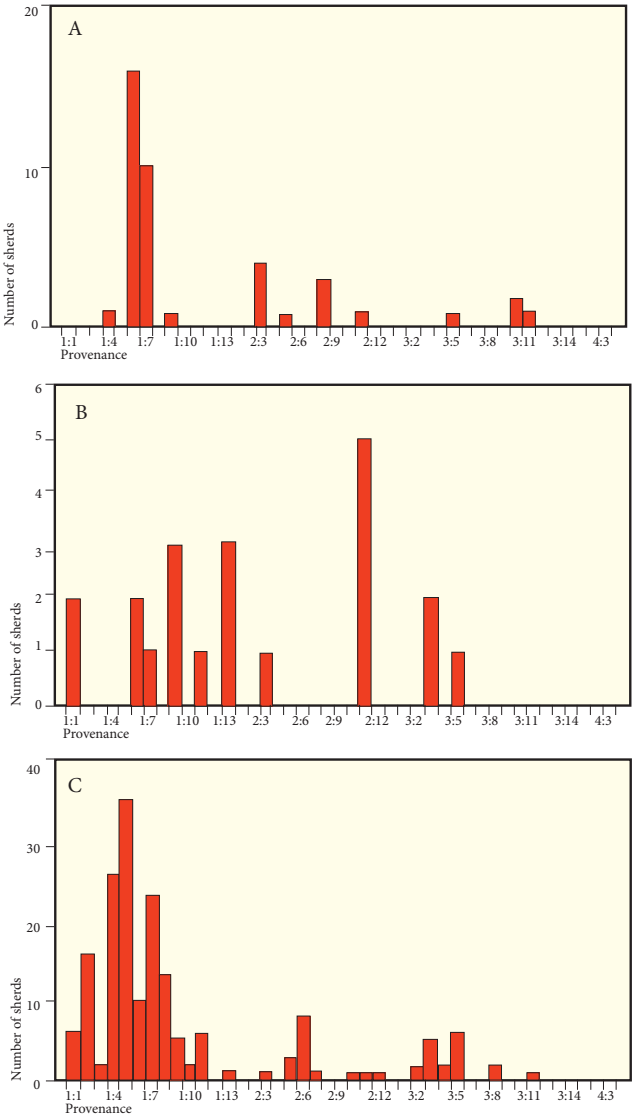


FIG. 33:13 The distribution of A: rim form 1 6B 16, B: rim form 1 5A 12 and C: rim form 1 5A 13 at Non Muang Kao

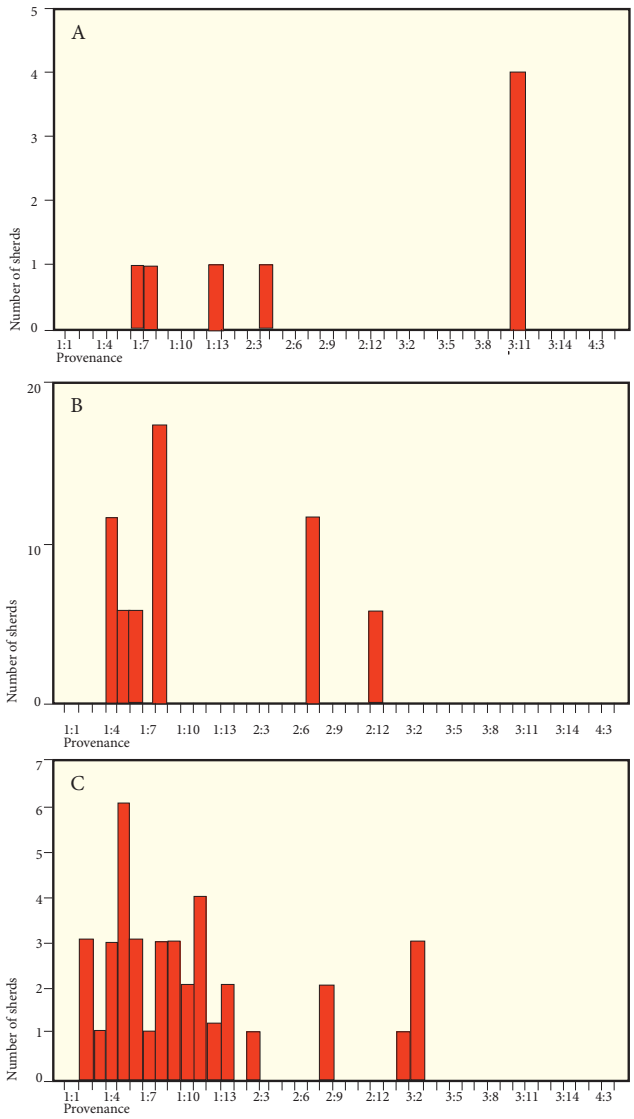


FIG. 33:14 The distribution of A: rim form 1 5A 14, B: rim form 1 11B 13 and C: rim form 1 10B 13 at Non Muang Kao

This does not rule out the possibility that the floors represent a structure which was related to mortuary activity during the period in which Layer two was deposited.

DECORATED SHERDS

Only 51 body sherds were decorated in a manner other than burnishing. There was also a limited range of decorative types found at Non Muang Kao. The most frequent decorative element was a jab impression made with what appears to have been a hollow stalk of grass, perhaps a rice stalk. Other jab impressions were probably made with a thumbnail, creating a continuous scalloped band on the sherd. Simple incised lines were the next most frequent element. None of the sherds was large enough to determine the nature of the incisions. The only other decorative element was a raised band which was approximately 5 mm thick, found on the exterior surface of some sherds.

The rim sherds seem to be predominantly decorated with incisions. The distribution of the decorated rim sherds is displayed in Fig. 33:11. Examining the rim sherds for decoration other than burnishing, one is struck again by the glaring absences in Layer two. There are only three rim sherds in the second Layer which have been decorated, two were incised and one had a raised band below the lip.

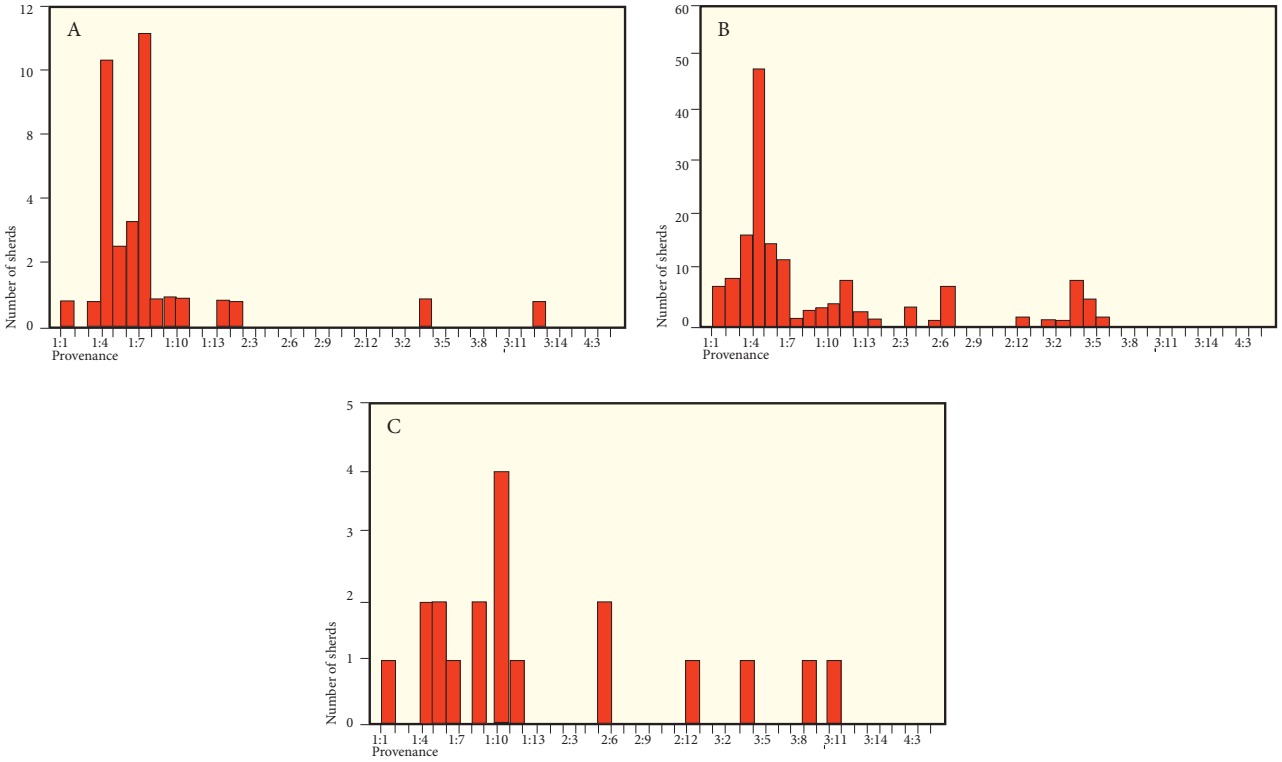


FIG. 33:15 The distribution of A: rim form 1 6A 12, B: rim form 1 6A 13 and C: rim form 1 6A 13 at Non Muang Kao

XXXIV. NON MUANG KAO BURIALS

D.J.W. O'REILLY

NON MUANG KAO BURIAL DESCRIPTIONS

This chapter describes the human burials from Non Muang Kao, in order of their discovery.

Burial one
A1:A 1-2 Transition. The remains of this adult were located in the southeast corner of the unit (Fig. 34:1). Burial one consisted of metatarsals and tibiae projecting out of the south baulk, with the head presumably orientated to the south. The burial appeared to rest on the lower of the two clay floors. In section, however, it was apparent that the body had been encased in a clay-lined grave. No grave goods were found in association with this interment.

Burial two
A1:A 2:2. The skull of this adult was found adjacent to what appeared to be iron slag from smithing operations (Fig. 34:2). Burial 2 was only partially exposed, nearly everything except the skull remained in the north baulk. The post cranial remains were poorly preserved. The burial cut through another feature, which consisted of potsherds in a matrix of laterite pebbles in which were several post holes filled with laterite nodules. The grave contained nine copper alloy bangles, found to the left of the skull (cats. 29 and 30), two glass beads, found to the right of the cranium (cats. 31 and 40) and several fragments of copper alloy recovered from the fill (cats. 33 and 41). Although it was difficult to ascertain it appears that this burial was orientated with the head to the south.



FIG. 34:1 Non Muang Kao burial 1. Scale 20 cm



FIG. 34:2 Burial 2, seen as a grave silhouette in the bottom right corner. Scale 20 cm

Burial three
A1:A 2:1. Human remains were encountered in the middle of the west baulk. Although the bone was very poorly preserved, several teeth were recovered which belonged to an infant. Burial 3 contained five copper alloy bangles (cats. 39 and 165), a copper alloy ring (cat. 96) and a 'Phimai black' pot (cat. 34). The pot was very fragile which distinguished it from the sherds found in non-burial contexts of the same level. The skeletal remains were surrounded by white carbonised rice and rested on a whitish-grey clay surface which was curved and bowl-like in section. The orientation of the burial was unclear, but probably ran north-south.

Burial four
A1:A 2:2. Burial 4 was discovered along the south baulk. Only the cranium was protruding into the excavated area. Beneath the mandible, an area of green staining was noted,

and interpreted as the remnants of a rice bed (Fig. 34:3). The grave of this adult was quite well appointed, containing four 'Phimai black' pots (cats. 54, 55, 59 and 95), a copper alloy earring (cat. 52) and a bimetallic earring (cat. 53). The individual was interred with the head to the north, contrary to the orientation of the previous burials.

Burial five

A1:A 2:8. Burial five was found in the south-west corner of the unit (Fig. 34:4). The grave fill was a pebbly lateritic material. The grave, which appears to have been lined with a whitish-grey clay, was about 70 cm deep on a north-south orientation. The burial was capped with a thin layer of white clay and contained an infant mandible. The only grave offering recovered was a copper alloy ring (cat. 80).

Burial six

A1:A 2:6. This interment was encountered along the eastern baulk (Fig. 34:5-7). Burial six contained great quantities of carbonised rice and pieces of the clay floor through which it was dug. The grave appears to extend north-south from the south baulk. The bone was very poorly preserved, only fragments of the skull, pelvis and parts of the tibiae being recovered.

Burial six was the richest of the burials encountered, containing 25 catalogued artefacts. The head lay to the south, an agate bead (cat. 120) rested on the chest, below the skull. On the arms, 14 bronze bangles (cat. 127) were found and the legs had several bronze bangles apiece (cats. 128 and 129). On the fingers numerous bronze rings were discovered (cats. 131 and 132). There was a bimetallic earring (cat. 133) as well as several other rings of iron (cats. 102, 103, 104, 106, 107, 108, 126) and bronze (cats. 109, 111, 110, 98, 99, 100, 101). The grave also included a hammer stone (cat. 84) and some concreted iron (cat. 133). There were also 48 glass beads recovered (cat. 124) and a 'Phimai black' bowl (cat. 130).

Burial seven

A1:A 3:10. Burial seven measured 50 x 20 cm and was 37 cm deep. The grave was full of carbonised rice and contained two sets of copper alloy wires twisted into spirals 1.4 cm in diameter (cats. 144 and 145), a complete 'Phimai black' bowl (cat. 146) and pot sherds (cat. 147).

Burial eight

A1:A 3:12. Burial eight was discovered in the western portion of the unit. A grave cut was clear, due to the line of carbonised rice which outlined it. A curious linear band of lateritic deposits was found in close association. There was a sharp division of soil types across the square running from north to



FIG. 34:3 Non Muang Kao burial 4



FIG. 34:4 Non Muang Kao burial 5. Scale 10 cm



FIG. 34:5 Burial 6. The white material in the centre of the image is a mass of silicified rice that filled the grave. Scale 5 cm



FIG. 34:6 Burial 6. Scale 10 cm

south. The grave was situated in a matrix of light brown soil/sand (7.5 YR 6/4), while the rest of the unit was of a reddish brown hue (5 YR 5/4) and much harder.

The grave cut appeared to reduce in size about 3 cm down. The cut, 130 cm x 57 cm, was full of carbonised rice. Burial eight contained a 'Phimai black' bowl (cat. 151), some pot sherds (cat. 162) and two small bangles (cats. 149, 150). It would appear to be a child's burial based upon the size, although no bone was recovered. The orientation was probably north-south.

Burial nine

A1:A 4:1. During excavation, a line of carbonised rice began to appear which identified this as an interment. The grave cut of burial nine was *c.* 210 cm long. As it was excavated, a significant amount of rice was revealed. The grave contained a 'Phimai black' shouldered pot (cat. 157), some animal teeth and 48 agate (cat. 158), 8 glass (cat. 160) and 739 clay beads (cat. 159) as well as a possible carnelian bead. The human remains could be seen in the baulk. Only 30 cm of the burial was exposed along the west baulk, although the orientation of the body could be determined, with the head to the south. The grave was dug into natural substrate.

Several features were encountered which probably represent burials but in which no human remains were found. These are detailed below.

Burial 2:6 Feature 20

This feature was a clay envelope which contained rice remains. Several artefacts were found in the grave including, glass beads (cats. 78, 93), a copper alloy ring (cat. 81) 'Phimai black' pots (cats. 86, 87) and an iron ring (cat. 89). The orientation of the grave cut was north-south.

Burial 3:6 Feature 1

This apparent grave cut through a clay floor feature, contained rice remains and 507 yellow glass beads (cat. 141) but no human remains. The orientation of the grave cut was north-south.

CONCLUSION

Although the data set from Non Muang Kao is small, it is apparent that there is a considerable difference in the mortuary treatment during the Iron Age compared to the Bronze Age at Ban Lum Khao. The graves contain more elaborate artefacts, some requiring a great deal of technical expertise to manufacture. Exotic items, such as agate and carnelian and possibly glass are more common and these burials are distinguished by copious quantities of rice.



FIG. 34:7 The bronze anklets of burial 6. Scale 5 cm

XXXV. NON MUANG KAO IN A REGIONAL PERSPECTIVE

D.J.W. O'REILLY

INTRODUCTION

An understanding of the cultural milieu of the Mun River valley from *c.* 2100 BC will help the reader place the recently excavated site of Non Muang Kao in context. Information on the regional prehistory, although still deficient, has been augmented considerably in the last four decades. Research programmes undertaken by the Thai Fine Arts Department, the Universities of Otago, Hawaii and Pennsylvania as well as a number of independent scholars have located habitation sites, mortuary assemblages, and industrial activity areas. An overview of archaeological research in Northeast Thailand is presented, followed by a closer examination of sites in the Mun River valley (Fig. 35:1).

There is a paucity of scholarly literature in the area of state formation in Southeast Asia. The presence of walled and moated sites on the Khorat plateau has been noted since the 19th century (Aymonier 1895, 1897). The first excavation of sites of this type occurred in 1955 when Quaritch-Wales (1957) dug test pits at Ban Thamen Chai and Muang Phet. Later the Thai Fine Arts Department surveyed moated sites in the Khorat region and undertook limited preliminary excavation at two sites, Muang Sema (Fine Arts Department Thailand 1959) and Kantarawichai (Diskul 1979). Non Dua, in Roi Et province, was investigated by Higham and Parker (1970), revealing evidence of occupation from 500 BC. Ban Chiang Hian, a large moated site, revealed evidence of occupation from 1000 BC (Chantaratiyakarn 1984). Wichakana (1991) excavated at Noen U-Loke finding evidence for Iron Age occupation above a Bronze Age cemetery. Other recently excavated sites include Ban Don Phlong and Non Yang. The former revealed evidence of iron smelting and inhumation burials and the latter demonstrated many similarities to Non Muang Kao (Nitta 1991). Ban Krabuang Nok lies at the confluence of the Mun and the Lam Sa Thaet Rivers. It was excavated by Indrawooth *et al.* (1990), yielding evidence of bronze and iron smelting. Moore (1992) excavated at Ban Takhong, another moated site situated on a tributary of the Mun River, finding evidence of occupation dating to the early part of the first millennium.

Several studies have used aerial photographs and topographic maps of the Khorat plateau. Saengwan (1979), Higham *et al.* (1982) and Vallibhotama (1984) located numerous sites in Northeast Thailand showing possible moats and earthworks. More recently, Parry (1992) undertook an examination of Landsat satellite images and conventional air photographs to categorise the main types of earth-works and demonstrate the value of this type of technology in settlement pattern analysis. Aerial photographs were used by Moore (1985, 1986, 1988) in locational analysis and classification of moated settlements. She has found significant size differences between moated sites that may indicate a hierarchical arrangement.

A thorough synthesis and interpretation of the social and political developments in Southeast Asia as they were understood at the time was undertaken by Wheatley (1983) who lamented the lack of archaeological research undertaken in the area. Welch and McNeill (Welch 1983, 1984, 1985; Welch and McNeill 1988-9) have turned their attention to the development of regional centres, working in the same area in which the present research was undertaken.

The moated settlements of Northeast Thailand pose an important and intriguing range of problems. Sites of this type are documented in the Angkorian heartland, posited as seminal aspects of the later Khmer empire (Moore 1989, 1992). The political climate in Cambodia at the time when excavations were planned, and a host of other logistical problems render an examination of sites of this type more feasible in Thailand. Recognised in areas of both Thailand and Cambodia, sites surrounded by channels are especially densely distributed in the Mun River valley.

The current research seeks to expand upon that which has already been undertaken, leading to a more complete understanding of developmental processes in the Mun River valley.

THE MUN RIVER VALLEY

Non Ban Kham

Surveying a 300 km² area, Welch (1985) identified several archaeological sites around the former Angkorian centre, Phimai. One such site was Non Ban Kham, a 2.3 ha mound, located approximately 3 km from Phimai. The top of the mound is about 1.6 m above the surrounding rice fields. Welch identified a possible rampart, 80 cm high and 15 m wide, situated 30 m from the edge of the mound.

Five test pits were excavated in various locations at Non Ban Kham. The first, on the top of the mound, reached natural deposits at 1.9 m below the surface. It contained six soil layers atop the substrate, all of which revealed cultural material. The three layers closest to the surface contained recent historic ceramics, while the fourth layer revealed a mix of these sherds as well as some dating to the early historic period. The fifth layer contained mostly early historic wares, while the lower spits contained 'Phimai tradition'

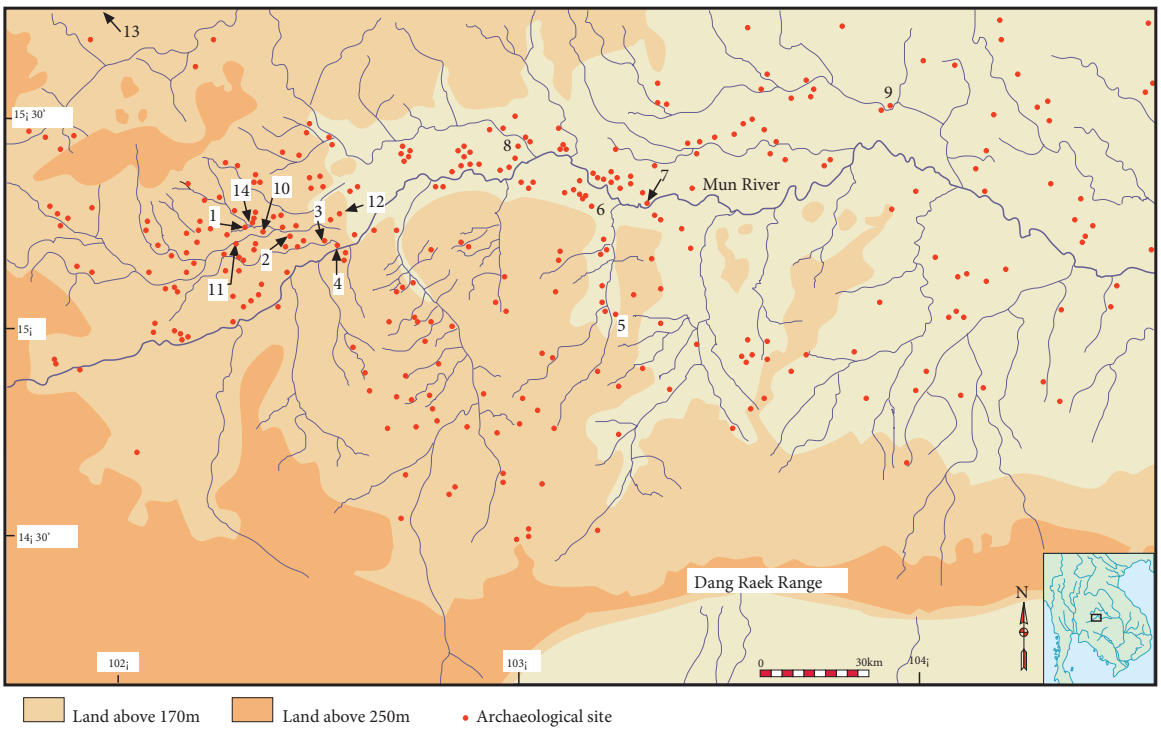


FIG. 35:1. The Mun Valley, showing the distribution of sites.
1. Noen U-Loke, 2. Ban Prasat, 3. Ban Tamyae, 4. Phimai, Ban Suai, Non Ban Kham, 5. Ban Takhong, 6. Ban Don Phlong, 7. Non Yang, 8. Non Krabuang, 9. Non Dua, 10. Ban Lum Khao, 11. Non Muang Kao, 12. Non Ban Kham, 13. Non Tung Pie Pone, 14. Ban Non Wat

pottery (*ibid.*).

The second test pit reached a depth of 2.1 m below the surface and comprised six layers similar to those in TP1. The uppermost layer contained recent historic and Khmer sherds while the third layer was dominated by Khmer period sherds. The fourth and fifth layers, as well as the top of Layer 6, contained early historic wares and the last layer contained 'Phimai black' sherds. A radiocarbon sample from Layer 5, test pit 2, rendered a date of 1180±100 BP, AD 660- 905 (2σ).

The third test pit, located on the south slope of the mound, comprised four layers. The topmost evidenced modern ceramic sherds while the second layer contained recent historic material. The third layer, separated from the first two layers by sterile soil, contained early historic sherds, as did the last layer. The fourth test pit was located on the northern slope of the mound and revealed a similar deposition history to the previous test pit.

The last test pit was excavated on the earthen embankment described above. Excavation reached a depth of 1.1 m from the top of the bank yet revealed no evidence of cultural material. The feature comprised sandy layers of soil that contained no datable material.

Ban Tamyae

The results of the test excavations at Non Ban Kham prompted Welch to examine other possible sites that would contain more bountiful deposits of prehistoric ceramics. The site chosen was Ban Tamyae, located about 15 km from Phimai and 2 km from the banks of the Mun River. The circular mound covers 17 ha and is 4.5 m higher than the surrounding rice fields. Five test pits were excavated at Ban Tamyae. Two were located inside the grounds of the Buddhist temple on the southwest slope of the mound, and a third was located off the mound on the west side of the site. Another unit was located on the edge of the mound to the east and a final test pit was located on the southern edge of the site. A total of 24 m² was excavated (Welch 1985).

Test pits 1 and 2 contained ten layers, reaching the substrate at 2.5 m. A great deal of ceramic material was recovered as well as a number of archaeological features. The third test pit revealed four layers, devoid of cultural features. Historic and plain chaff-tempered sherds were found in the first layers of all the pits. The chaff-tempered sherds were found down to the fourth layer where excavation stopped. The fourth unit was excavated down to 1.7 m. There were three layers beneath a thick deposit of modern fill (layers 1-2). The third layer contained recent and historic ceramics while the fourth layer revealed a shell midden, with associated chaff tempered sherds. The last level excavated contained plain and cord-marked, chaff-tempered pottery in a clay matrix. The fifth test pit was excavated to 0.8 m below the surface, in which four

soil horizons were distinguished. There were few sherds found, the upper layers containing modern and historic sherds. Chaff tempered sherds were found in Layer 3, below which lay sand-tempered and glazed 'Lopburi tradition' (*c.* AD 900-1300) sherds. Sand and grog tempered earthenwares were found in the last layer excavated and it is likely that the cultural deposit continues below this level (*ibid.*).

The ceramic material recovered from the excavation of Ban Tamyae has allowed Welch to elucidate a number of traditions, the first of which is eponymously named the 'Tamyae tradition'. Ceramics of this type are thin walled, sand or sand and grog tempered and are highly fired. The surfaces of vessels in the tradition are often lustrous with impressed, incised and relief decorations. Welch (1985) hypothesises that the vessels were fired in an enclosed space due the absence of fire clouds and smudging and the fact that sherds were close to vitrification. Most of the vessels were fired in an oxidising atmosphere indicated by their light colour. It is Welch's (1985) opinion that the Tamyae vessels represent the acme of ceramic production in the Phimai region, standing out for their superior craftsmanship.

The 'Phimai tradition' includes ceramics that are primarily chaff tempered but often sand, laterite or grog are used in conjunction with the rice husks. The surfaces are sometimes slipped or burnished. The most distinctive vessels of this type are the 'Phimai black' pots but the tradition also includes thick fibre-tempered earthenware (Solheim 1965; Solheim and Ayres 1979 in Welch 1985).

Vessels within the tradition take a number of forms, the most common being a large ovoid jar with a constricted neck and everted rim. The bodies of these pots are usually thin and cord marked while the rims are thick and undecorated. Bowls are also a common vessel type within the 'Phimai tradition', demonstrating much variation. Many of the sherds are burnished to varying degrees and some vessels were pattern burnished, this being the most common decorative technique. The burnishing takes many forms including horizontal and diagonal streaks, spirals and lenticular patterns, cross-hatched squares and diamonds on pot bodies and less frequently, impressed circles or banded grooves on pot shoulders.

'Phimai tradition' vessels were usually fired in an oxygen-poor atmosphere, with some probably being removed prior to complete blackening. A characteristic of pots of this tradition is a flaky and pitted appearance caused by the burning out of the rice chaff.

The 'Early Historic tradition' is recognisable by highly fired earthenware, tempered with grog, sand and laterite. The temper, although similar to that of the Tamyae phase, is distinguished by the coarse nature of the inclusions. The surfaces are partly smooth, with a grainy texture where particles protrude. Many vessels appear to have been wheel made, the most common form being a globular jar. Decoration was a low priority, as most vessels were plain but there are some with incised bands, grooves or ridges around the shoulders. The surface colour of most sherds ranges from light red, yellowish red, reddish yellow, light brown, light grey to white. Welch (1985) believes that they were probably fired in a kiln with a flow of oxygen.

Another distinct tradition identified was the 'Khmer' or 'Lopburi tradition' which includes vessels of high fired earthenware and stoneware. Vessels of this tradition have few noticeable inclusions other than fine sand. Khmer ceramics are wheel made and kiln fired. Most are glazed with colours ranging from olive, brown/black, to dark brown (Welch 1985).

The 'Recent Historic tradition' is recognisable by the use of chaff in the temper and a return to paddle and anvil techniques. The exterior of the vessels is often cord marked and in some instances carved paddles were used.

Seven radiocarbon dates are available from Ban Tamyae, all from test pits 1 and 2. Layer 7 indicated an occupation of 820-415 BC (1 σ) while samples from the transition between Layer 6 and 7 gave two dates, 390-160 BC and 175 BC-AD 15 (1σ). Two samples from Layer 6 gave dates from 190-15 BC (1 σ) and the final two dates from Layer 3 ranged from 605-495 BC to 440-395 BC (1 σ).

Non Yang

Non Yang, a mound rising 8 m from the surrounding rice fields, is located in Changwat Surin on the bank of the Mun River. This site has been investigated on two occasions, first in 1981 and again in 1990. The first work, conducted by Suchitta (1983), involved the delineation of strata on an exposed cliff face. The cliff is a result of severe erosion and most of the site has been swept away by the Mun River. This unfortunate situation does, however, afford an excellent opportunity to examine the stratigraphy of a large Iron Age site.

Suchitta's (1983) investigations revealed seven soil horizons in 4.60 m. Two radiocarbon determinations from the vicinity of Layer 2 suggest an occupation between 3000±250 BP and 4000±600 BP. These dates do not accord well, however, with those obtained by Nitta (1991). Carbon samples from the deepest layer containing sherds rendered dates from 1650±340 BP to 2300±85 BP (*ibid.*).

Nitta (1991) excavated at Non Yang in an attempt to elucidate the chronology of ceramics in the middle Mun basin. He identified eight cultural layers, three of which were excavated. The excavation revealed several intriguing features, including clay floors, jar burials and the remains of a large ditch and fence posts. Nitta has compiled a typology of pot sherds recovered from the cliff face, which should serve as a benchmark for other sites in the area. Many of the sherds recovered are Roi-et/Thung Kula ware (Higham 1977b, Vallibhotama 1984).

The lowest level excavated by Nitta (1991) revealed the remains of what he has interpreted as four habitation

structures. These were built at ground level by digging a shallow pit (20 cm), *c.* 2.6 x 1.7 m, into which half-split logs were placed horizontally. Nitta believes a layer of clay was applied over this foundation, the purpose of which was to counter subsidence. All of the floors were highly heated but whether this was intentional or accidental is impossible to determine. The walls of the former structure appear to have been constructed using bamboo mat, the impression of these being found in several wall remnants. In some instances there were pots placed lip to lip underneath these floors. Nitta (1991) believes that these may represent foundation offerings. The structures have been dated using the carbonised remains of the foundation timbers to the period 300-1 BC which Higham (1996a) notes is in agreement with the Roi-et ware underling the strata containing the floors.

A large ditch was also discovered which was *c.* 50-100 cm wide and about 70 cm deep. Thirteen post holes ran along the bottom of the ditch and the feature may represent the remains of a fence. An iron implement, that the excavator believes was used in the construction of the ditch, was found in the bottom. Another ditch was interpreted by Nitta as representing the unfinished foundation trench for a fence.

The top of the mound at Non Yang was surrounded by a large trench that was approximately 4.5 m at its widest and over 2 m deep. The trench had a Y-shaped section and appeared to have been regularly maintained.

Several jar burials from different layers were excavated by Nitta as well. Some of the largest of these were 55 cm in diameter and were covered by other pots. In two instances the jar burials were found in groups of five and six. Another jar contained three human skulls.

Ban Don Phlong

This 10 m high mound is located in Amphoe Satuk, Changwat Buriram, on the south bank of the Mun River. Earthworks and three channels surround the occupied site. Road works and recent modifications have destroyed part of the mound and large sections of the moats.

Nitta (1991) recognised seven cultural layers at Ban Don Phlong, and industrial activity was predominant in the area excavated. The remains of a structure with clay walls is interpreted by the excavators as an annex used by prehistoric iron smiths. The structure was destroyed by a fire, evidenced by burnt, fallen pillars and copious amounts of charcoal. A total of 17 furnaces, belonging to three different cultural periods were uncovered. These were of two types, one for smelting and the other for refining. Nitta believes that the prehistoric inhabitants produced wrought iron from locally available laterite or iron rich sand. On the basis of the associated faunal remains, which demonstrate seasonal indicators, the excavator feels that the iron production took place in the dry season, from October to February. His hypothesis receives support from ethnographic research among the hill tribes of modern Thailand who also produce iron during the winter months (Nitta 1991). The iron is thought to have been produced in the third century BC.

Prior to its use in the production of iron, the excavated area was used as a cemetery. Six burials were discovered in a supine position, most orientated with the head to the south. The first interment, an adult male, was encountered in cultural layer four and contained two bronze bangles. The walls of the grave were plastered with clay. Two burials were found in the fifth cultural layer. One was an adult male interred with a bronze bangle, 23 bronze rings and a glass ornament. The other burial contained ten bronze rings but no skeletal remains. The richest burial, in cultural Layer 6, was orientated with the head to the north. The skeleton was accompanied by six bangles, four rings, 10 agate and 31 glass beads. The skull in this interment was covered by a block of clay and the face by a large sherd. Nitta (1991) believes that the body was buried in a wooden coffin and placed in a clay-plastered grave. A clay-lined child's burial was encountered in Layer 7. This individual was interred with a clay block over the head. The grave contained two bronze bangles and one ring. One other burial was discovered in an undetermined cultural layer in the main excavation area. Although badly disturbed it was determined to be an adult male buried with two bangles and a bronze ring.

A test pit excavated 14 m away from the main trench revealed the grave of a small baby, again orientated to the south. The grave contained two ivory bangles and six agate beads and is estimated to have been dug after the deposition of Layer 2 (Nitta 1991).

Ban Takhong

Ban Takhong, is situated near the Lam Takhong, a tributary of the Mun River. This prehistoric site is encircled by two channels.

Three test pits, each 2 x 3 m, were excavated by Moore (1992, 1993) in 1989. The stratigraphy reached a depth of nearly 6 m. The resulting radiocarbon dates and material gathered during survey indicate that the mound was occupied from at least 1500 BC to 1500 AD.

Several features are notable at Ban Takhong, including clay floors and walls similar to those found at Non Yang. Some artefacts demonstrate similarities to other sites in Northeast Thailand. Moore believes that there are parallels between ceramic rollers, for impressing designs, found at Ban Takhong and those uncovered at Ban Chiang in the Songkhram River valley. Parallels are also drawn from pieces found at Ban Krabuang Nok and southern Vietnam.

Four distinct mortuary customs are noted, some of which demonstrate similarities with other sites in the region. The uppermost burials comprise globular open mouth pots, containing human remains, aligned in a row, east to west. Deeper still, a flat-bottomed pot with straight sides was recovered. This vessel, which contained human

remains, was sealed by another ceramic vessel. This type of 'mouth to mouth' placement of burial jars is reminiscent of that at Non Yang. At 3.90 m below the surface a rather unusual interment was encountered. A skeleton was buried upright, in a kneeling position, facing northwest with a number of accompanying pots, including red burnished wares. A glass 'plug' was also found near the right elbow. The deepest burial recovered comprised a large urn, 70 cm long. The vessel was aligned north-south and rested upon a turtle carapace. Moore (1993) believes the urn may have been carried upon the carapace prior to interment as part of the mortuary ritual.

Moore states that two of the four burial forms, the three large urns and the 'mouth to mouth' jars, are often found at Dvaravati sites in central and Northeast Thailand. The flexed burial is unparalleled, as are the jar and turtle carapace.

Ban Krabuang Nok

Ban Krabuang Nok, located near the Lam Sa Thaet River where it joins the Mun, is a 25.6 ha moated site. The mound, which rises 8 m above the surrounding fields, was excavated in 1988 (Indrawooth *et al.* 1990). A 3 x 6 m unit was dug, reaching sterile soil at 8.5 m below the surface. Six cultural layers, comprised of 14 natural layers, were recognised and divided into three phases by the excavators. The first phase is thought to date to *c.* 300 BC-AD 200. The ceramics of this period are red slipped or polished, red on buff. The next phase is thought to date to the Proto-Historic period, *c.* AD 200-900. The ceramic assemblage is dominated by appliqué and cord marked/slipped wares and jar burial was practiced during the deposition of this phase. The third phase is placed in the Early Historic period, *c.* AD 900-1300. The ceramics from these layers are largely locally produced brown glazed wares, similar to Khmer pottery. Cremation replaced the practice of burying the dead in jars and it is thought that the site was under Buddhist influence at this time (Indrawooth *et al.* 1990).

The authors relate the site to others based on ceramics. The first phase is thought to correspond to the late period at Ban Chiang and the fifth and sixth cultural layers at Ban Na Di, in Udon Thani province. This is interesting as there is a considerable distance between Ban Krabuang Nok and these sites. Non Chai and Ban Chiang Hian also share similar artefacts. At the former, the Early period is similar to the first phase at Ban Krabuang Nok as is the second phase at Ban Chiang Hian, located in the Chi River basin (*ibid.*). The second phase at Ban Krabuang Nok exhibits traits that are widespread through the Mun and Chi River valleys, especially the practice of jar burial. Indrawooth *et al.* (1990) believe there are demonstrable similarities between the iron tools from sites in the Chao Praya Valley and those found in the Mun and Chi valleys. The ceramic assemblages from these sites are quite different, however. During the Proto-Historic period, spouted jars began to appear in the Mun Valley which may be related to those found in southern Vietnam. Indrawooth *et al.* (1990) believe these to be of Indian manufacture or at least derived from Indian design. Ceramics of this type do not appear in the Chao Praya Valley. This may indicate that contact with Indian culture and trade items, evidenced in the Mun and Chi Valleys, occurred via the Mekong River valley (Malleret 1959-63; van Liere 1988 in Indrawooth *et al.* 1990).

Ban Ya Weuk

Ban Ya Weuk is located in Amphoe Chumphonburi, Surin Province. A small test pit at the crest of this 5 m high mound was excavated by Suchitta (1983). He posits the site to be contemporaneous with Non Yang, based upon the ceramic types encountered, including red on buff painted wares. Evidence of iron working was also encountered in the form of slag. Analysis has revealed this material to contain a significant quantity of iron. The evident inefficiency in iron production may indicate a low level of technological skill (*ibid.*).

The burial tradition at Ban Ya Weuk is poorly defined. One jar burial containing a human skull similar to those encountered at Non Yang was encountered although the remains were not cremated.

Non Tung Pie Pone

Non Tung Pie Pone, located in Amphoe Bua Yai, Nakhon Ratchasima Province, is a 5.5 m high mound excavated by Nitta (1995, 1997). The mound is one of a pair, Non Tung Pie Pone and Non Sung, the latter of which has been destroyed by road construction. An excavation unit, 5 x 15 m, was situated on the top of the mound. Nine cultural layers were identified in ten layers of stratigraphy. The archaeological features represent, for the most part, the remains of salt making activities. Water tanks and filtration tanks as well as furnaces for boiling water were uncovered. Nitta has interpreted several post holes as representing the remains of temporary shelters used by the workers. The storage tanks were square, thinly-plastered depressions, with a trough leading from one wall. The trough would have been filled with saline soil through which the water would run, being collected in a pot or pit for boiling later. It was apparent that the mound at Non Tung Pie Pone accumulated largely through the dumping of filtered soil.

Most of the pottery from Non Tung Pie Pone comprised round-bottomed, cord-marked bowls. Some sherds of 'Phimai black' were also noted which date the site to the Iron Age (Nitta 1995), an assumption supported by the lone radiocarbon date. The sample from the seventh cultural layer rendered a date of 1740 ± 185 BP (AD 210±185 2σ). The earliest evidence of salt extraction comes from Bo Phan Kan in Roi Et province dating to the fifth century BC (Higham and Parker 1970). There is little differentiation in ceramic form through the stratigraphy at Non Tung Pie Pone, which leads Nitta to suggest a very short period use.

Ban Prasat

The excavations at Ban Prasat, now preserved as a museum, were undertaken by the Fine Arts Department of Thailand in 1991. Ban Prasat is located only 3 km down the Lam Prasat Stream from Ban Lum Khao. Higham (1996a:224) proposes that the site would have been naturally moated during the wet season as the Lam Prasat flooded .

Three excavation units were opened at Ban Prasat, the largest in the centre of the mound, with two other peripheral areas also investigated. The large unit reached a depth of 5.2 m and contained many inhumation burials. A smaller area to the northwest attained a depth of 4.8 m. The remains of a Buddhist *stupa* or religious structure were located in the upper strata but far fewer burials were located in this unit. The third square, located to the southwest of the village, contained six inhumation burials.

The largest excavation area indicates a long and continued occupation of Ban Prasat. The ceramic assemblage suggest that the mound was first occupied around 800-1000 BC. This assemblage is nearly identical to that found at Ban Lum Khao. A thorough comparison is hampered by the paucity of published material on Ban Prasat and the fact that most of the vessels have been left *in situ*. Burials at the lowest levels contain pottery which is red slipped, and often cord marked. The eponymously labelled 'Ban Prasat type' pots have been divided by the excavators into 11 morphological categories based upon their shape. It is important to note that vessels of similar shapes were found in secular contexts as well but were unslipped (Fine Arts Department Thailand 1992).

Globular pots with trumpet rims were found in the earliest burials. These vessels appear to have been constructed in three parts, neck, upper and lower body. The bottom is often cord marked. The interior and upper portions of these pots are slipped with red clay and some vessels have a ring base.

Round-bottomed plates atop pedestals of varying heights were also found. The interior of the bowls were polished, while the exterior is bare. The pots are either red or black, and often decorated with incised lines around the rim. A conical bowl with a flat bottom is described, in which the body is indented just before the rim. The rims are either rounded or flat and the vessels are plain.

Globular pots with short necks and wide mouths were also found. Many have a cord-marked exterior although some are polished. Another pot of similar morphology is the potted jar. This vessel is distinguished by a flat base which the excavators believe indicates its use in storage (*ibid.*). The shoulder is often decorated with appliqué, above which are red painted curvilinear designs and below, vertical red stripes run atop cord marking.

Vessels called 'small pots' are described as having a fairly flat bottom. The contour of the body is quite straight and the neck is long and slightly flared. Tubular jars are vessels with a slightly concave body, a flat bottom and a straight rim. The interior and exterior of these pots is polished.

'Phimai black' vessels were found in abundance at Ban Prasat. Most are highly polished black pots, although some are oxidised and others, slipped with red clay. These vessels have been grouped into round-bottom bowls with and without a foot, round-bottom plates, small conical bowls and small round-bottom bowls. The first is described as semi-spherical with a rounded, flat or indented rim. These are highly polished although some are slipped and then polished. It is this type of bowl which was occasionally found buried rim to rim containing human remains. The globular bowls with foot ring were very similar to the preceding vessels although the exterior often exhibits fire clouds and a yellowish-grey colour due, probably, to an insufficient reduction of oxygen during firing. The round-bottom plates are described as being shallower than the bowls but otherwise very similar, as is the case with the small round-bottom bowls. The small conical bowl is said to have a straight body contour indented just before the rim, which may be round or flat.

The next group of vessels described appear to be distinguished on the basis of stratigraphic location, being attributed to the Dvaravati period. These carinated pots are divided into three groups, round-bottomed, round-bottomed footed and flat-bottomed. No other information is provided concerning these vessels (Fine Arts Department Thailand 1992).

Miscellaneous ceramic artefacts recovered from Ban Prasat include conical spindle whorls. Other items uncovered include anvils used in pot manufacture and clay hunting pellets, anthropomorphic figurines and round, tubular and disk-shaped beads. Artefacts relating to the production of metals include clay moulds, one in the shape of an axe, and clay crucibles.

Most of the bronze artefacts recovered comprise decorative items. Finger and toe rings were found in several burials. Some of these were zoomorphic, but a more common design is two fused rings. Bangles range in diameter from 4 - 6 cm. These were either round or square in section and some are made from a flattened sheet of bronze. A considerable degree of craftsmanship is evident in one bangle which is hollow and filled with bronze pellets. Other ornamental items include bells, which comprise a hollow bronze ball containing a pellet, and earrings. Small bronze coils were found in the upper layers of the stratigraphy. These were made by coiling bronze wire up to eleven times forming a ring. These are very similar to those recovered at Non Muang Kao. The coils were often found in association with bimetallic bangles at Ban Prasat. These rings are fashioned of bronze and sheathed in iron. These are the only iron artefacts from burial contexts, although some artefacts were found in occupation deposits. Two burials contained bronze ornaments which are of note, one is a forehead band with coils sitting over the cheeks, similar to those recovered at Noen U-Loke (Higham pers. com.). The position of the other ornament is unclear but

it appears to be a flattened crescent of bronze decorated with short curved wires.

Stone was used in the manufacture of several items at Ban Prasat, including adzes which appear to have been used only ceremonially as evidence of use-wear is absent (*ibid.*). The adzes are made of both locally available and imported lithics. Three marble bangles were found in two burials. Exotic stone was used in the manufacture of beads and pendants. Carnelian and agate were used for beads of many forms, including balls, tubes, barrels, elongated septagons and octagons. Beads found in the upper layers of the site were made from glass in many colours and fragments of glass bangles were found in blue and deep blue.

Shell beads and bangles were also encountered during the excavation. The majority of beads are disc shaped, although some were tubular. The bangles are robust, having an average diameter of 8 cm, the largest being 16 cm across. It appears that these were manufactured at Ban Prasat, based on the presence of shell bangle cores.

During the excavation of Ban Prasat a total of 66 burials were encountered. Most were supine, primary interments, although eight secondary burials were found, all of which were infants. The largest excavation unit yielded 38 burials, 22 of which are described. Two distinct burial periods are discerned at Ban Prasat as well as a transitional phase.

The earliest interments were encountered from 4.6 to 5.2 m below the surface. Each of the six graves in this period is orientated to the southeast, with pots placed at both the head and the feet. There is some differentiation in grave goods among the burials which included three males, two children and a female. One male is interred with significantly more pottery than any other burial, with at least 49 vessels. The wealth differences between the remaining burials is not substantial. All the adults have shell bangles and all are buried with more than five vessels each.

A transitional layer begins at 3.3 m below the surface, and is defined by variable grave orientations and a decrease in shell and stone ornaments. Eight burials are included in this layer, all of which are either females or children although the sex of one remains undetermined. The last mortuary phase, containing Iron Age interments, is described below.

The excavation to the southwest revealed 15 burials, of which ten are described in the Fine Arts Department report (1992). Most of these are attributed to the early occupation of the site based upon the ceramics. All are orientated on an east-west axis with the heads to the east.

Two of the burials are adult females and the rest are children. The burial practice in this area saw pots smashed over the bodies, an attribute not widely noted in the main excavation unit. Two interments, a female and a child, contain a bivalve shell and all the other burials, save one, contain pig phalanges. Three of the children's burials contain ochre and five of the graves include spindle whorls, some of which were slipped. Only one of the graves contains bronze, a child wears three bronze bangles as well as one of shell. The skull of one, otherwise complete, adult female skeleton is missing and the knees and feet appear to have been bound (*ibid.*).

Burials ascribed to the Iron Age at Ban Prasat are located 1.9 m below the surface. Seven burials of this period and are orientated either north (n=2) or south (n=5). These interments all contained 'Phimai black wares. The Bronze Age habit of placement of ceramics at the head or the feet is not observed during this phase. Shell jewellery is completely absent but glass beads are abundant. Two children interred side by side, orientated in different directions, have 14 bronze bangles each and many blue glass beads. These graves also contain complete ceramic vessels.

There appears to be a degree of wealth differentiation in this small sample. One male is buried with a small amount of bronze, a pot and some animal teeth, while other burials contain several pots, agate and glass beads, and bronze ornaments (Fine Arts Department Thailand, 1992).

In the northwest excavation unit two more burials, of a total seven, are described in the site report (*ibid.*). One individual, located 2.4 m below surface, is buried with 14 bronze rings, placed over the skull. More bronze rings were found on the legs and fingers. The other complete burial, orientated to the south, contains seven bronze bangles and several rings scattered near the head. A small perforated iron disc was found by the pelvis and 'Phimai black' sherds are scattered around the body.

One of the 15 burials in the southwest excavation area (described above) is ascribed to the Iron Age. It is located 1.48 m below the surface and the head is orientated to the west. The grave includes bronze and bimetallic artefacts. Ten bronze bangles and numerous bronze coils are distributed throughout the burial.

Ban Suai

Located within the precincts of modern day Phimai, Ban Suai is a 2 to 3 m high mound located to the southeast of the Khmer temple ruins. The western portion of this mound had been levelled prior to excavation which took place in 1966. Four 3 x 1.5 m units were dug atop the mound, with another two located at the foot of the face exposed by levelling. Thirty metres from these excavations, a 4 x 4 m unit was dug on the levelled surface. The preliminary results are set out in an unpublished manuscript (Parker 1966) and summaries of the excavation have been published (Solheim and Gorman 1966; Solheim 1970) as well as the results of the ceramic analysis (Solheim and Ayres 1979).

The sequence revealed through the excavation atop the mound was 1.6 m deep with eight layers being recognised (Parker 1966). The first four comprised modern and prehistoric sherds, below which were layers containing mostly 'Phimai black' ware and plain earthenware. Layer

5 was approximately 15 cm thick and Layer 6 was found to be a complex deposit, which was subdivided into three sections. Layer 7 comprised a thick band of eroded soil through which was cut an erosion channel. The final layer was a 10 to 20 cm thick band of yellow-brown soil containing animal bones and large pot sherds. The natural substrate was seen to be very similar to Layer 8. The presence of iron and 'Phimai black' sherds throughout the strata suggests the mound accumulated during the Iron Age.

The cleaning of the exposed face revealed large quantities of pottery, animal bone and beads which appeared to be midden deposit (Parker 1966). The large unit, 30 m to the southeast, revealed a very interesting feature. The greater part of the square was occupied by a shallow bowl shaped depression in the centre of which was a low rectangular platform formed from lumps of burnt clay. The platform was 3 x 2 m and 10-15 cm in height. It was apparent that a series of burning events had taken place on the platform, resulting in a blackened surface. Imbedded in three of the corners were pots which contained unburnt human bone. One pot had bone remnants and a bronze finger ring, the other two vessels contained what appeared to be complete skeletons. This is somewhat reminiscent of modern mortuary practice in Cambodia where in some communities, four pots of rice are cooked in the corners of a funeral pyre (Mabbett and Chandler 1995).

Of the three radiocarbon dates obtained, its seems two were either intrusive or contaminated. Two samples recovered from the units atop the mound resulted in dates of 280 BP for layer 6b (Gak 992) and the date for layer 7 (Gak 1035) was modern. The third sample (Gak 991) from Layer 6 was more promising, rendering a date of 1930±100 BP calibrated to 165 BC- AD 240 (Klein *et al.* 1982 in Welch 1985).

Lam Phla Phloeng Rock Shelters

The Lam Phla Phloeng is a tributary of the Mun River, the valley of which was found to contain a number of rock shelters. Investigation of these revealed sand tempered pots which were similar in morphology to 'Phimai black' vessels and test pits indicated that the occurrence of chaff-tempered ware increased with depth (Green n.d. in Welch 1985). Radiocarbon determinations suggest the sites were occupied *c.* AD 410-765 (2σ) (Klein *et al.* 1982 in Welch 1985). Welch notes that this date is congruent with the ceramics found, with 'Phimai black' ware being replaced by a heavier sand tempered pottery. It is possible that these shelters were used by agriculturalists during hunting and foraging expeditions (Solheim 1967).

Nakhon Ratchasima (Khorat)

Excavations within the walls of the city of Nakhon Ratchasima were undertaken in 1979 by Prayoonsak Chimchang, leading to the discovery of two burial phases. The uppermost burials, located some 50 cm below the surface, were interred with 'Phimai black' vessels while burials 1 m below these were buried with red slipped and red on buff wares (Welch 1985).

Non Dua

Non Dua, located on a tributary of the Mun River, was identified during a survey in 1970 (Higham 1996a). This moated site is approximately 2 km long and 1 km wide. Excavations in a 2 by 2 m unit revealed a stratigraphy comprising 18 layers to a depth of 4.5 m. Ceramics from the earliest levels are predominantly polished and red slipped, many with painted rims. These were found in context with iron artefacts. Another distinct ceramic assemblage was encountered above this beginning in layer 11, characterised by smoothed cord-marked sherds which are often painted with alternating broad and narrow, red-brown and white bands ('Roi-et'/'Thung Kula ware'). The temper is almost exclusively rice chaff. Above the layers containing 'Roi-et wares' lay strata containing mostly plain, white, sand tempered pottery. The radiocarbon dates obtained were problematic but Higham (1977b) has pooled these to formulate a chronology in which Phase 1 dates to 500-1 BC (2σ), Phase 2 to AD 1-700 (2σ) and the final phase to AD 700-1000 (2σ) (Stuiver and Reimer 1993).

Bo Phan Khan and Don Taphan

The phases delineated at Non Dua were readily identifiable at the adjacent sites of Bo Phan Khan and Don Taphan. At the former two, 2 x 2 m squares were excavated while one 2 x 2 m unit was dug at the latter. Bo Phan Khan was excavated to a depth of 5.3 m in which were 24 layers. The excavations confirmed the suspected use of the mound in salt extraction. In some layers the remains of clay-plaster were found which may represent the same type of feature found by Nitta (1997) at Non Tung Pie Pone. The pottery from the basal layers to the surface was akin to that of Phase 2 at Non Dua, although most of the sample comprised coarse ware which is thought to have been used in preparing brine. Radiocarbon determinations from the basal layers provided a date of AD 228-597 (2σ) (Stuiver and Reimer 1993).

Don Taphan is a 15 ha mound and excavations at the edge reached a depth of 5.85 m, containing 61 layers. The basal layers contained 'Roi-et ware' and dated to 250 BC-AD 341 (2σ) (Stuiver and Reimer 1993).

Muang Phet

The 6 ha mound of Muang Phet, surrounded by two channels and three earth banks, is 3 m in height. Quaritch-Wales (1957) commenced excavations on the top of the mound in 1955, digging an 18 ft (5.4 m) trench and a 7 (2.1 m) x 9 ft (2.7 m) area adjacent to it. Although the first metre of stratigraphy was badly disturbed, two occupation episodes were discerned, the first (Period II) began 97 cm below the surface and the second (Period I), began 1.32 m down reaching a depth of 2.72 m. Period I contained

ceramics described as fine black ware, thin brown cord-marked and coarse red and yellowish wares. There was also iron present in the Period I deposit. Period II sherds comprised mostly red and yellowish coarse ware as well as fine white wheel made pottery.

The original interpretation of the site has been challenged based upon the recent excavation of test pits at Muang Phet (McNeill 1997). The new excavations atop the mound found Quaritch-Wales' interpretation of the stratigraphy to be fairly accurate if a little simplistic, delineating nine layers where Quaritch-Wales had seen three. Layer 1 was largely disturbed, reaching a depth of 25-35 cm and Layer 2 and 3 corresponded with Quaritch-Wales' Period II. These strata contained chaff and grog tempered sherds. The fourth layer was transitional, containing sherds found in the layers above and below it. From Layer 5 to the bottom, the ceramics were mostly 'Phimai black', plain black and plain wares and corresponded with Quaritch-Wales' Period I. A charcoal sample from Layer 5 rendered a date of AD 260-320 (2σ) (Stuiver and Reimer 1993) which accords well with the date published by Quaritch-Wales. The second test pit excavated was located on the innermost rampart. The radiocarbon results (AD 210-530 2σ) (Stuiver and Reimer 1993) from the base of the wall indicate that the 'rampart' and 'moat' may be contemporaneous with the earliest occupation of the site.

The reassessment of the chronology at Muang Phet has pushed the original occupation and abandonment of the mound back to the Early Historic Period, a much earlier date than that suggested by Quaritch-Wales (1957).

THE INVESTIGATION OF CEMETERIES IN NORTHEAST THAILAND

There have been four major excavations of Bronze Age cemeteries in Northeast Thailand with extensive mortuary assemblages. Ban Lum Khao has been fully described in volume I of this series (Higham and Thosarat 2005). The other three sites are not located in the Mun River valley the results obtained are nonetheless pertinent from an analytical as well as a comparative perspective.

Non Nok Tha

Non Nok Tha, excavated in the late 1960s, has elicited considerable discussion, focused mainly on the chronological interpretation of the site (c.f. Helms 1994, Bayard 1996). This site, which is located in the Chi River basin, represents one of the first large scale explorations of a Bronze Age cemetery in Thailand, comprising 217 mortuary contexts in an excavated area of 340 m^2. The mound itself is inconspicuous, being a little over 1 m in depth and covering just 1.5 ha. Higham (1996a) strongly supports an initial occupation date of Non Nok Tha in the second millennium BC, based upon recent AMS dates, far later than those suggested by Bayard (1971a, 1972).

The cemetery is divided by Bayard into a series of mortuary periods, early (Phu Wiang), middle (Non Nok Tha) and late (Don Sawan), differentiated technologically. The most numerous artefact type at Non Nok Tha was the ceramic vessel, the numbers of which varied between interments. After categorising these vessels based upon their morphology, Bayard (1984) recognised some exclusivity in certain forms. The absence of any dramatic mortuary differentiation in other artefact items led him to conclude that the exclusivity evidenced by the ceramic vessels represented two separate groups of affiliated people. He further hypothesised that one of these groups was slightly wealthier than the other.

Bayard's interpretation has been questioned, primarily because the vessel forms used in the original interpretation were not mutually exclusive between the groups (Higham 1994). An alternative interpretation is suggested in which the different vessel morphologies represent chronological rather than social factors. The wealth differences in this interpretation may be related to chronology, where later graves are comparably richer (*ibid.*).

Ban Na Di

Ban Na Di, located in the Pao River valley, was excavated in 1980-1. Eight layers were distinguished in an area of 65 m^2, and the natural substrate was reached at a depth of the 4.2 m. Sixty burials were discovered, most being orientated in a north-south direction. Men were buried with their heads to the south and women to the north. Infants were interred in jars or inhumed close to adults. Higham (1996a) believes that the cemetery represents a short span of time as the ceramics are similar and there is little variation in the mortuary ritual. It is, however, possible to divide the interments into a number of phases based upon superposition.

In the earliest phase (1a) bronze was relatively scarce but these artefacts became more numerous in the next phase (1b). The last phase (1c) again revealed an increase in the number of goods buried with the dead. The excavation of two separate areas at Ban Na Di allowed a comparison of graves from widely-separated parts of the cemetery. It was noted that one area contained burials that were notably richer, yet were contemporaneous. This distinction has led Higham to propose that the individuals buried in the area with the wealthier graves were of a higher status. The exclusive presence of crocodile bone in some of the richer burials has also been hypothesised as representing a symbolic distinction between the groups. The charcoal from which the radiocarbon dates were taken form a terminus post quem for the burials and render a pooled date of 1313-903 BC. Only the latest graves contained iron artefacts at Ban Na Di.

Ban Chiang

Ban Chiang, located in the upper reaches of the Songkhram Valley, has been excavated on a number of occasions, the last time in 2003. Although no final report is available, it

is possible to assess the structure of the cemetery based upon preliminary reports. Bronze was used by the initial occupants of the area excavated in 1975, as it appears in the earliest burials. These were dated by the excavators to 3500 BC (Gorman and Charoenwongsa 1976), a date that caused a great deal of interest in the site as it predates the inception of bronze technology in Mesopotamia. It has become apparent that these initial dates are inaccurate. No other site in Southeast Asia has revealed a comparable date for bronze technology. It is generally accepted that the earliest Bronze Age burials at Ban Chiang date from the mid second millennium BC (Higham 1989, Pigott 1992, Higham 1996a).

White (1986) has divided the burials at Ban Chiang into three periods, Early, Middle and Late, which are subdivided into phases. The burials at Ban Chiang are orientated just west of north, and infants were interred in jars during some periods and inhumed during others. The grave goods comprise predominantly ceramic vessels, with most individuals being buried with between one and three pots. These were usually placed at the head or feet (Higham 1996a). During the Early Period the graves were orientated for the most part, just west of north and infants were interred in jars. The Middle period burials, which are richer than those preceding them, are seen to cluster.

BRONZE AGE SOCIAL ORGANISATION[1]

Regarding Bronze Age social organisation, Higham (1989:153) has remarked that "only partial conclusions or tentative statements may be made on the basis of the available evidence." Regrettably little has changed and we must rely upon the preliminary reports from Non Nok Tha, Ban Chiang and the more comprehensive data from Ban Na Di in an assessment of Bronze Age social organisation.

The differential wealth observed in the burials from separate areas at Ban Na Di may indicate some form of social hierarchy. Higham (1989) has proposed the possibility that the wealthier group had access to valuables which symbolised rank. It is further proposed that these individuals may have been related. Bayard (1984) too, has perceived two groups differentiated by wealth in the Non Nok Tha cemetery. During the Non Nok Tha phase the site may have been used by these two affiliated groups as a cemetery. It must be stressed that evidence for hierarchical organisation is very weak.

Site surveys carried out in the region (Kijngam *et al. 1980*) found no evidence for regional centres or large settlements that may have held hegemony over satellite sites. This evidence, combined with that from the cemeteries at Non Nok Tha and Ban Na Di has led Higham (1989) to suggest that there existed, in the Chi River valley, a network of autonomous villages. He believes that these communities may have comprised affiliated kin groups that exhibited differential rank. Such an organisation would be congruous with models of a segmentary society as Higham (1989) has proposed. Individuals in a simple chiefdom are ranked based upon their sanguineous relationship to the chief, a relationship which may be reflected in the evidence from Ban Na Di and Non Nok Tha. The lack of larger centres during this period would suggest a simple chiefdom rather than a paramountcy. There is, however, a notable lack of military paraphernalia at both Ban Na Di and Non Nok Tha. As we have seen chiefdom societies are often characterised by frequent warfare. The presence of a bronze spearhead in an Early Period burial at Ban Chiang reveals that the technology was familiar. It is difficult to envisage taphonomic factors being responsible for the lack of bronze military implements, but one may consider the possibility that such items were excluded from the mortuary ritual. An alternative explanation for the lack of military paraphernalia is an absence of warfare. Chiefdom societies resort to conflict most commonly in bids for territorial conquest. The fact that, on present evidence, the Mun River basin appears to have been sparsely occupied before *c.* 1500 BC may indicate that there was ample room for expansion from the Chi drainage basin. This outlet may have had the result of diminishing conflict over land.

A tribal organisation of Bronze Age societies in the Songkhram Valley is another alternative, although consanguineous relationships are not generally attributed to this type of social organisation. The ascription of wealth to infants is another indication that wealth and perhaps status was inherited, a trait not usually associated with a tribal organisation. The lack of weaponry is also perplexing if we are to consider these cemeteries as representing a tribal society. Warfare is perhaps an even more prevalent aspect among these societies than among chiefdoms. Apart from cultural, ritual or economic reasons there are no satisfactory explanations for the lack of weaponry in interments if these cemeteries represent the remains of tribal societies.

IRON AGE SOCIAL ORGANISATION

Higham and Thosarat's findings at Noen U-Loke seem to support the hypothesis that social hierarchies existed in Iron Age cemeteries in Northeast Thailand. The fact that rich graves were associated with exotic carnelian, agate, gold, silver and glass jewellery as well as an impressive range of bronzes suggests that redistribution and craft specialisation may have been at work within the community.

Evidence from Noen U-Loke indicates a concentration of wealth in the hands of some individuals. Other indications of developing complexity include the production of bronze and iron weapons and tools. Exotic stone and

1. Since this section was written, unpublished excavations at Ban Non Wat have revealed Bronze Age graves containing individuals of outstanding mortuary wealth (editors)

glass ornaments are testament to an established and wide-ranging exchange network. The distribution of these items does not appear to be egalitarian. Some individuals at the cemetery in Noen U-Loke appear to have been interred with more artefacts of greater value than others and this may be indicative of a hierarchical social structure.

CONCLUSION

On the basis of available evidence, it appears that the Mun River valley was unoccupied prior to *c.* 2100 BC, the date for the earliest Neolithic occupation of Ban Non Wat (Higham and Thosarat 2006). Welch (1985) hypothesised that the initial colonists of the Mun River valley were responsible for producing the 'Tamyae tradition' ceramics that he believes date from 1000-600 BC. This ceramic tradition is superseded by 'Prasat phase' pottery which Welch (1985) dates from 600-200 BC. Ceramics recovered from pits excavated into the natural substrate at Ban Lum Khao are thought to belong to Welch's 'Tamyae phase'. These ceramics are thin bodied, fine textured, earthenwares which date to *c.* 1280 BC (Higham T.F.G. 2005). Lying on top of the pits and separated from them by a shell midden are the burials, which contain 'Prasat tradition' wares. These burials date to some time after the earlier 'Tamyae phase'. Regrettably, a reliable date was unobtainable. It may be prudent to expand the original chronological depth of the 'Tamyae' and 'Prasat' traditions, as the earliest wares are quite distinct from all 'Phimai tradition' vessels. There may indeed be some continuity in ceramic production from the Bronze Age into the Iron Age, evidenced in the vessels recovered from the later burials at Ban Lum Khao and those from the earliest burials at Noen U-Loke.

The culmination of the ceramic development during the prehistoric era in the upper Mun River valley is found in the 'Phimai black' ceramic tradition. Vessels are invariably discovered in archaeological contexts associated with the Iron Age. During this period there is also a proliferation of bronze ornaments in graves as well as the appearance of glass beads and semi-precious stones such as agate and carnelian. These developments signal not only technological advances but also the expansion of interaction networks. There is a possibility that some of the glass found in the sites of the Mun River valley originated in India. Evidence of early trade links with India are found at Ban Don Ta Phet in central Thailand and Khlong Thom in Krabi province. At the former artefacts engraved with South Asian motifs have been found (Glover 1989) and similarities between bronze artefacts from Ban Don Ta Phet and sites in Southern India have been highlighted (Rajpitak and Seeley 1979). Khlong Thom has provided possible evidence of trade links with the Roman Empire in the form of seals dated to *c.* AD 161-180 (Veraprasert 1992). It should be noted, however, that much of the glass recovered from Khlong Thom was produced indigenously as may be the case at Non Muang Kao and Noen U-Loke where industrial features, interpreted as possible glass manufacture locales, have been uncovered.

The Iron Age settlements in the Mun River valley appear to be much larger than those of the Bronze Age. There is also an apparent proliferation of sites in low-lying riverine swamplands suited to rice cultivation. These sites are also often surrounded by moats.

SYNTHESIS

Non Muang Kao was occupied from around the beginning of the first century AD and abandoned sometime during the Early Historic period. The site was probably selected for settlement due to the presence of a natural mound in close proximity to a river. Such a location afforded the occupants protection from floodwater and enemies as well as access to a major trade and communication route.

It is apparent that the area excavated saw a variety of uses including, habitation, industrial activity and disposal of the dead. Only eleven mortuary contexts were identified making it difficult to assess the nature of the mortuary regime and the chronological sequence. Stratigraphic location and interment morphology are perhaps the best indicators of contemporanaeity. All but one of the mortuary contexts are orientated on a north-south axis suggesting a degree of continuity in mortuary practice. Five periods are discernible. Several burials above 2.5 m bd were enveloped in a layer of white clay, most containing rice. Burials below this level were not clay-lined but did contain rice. There is also a recurring grave assemblage of shallow, streak burnished, 'Phimai black' bowls, pot sherds and copper alloy artefacts such as bangles.

Another interesting component of the site was the discovery of ten successive clay floors. The first eight were constructed successively on top of one another. There are several possible explanations for the intriguing clay floors at Non Muang Kao. They may represent work areas, perhaps for rice threshing. It is also possible that the clay floors represent domestic occupation. A possible association with interments must be considered. Several of the graves were lined with white clay, similar to that of the floors. The clay floors were frequently found in close association with burials, a relationship being very difficult either to confirm or dismiss.

It is regrettable that the soil at Non Muang Kao was so hard, ruling out a larger opening in the time available. It is, nevertheless, possible to delineate certain similarities between this site and other Iron Age settlements.

The clay floors encountered at Non Muang Kao are also reported at Non Yang (Nitta 1991) and Ban Takhong (Higham 1996a). The excavators of these sites also reported encountering bowls placed mouth to mouth, a practice seen at Non Muang Kao, Noen U-Loke and Ban Prasat during the Iron Age.

There is also a marked degree of similarity in the ceramic assemblage of these sites. All contain 'Phimai black'

ceramics, a tradition particularly dominant within a 50 km radius of present day Phimai. There also appears to be evidence for cultural continuity in the transition from the Bronze to the Iron Age in the region. This is especially evident in some ceramic forms where early Iron Age vessels appear to have precursors in the Bronze Age assemblage. The possibility of continuity is intriguing as there appears to be a dramatic shift in the mode of ceramic production in the Mun River valley. It appears that the manufacture of ceramics shifted, from the household during the Bronze Age, to a specialist niche during the Iron Age. Evidence for this is circumstantial but the abundance of tools used in ceramic production found at Bronze Age sites and the rarity of these artefacts in Iron Age sites is suggestive. There is also a marked uniformity among ceramics found at Iron Age sites.

The continuity demonstrated in the vessels from late Bronze and early Iron Age sites would seem to indicate a stable population base. It does not appear as though there were any population movements or cultural intrusions at the inception of the Iron Age and sites appear to be continuously occupied (ie. Ban Prasat, Noen U-Loke). The shift in the mode of production is, however, of immense importance when considering the political and social structure of prehistoric society. The corporatisation of ceramic production may represent a major change in the lifeways of the people of the area and could be indicative of sweeping cultural change.

Although no statistical analysis of the mortuary population at Non Muang Kao was possible there are a number of important and interesting differences between it and the population from Ban Lum Khao. Perhaps the most striking is the amount and range of grave goods found at Non Muang Kao. There are several exotic materials included in these graves that are not found at the earlier site. These items evidence technological advances and the possible expansion of trade networks that occurred after the Bronze Age. Bronze is commonly encountered in the graves from Non Muang Kao, fashioned into rings, spirals and bells often evidencing a high degree of technical skill. Iron is present at the site as well, found as tools outside mortuary contexts and often combined with bronze in jewellery found in graves. There is evidence of large quantities of rice being placed in many of the graves, a sign, it could be argued, of surplus agricultural production. Another interesting and important change is in the ceramic assemblage. All the interments at Non Muang Kao contain ceramics that are part of a large regional pottery complex. It is likely that these vessels were produced off-site as no evidence for ceramic production was encountered during the excavation of the site (nor was it encountered during the excavation of Noen U-Loke). This may signal increased specialisation and regionalisation by a political entity.

Clarification of this point is assisted through the inclusion of some of the evidence from Noen U-Loke. Several factors are of interest, including evidence of significant disparity between interments. Some individuals have no grave goods while others are adorned with incredible numbers of bangles, rings and necklaces made of precious metals. Another significant observation is the nucleation of burials. It could be argued that this is due to an increase in the importance of consanguine relationships. Hierarchically organised entities such as chiefdoms regularly stress the importance of kinship, a dimension often reflected in mortuary patterns. Several clusters include an outstandingly rich individual and the groups seem to have recurrent singular characteristics. There is also an apparent increase in the differentiation of the sexes through the inclusion of certain burial goods. Only males were buried wearing bronze belts and were often found with bimetallic rings in the area of the groin.

Evidence of conflict is another notable feature at Noen U-Loke. Several burials included iron spears and knives and there is evidence of trauma suffered by two individuals incurred, possibly, during combat. The large number of Iron Age sites in close proximity to both Non Muang Kao and Noen U-Loke may be indicative of a population increase and attendant competition over resources.

The number and quality of bronzes appears to increase dramatically at Iron Age sites compared to Bronze Age sites. The method of production also seems to be more technically demanding, many items encountered at Noen U-Loke having been made using the *cire-perdu* method. There is further evidence of enhanced technical expertise in the bimetallic jewellery found at both Non Muang Kao and Noen U-Loke as well as in the application of gilt to some items at the former site. There is some indication that glass was also manufactured during this period.

The purpose of the moats that surround these sites remains enigmatic. It has been hypothesised that they served defensive purposes. Such a proposition is unlikely based on the morphology of the channels. Defensive ditches are likely to be V-shaped in section to impede attackers more effectively. The channels around the Iron Age sites so far investigated are flat bottomed and would have held no more that a metre of water (Boyd pers. comm.). Other possibilities include agricultural purposes for the moats. This is improbable if the hydrological analysis is correct as the channels would have held flowing water unsuitable for rice agriculture although aquaculture or the cultivation of aquatic plants is a possibility. There may, alternatively, have been some religious significance to the channels or perhaps they share a similar purpose as that proposed for the European forts, ostentatious display.

It is possible that the channels did serve a defensive purpose, but from another kind of enemy. Evidence from other parts of Thailand, China and Denmark offer insights into the climatic regime during the Iron Age. There appears to have been a change in Thailand to a wet environment *c.* 3500 BP (Nutalaya and Sophonsakularat 1988). Han dynasty annals report crop losses, rain and cold from

207-205 BC (Anderson 1987). This type of climate appears to have had a global effect. Evidence from Danish bogs indicate an abnormal amount of rain during the same period in northern Europe (*ibid.*). A 5 m flood deposit at Ban Non Chai appears to be coincident based on C14 dates. According to Nutalaya and Sophonsakularat (1988) the Mun and Chi Rivers carried excessive discharges during the period 2,270 ± 70 to 1650 ± 90 years BP, a period coincident with the Iron Age in Thailand.

One must consider the possibility that the channels around the Iron Age sites were constructed as part of a flood defence. The proliferation of Iron Age sites on the agriculturally marginal "higher terraces" noted by Moore (1988) may represent an attempt to escape flood-prone valleys. A corollary of this environmental stress may have been the need for an increase in centralised control and a development of hierarchical structures, the evidence of which have just been described. It is also possible that this flooding and the consequent deposition of alluvium may explain the rarity of 'Neolithic' sites on the Khorat Plateau.

PART FOUR
XXXVI. THE ARCHAEOLOGY OF SALT PRODUCTION

P. RIVETT AND C.F.W. HIGHAM

The importance of salt has been widely recognised as a major factor in coastal Southeast Asian economics (Reid 1988:28-29), this is no less so for the hinterland. In the thirteenth century Zhou Daguan, a Chinese envoy at Angkor, mentioned that ". . . l'exploitation des salines n'est soumise à aucune restriction" (Sahai 1970:117). An Angkorian text inscribed in AD 934 mentions the existence of an inspector of salt, which testifies to the existence of a tax that was in effect in pre-Angkorean times (*ibid.*). The exploitation of salt in Northeast Thailand was underway by at least the middle of the first millennium BC at Bo Phan Khan in Roi-et Province, where extensive salt working mounds clustered round the large moated site of Non Dua (Higham 1977b; 1996:218). Recent excavations by Nitta (1992, 1997) at the salt-making site of Nong Tung Pie Pone, just to the north of the current study region, gives important information regarding the nature of the technology, the date that it was first introduced, and the processes that were involved in its production. This site dates from the first - sixth century AD. Perhaps more important than the date was the recovery of a variety of structures used in the salt-making process. Water tanks, troughs for the filtration of salty water, and furnaces for boiling the brine were recovered, structures that resemble those used today (Nitta 1992:65-6). Nitta argues that Nong Tung Pie Pone represents a site that underwent salt-making for only a short duration, and that many furnaces were run at the same time. The process of salt production means that the mound accumulates quickly (Figs. 36:1-3, Pendleton 1962:256, Nitta 1992:66) and as each mound is abandoned, new sites to continue the activity are founded nearby; thus, the perpetuation of the industry and the expansion of territory. The best places for these sites are along the edges of flat stream valleys that are flooded during the rainy season. We would expect, then, large numbers of salt-making mounds in clusters close to habitation sites and adjacent to stream valleys.

Such a cluster lies to the southwest of Phimai. This dome, centred on the moated site of Ban Bing, has a total of 25 salt-making areas represented by small mounds rising above the alluvial plain. These salt-making mound show up clearly on the aerial photographs (Fig. 36:4).

If we look further afield than the area surveyed by van Liere, we can see that there are large numbers of these sites in close vicinity. In nearly all cases they are associated with a prehistoric site, or group of prehistoric sites and located close to former river channels. There is a total of 86 possible salt-making mounds, with 67 (78 per cent) clustered in the southeast section of the study area with Ban Bing in the centre (Fig. 36:5). The overall nearest neighbour statistic for the salt mounds is R = 0.3055, which indicates strong clustering. Although it is difficult to date these sites, surface remains suggest that they were of a similar antiquity to those excavated by Higham (1977b). There is also pottery dating to the historic periods of Ayutthaya and Sukhothai, which gives some indication to the impor-



FIG. 36:1 The process of salt making in the area of Noen U-Loke, involves scraping up the salty surface soil, as seen in the background, and bringing it to a working place where it is processed. This results in mound formation



FIG. 36:2 The salty soil is placed in a wooden trough, and water passed through it is collected as brine at the base. Here the worker is collecting the brine before taking it to be boiled

tance and duration of the industry.

In a late nineteenth century account of these sites. McCarthy (1902:27-28), who spent 12 years surveying Thailand, notes that the Boribun River was brackish and that large supplies of salt are obtained from this region. The Boribun is a tributary of the Mun River and is flows to the south of Ban Bing. It is the river where the Khmer temple sanctuary of Phanom Wan is located.

We suggest six topics that this distribution introduces: the availability of natural salt domes; the targeting of fish from the Mun River; trade; distribution and spread of the mounds; the effect on the environment; and independence or co-operation. First, these salt mounds are located on a naturally-occurring salt dome. Relatively recent upward tectonic movement has seen the solid rock salts of the Mahasarakham formation move closer to the surface. As a result of this movement, in some areas the salt is closer to the surface and during the dry season thick layers of crystallised salt are brought to the surface due to the evaporation of water. As this causes salt domes to occur in specific places, the salt-making sites are distributed accordingly, hence the clustering and the localised activity of salt production. But why did this develop?

Second, these salt flats are located very close to the former river channels of the Mun River (Fig. 36:5). This is the major river running through this region of the Khorat Plateau and has vast quantities of fish. The traditional mainstay of the Northeast Thai diet is preserved fish and sticky rice and recent excavations at Ban Lum Khao (Thosarat 2005) show the importance of fish during this time. It is plausible that substantial numbers of fish were being caught at these communities situated near the major



FIG. 36:3 The brine is boiled until only the salt remains. The finished product is seen in the basket at left, and is widely traded

rivers. Although we are not arguing for a simple causal explanation for the development of techniques for preserving fish, there cannot be much more to the equation than fish + salt = preservation for the dry season. As this technique developed, substantial quantities of fish were potentially being preserved leading to the proliferation of salt-making sites in the area of these salt domes.

This leads to the third point, trade. The assumption being logically that the exploitation of these two resources, and the supplementation of the diet over the dry season, led to the full-time production of salt by some communities during the dry season. The abundance of sites implies that this was a worthwhile pursuit, otherwise the activity would have discontinued. Alternative dry season activities would have amounted to some fishing, limited to the larger rivers, and the scavenging for food such as crab, frogs and wild roots. As in West Central Africa, the dry season sees little activity in agricultural terms and it was a period when people waited for the rains (Lovejoy 1986). The production of salt on the scale seen in Northeast Thailand, while not comparable to Africa, was still substantial (Nitta 1992:66), and would undoubtedly have created a surplus in either salt as a raw material or preserved fish, perhaps both. Due to the apparent lack of evidence for salt production in other parts of the region, apart from a few confined areas of small clusters that would have been enough for local uses, it was plausible that there was some demand coming other areas.

In Belize, prehispanic Mayan salt-making sites have also been excavated. There is debate whether production was for community consumption (MacKinnon and Kepecs 1989) or whether it was produced to preserve fish for export into the interior (Valdez and Mock 1991). A complicating factor is that salt is not recovered archaeologically, so it is difficult to develop notions of trade and the role of salt production in these complex societies (Marcus 1984, 1991). This is a similar situation to Northeast Thailand, where production implements are recovered, techniques can be reconstructed, but we have no way of knowing the volume of salt production or the salt trading networks. Hypothetically, salt could have been moved two ways - down the Mun River, or across land. In the case of the former, it is interesting to note that Phimai is situated directly downstream from these sites. Phimai acted as the symbolic centre of this part of the Khmer empire, and perhaps the economic centre for some time prior to this. There is an early brick structure directly underneath the present temple (Talbot and Janthed 2000), and given its



FIG. 36:4 Air view of Ban Bing, showing the location of salt making mounds

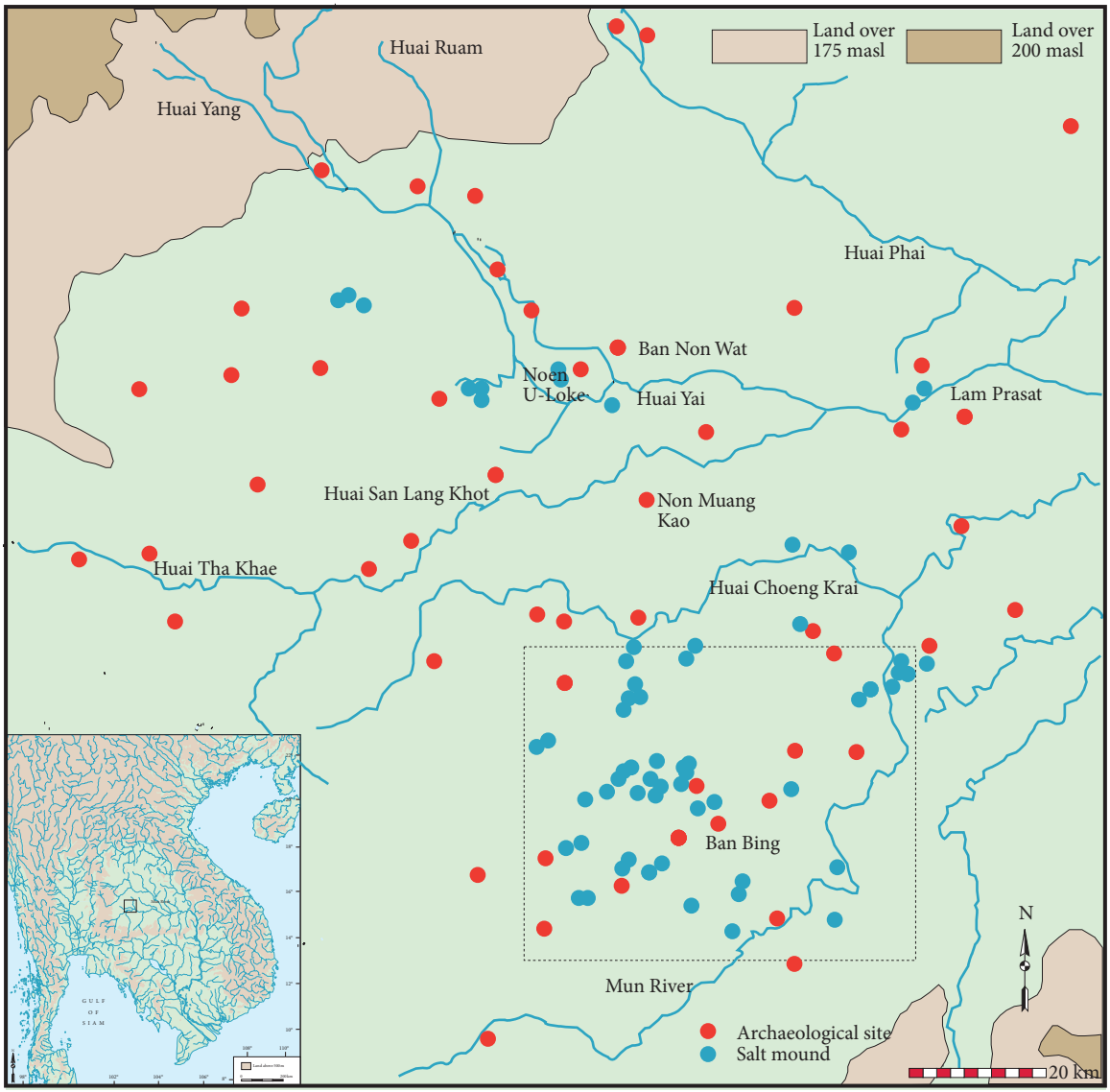


FIG. 36:5 The distribution of salf making mounds. The sites within the enclosed area surrounding Ban Bing have been identified by survey. The other mounds have been identified by chance, and represent only a fraction the real situation.

location and the fact that it is surrounded by three rivers, it undoubtedly played an important role for some time before the development of these early 'states.' Another major temple in the region, Phanom Wan, is situated less that 50 km from these sites. This area in conjunction with Phimai could have contained major markets in the salt trade. In the case for trade over land, these sites are located in a region that commands one of the few possible thoroughfares through the Khorat escarpment into Central Thailand and Northwest Cambodia (Welch 1985:42); these areas have seen evidence for trade with India to the West. The site of Ban Don Ta Phet (Glover 1989) in particular shows evidence for this.

Fourthly, Ban Bing is situated in the centre of the salt producing communities, and is also surrounded by the largest concentration of salt-making sites. It would be interesting to excavate and to determine the dates of the different sites and the salt-making mounds to establish a chronology for the distribution of settlement. It could be, for example, that Ban Bing was the initial site where this activity took place and it expanded out from there along the Mun River as production increased. All but two of the salt mounds are located within three kilometres of moated settlements. This does not mean that these sites did not have access to rice lands; even Ban Bing has access to large areas of land (Fig. 36:5). The distribution of the salt mounds appears to follow a linear spread, with the mounds getting progressively further away from the site, perhaps following the availability of timber resources.

The fifth point deals with the effect this production had on the surrounding environment. Nitta (1992:72) has calculated that one furnace requires more than 20 large trees

to supply charcoal for one season, while Stott (1990:374) notes that the structure of the dry deciduous forest is 9-12 trees per 200 m^2. To keep one furnace operational for a season would require up to 400 m^2 of forested land. The total area surrounding the sites near Ban Bing is *c.* 400 km^2, and if there were 10 furnaces operating each year, then this total area would have been completely cleared of trees within 100 years. This assumes that the whole area was forested, no consideration is given to rice fields or other areas that were not forested. Given that there are at least 67 possible salt mounds in this region, it is probable that there were more than 10 furnaces being used at any one time, hence the rate of deforestation would have increased by 10 per cent for each extra furnace. At the least, the timber resources would be quickly depleted.

This leads to the final point; were these communities acting independently, or were they co-operating at some level along the production line? Given the suggestion above regarding the preservation of fish there could be some kind of production line, with some communities producing salt with others undertaking the preservation of fish. This kind of co-operation has been documented in the Sakhon Nakhon Basin with regard to metal artefacts, and White and Pigott (1996:160) argue that these co-operative networks existed prior to the appearance of metallurgy, "producing and exchanging stone, and probably shell and salt." This depends on the scale of the activity, which is impossible to discern without further excavation.

These ideas will take much archaeological excavation to substantiate. The nature of salt-making has not yet been dealt with adequately in ethnographical, historical or archaeological terms, and this awaits redressing.



FIG. 36:6 Two salt-making mounds located west of Noen U-Loke lie on the horizon. They are known as Noen Song Phi Non, "The two sibling mounds"

PART V
XXXVII. SUMMARY AND CONCLUSIONS

C.F.W. HIGHAM

INTRODUCTION

The excavation of Noen U-Loke took place within a larger research project designed to identify and understand the formation of early states in Southeast Asia leading to the foundation of the civilization of Angkor. Historic, epigraphic and architectural sources have for long contributed to explanations for the rise of Angkor made to a background of insufficient information on the society of the indigenous prehistoric societies. This deficiency has been redressed over the last ten years by a number of initiatives. In the lower Mekong region, Stark (2003) has identified prehistoric occupation under the major city site of Angkor Borei in the form of an Iron Age cemetery. It has often be said that the early state of Funan, of which Angkor Borei was a likely capital, rose to prominence on the basis of international maritime trade. Excavations at late prehistoric sites of the Sa Huynh culture, have stressed the widespread trade links already in existence during the first millennium BC.

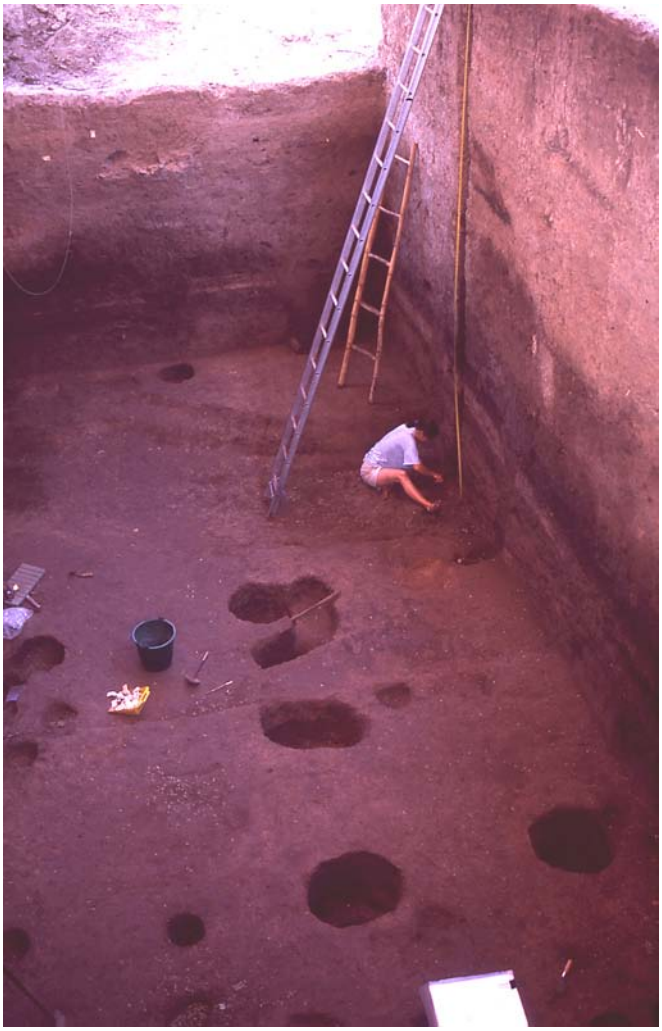


FIG. 37:1 View of the excavation towards the end of the first season, from square A2 to A1.

Inland, the existence of rich Iron Age settlements in the vicinity of Angkor itself has been demonstrated by the recovery of an inhumation grave within the confines of the Western Baray (Pottier 2005), while further west, the large settlement of Phum Snay has been investigated and shown to contain rich Iron Age burials (O'Reilly and Pheng Scytha 2001).

These developments in Cambodia followed our excavation of Noen U-Loke in the upper Mun Valley. Here, in the northwestern part of the Angkorian kingdom, we find many large prehistoric settlements that precede a period when small brick shrines were erected for the worship of exotic Indian deities, and the subsequent foundations of large Angkorian temple sites such as Phimai, Phanom Wan and Phanom Rung. Noen U-Loke was chosen for excavation because it was complete, not occupied, and not seriously disturbed. It had, importantly, been opened already by Wichakana (1991), and his two small squares had revealed Bronze and Iron Age burials. Only Iron Age graves were located in one of his areas, and these formed a sequence of at least three phases. One of the dead wore a bronze headdress. Our own excavation was placed adjacent to the location of this burial, because we sought to illuminate late prehistoric developments in this area through as long an Iron Age sequence as we could identify.

In the event, over two seasons, our expectations were fully rewarded. We encountered a cultural sequence that began in the late Bronze Age, dated to about 600-500 BC, followed by four phases of Iron Age occupancy defined by changes in mortuary rituals that occupied a period of about seven centuries. It had been our wish to continue for a further season at this site, because at least two of our very rich Iron Age burial clusters were only partially recovered. This did not prove possible, largely due to the local headman's demand that we provide a road to the site and construct a museum before agreeing to further excavations. Denied permission, we turned to Ban Non Wat, a similarly-sized prehistoric settlement about three kilometres distant, and over five seasons there, we have been able greatly to expand our data on not only the Iron Age occupation of the region, but also that of the preceding Neolithic and Bronze Ages. These findings will be incorporated



FIG. 37:2 The innermost moat of Ban Non Wat. The site mound lies to the left, the bank to the right.

into our final reporting on the project, but this chapter will summarise the relevant results bearing on the Iron Age occupation of Noen U-Loke.

In 1995-6, when excavating the Bronze Age site of Ban Lum Khao, we asked Dougald O'Reilly to open a small square at the very large Iron Age site of Non Muang Kao. It transpired that the area he excavated was occupied during part of the long span seen at Noen U-Loke. Both these sites, and many others in the Mun Valley and northern Cambodia, were ringed by moats and banks. Until the fieldwork described above, little was known of the nature or date of the moats and banks that ring these and many other sites in the Mun River valley. One of the most significant aspects of the fieldwork described in this volume, is the opening of long cuts through the moats and banks at several sites, leading to the integration of their construction periods with the occupation and mortuary activity within.

THE REGIONAL SEQUENCE

Before summarising these results, it is necessary to describe the structure and chronology of the prehistoric and early historic sequence in our study area. We have isolated ten phases, as follows:

Phase 1. Neolithic. There is a group of early Neolithic burials at Ban Non Wat, characterised by large ceramic vessels incised and painted in a range of designs. The radiocarbon determinations range from 2100–1300 BC. At Ban Lum Khao, there is a series of pits below a Bronze Age cemetery, and a thin occupation layer, that has produced black incised pottery characteristic of the Neolithic in Central Thailand and further north in the Sakon Nakhon Basin. Radiocarbon determinations suggest that this is a late Neolithic occupation, dated to the middle of the second millennium BC.

Phase 2. There is an enigmatic series of burials placed on an east to west axis at Ban Non Wat, a series matched at Ban Lum Khao. There is no evidence for or against these being Late Neolithic or Early Bronze Age. At Ban Lum Khao, they are dated slightly later than 1300 BC.

Phase 3. Early Bronze Age. Within the span 1200–900 BC. There are burials at Ban Non Wat in which the dead were interred with exceptional wealth. In some cases, bodies were partially exhumed after burial and then carefully replaced in the grave. Grave goods were opulent, with many large painted pottery vessels, multiple shell ornaments, and bronze axes, chisels, anklets and bells.

Phase 4. Middle Bronze Age. 900-600 BC. The middle phase of the Bronze Age is present at Ban Lum Khao and Ban Non Wat. It is characterised by rows of burials associated with red slipped or painted vessels of great diversity in form and size, exotic marble and marine shell jewellery and animal limb bones. There are very few bronzes in graves, but much evidence for local casting.

Phase 5. Late Bronze Age. 600-400 BC. This phase

is found at Ban Non Wat, and in a handful of burials at Ban Lum Khao. The form of the pottery vessels changed, and grave goods included animal limb bones and spindle whorls for preparing yarn.

Phase 6. Iron Age I. 400-100 BC. A small number of burials at Noen U-Loke contain ceramic vessels virtually identical with those of the late Bronze Age at Ban Lum Khao. They have also yielded iron artefacts.

Phase 7. Iron Age II. 200 BC-200 AD. This phase is present at Noen U-Loke in the form of two clusters of inhumation graves. There is also an occupation and mortuary episode at Ban Non Wat. There, the dead were interred with iron artefacts, bronze casting equipment and the complete skeletons of pigs. One burial contained two glass items.

Phase 8. Iron Age III 200-400 AD. Four clusters of inhumation burials belonging to this phase have been found at Noen U-Loke, while further burials and house floors and foundations have been identified at Non Muang Kao. Domestic and industrial contexts were found at Ban Non Wat.

Phase 9. Iron Age IV 300-500 AD. This late Iron Age phase was documented in a series of burials at Noen U-Loke and Ban Non Wat. Iron Age ceramics were also found in the lower layers at the Phimai temple excavation (Talbot and Janthed 2001, Talbot 2003).

Phase 10. Early Historic, from 500 AD. The remains of a brick temple were found at Phimai, underlying the Angkorian shrine, and occupation belonging to this period was present in the uppermost layers at Ban Non Wat.



FIG. 37:3 Psuedomorph of fabric from an Iron Age knife, Mortuary Phase 4. Scale 1 cm

INDUSTRIAL ACTIVITY

Salt processing

During the course of the excavation, we encountered much evidence for local industry. Barely two kilometres west of Noen U-Loke, lie two small mounds with steeply angled edges (Figs. 1:3, 36:6). Although not examined archaeologically, excavations at similar sites have indicated that they were centres for the processing of salt in antiquity. The upper Mun Valley contains areas of highly saline soil. To this day, the villages turn in the dry season, to the production of salt by bringing this saline soil to a central point and then placing it within a wooden container through which water percolates. The resultant brine is then boiled, formerly in large ceramic vessels but now in metal trays. The salt is then widely traded. Many such industrial mounds cluster round Iron Age settlements, and it is highly likely that salt production was a source of wealth the their inhabitants. Salt is vital in preserving the wet season surplus of fish for dry season consumption.

Metal working

Compared with the equivalent period at Ban Non Wat, there is very little evidence for casting bronzes in the area of Noen U-Loke excavated. Only five fragments of sandstone moulds were recovered. Two came from layer 5, two from lower layer four and one from layer 3. One possible piece of a crucible was found in lower layer 4. Several enigmatic clay artefacts covered in a thin film of what looks like lead were found. These look like a clay insert to create the socket of a bronze axe, and have been sent to Dr. G. McDonnell for reporting. The rarity of moulds, crucibles and possible furnaces for heating bronze prior to casting does not negate local bronze casting. We have only opened a fraction of the site of Noen U-Loke, and industrial activity involved in bronzes might well have been undertaken at another part of the site.

Sixty-five pieces of what looks like iron slag have been recovered. They are found in all layers with a peak in layer 4:10-14. These probably result from smithing rather than forging. They concentrate in the vicinity of small clay furnaces that had been raised to considerable heat, in association with clay



FIG. 37:4 The innermost moat at Noen U-Loke, with the mound to the left and the bank on the far right

tuyère pipes.

Textiles

Several iron artefacts from burials bear the pseudomorps of fabric. Mortuary phase 4-5 burials also contain spindle whorls used to produce yarn. Spindle whorls almost certainly indicated a local weaving industry, and their origin, ultimately, probably lies in China. Early historic inscriptions often refer to weavers, and patterns and styles, in ethnographic contexts in Southeast Asia, textiles are a widespread way of expressing status and group affiliation
(Cheesman 2006, Lefferts 2006).

Glass making

Some pits at Noen U-Loke contained sand, and glass beads were a prominent form of ornament in the later burials. However, Saitowitz (chapter 25) has not been able to confirm that glass beads were locally manufactured.

Pottery making

Only four clay anvils for fashioning ceramic vessels have been found. This compares with 120 at Ban Non Wat after three seasons of excavation. The mortuary vessels from Noen U-Loke, particularly during mortuary phases 4 and 5 are of exceptional quality. They have complex forms, and are often eggshell-thin. It may well transpire that the fine ceramics were manufactured in specialist workshops and imported to the site. If this was the case, then a clear candidate for a manufacturing centre is Ban Suai. This large mound lying on the outskirts of Phimai, has furnished equally fine so-called "Phimai Black" vessels, in association with many clay anvils for their manufacture. On the other hand, the possibility that vessels were made in another past of Noen U-Loke cannot be set aside.

House construction

Chetwin (chapter 23) has shown that structures at Noen



FIG. 37:5 This large, iron socketed spade is vital evidence for the intensification of agriculture and ability to transform the landscape. It comes from burial 86, Mortuary Phase 4C and has a maximum width of 18 cm



FIG. 37:6 Silicified rice grains from a Mortuary Phase 4

U-Loke were made of a wattle framework, often incorporating bamboo, covered in daub. Only when subjected to intense heat have the remains of wattle and daub survived. There is some evidence from this site, and abundant remains from Non Muang Kao, to indicate that dwellings were built at ground level, with a clay floor and, presumably, wattle and daub walls. These floors at Non Muang Kao superceded each other on the same location over a considerable time, suggesting stability of settlement in the same locale.

THE MOATS AND BANKS

The moats and banks, which are such a distinctive feature of the archaeological sites of the Mun Valley, have for long been enigmatic (Williams-Hunt 1950). Moore (1988:67) noted in particular, that "there has not been a stratigraphic excavation of the moat/earthwork construction in the Mun Basin". Many have speculated on the possible date and function of these impressive and extensive earthworks (Welch and McNeill 1991, Higham 1996), with defence and flood control being prominent. In order to contribute to this issue, we decided to excavate sections across the moats at Noen U-Loke. However, over several days toil in the very hard soils, our workers were left with sore wrists and broken tools. Consequently, we took the bull by the horns and hired a mechanical digger. As a result, we rapidly opened long and straight cuts down to the natural substrate, and were able to record the stratigraphy and take datable material before the trenches were filled to the level of the water table.

Three trenches were excavated at Noen U-Loke, measuring between 130 and 244 metres in length (Fig. 4:1). The longest of these crossed five moats and the intervening banks, the shortest crossed two. Two similar trenches were excavated at Non Muang Kao. It was found that the moats so evident on the ground covered a number of old stream or river channels infilled with grey clay, while the banks were clearly of human origin, some containing fragments of bedrock in their composition. These river channels underlay Iron Age cultural material at the edges to the sites, indicating that they had been active during earlier occupation phase or phases. Indeed, one old stream channel was found at the base of our excavation located at some distance from the margins of the site (Figs. 5:5, 5:7). Samples of the sediments taken from the moat infills showed that the water regime within differed from that evidenced at



FIG. 37:7 The black particles in this cross section through a layer 4 pit are individual rice grains



FIG. 37:10 The pottery vessels from Iron Age ceramic phase 1. A. cat. 1542, MP2, B. cat. 1543, MP2, C. cat. 1464, MP2, D. cat. 475, MP2, E. cat. 747, MP3A, F. cat. 1545, MP2, G. cat. 748, MP3

a river in the vicinity, the former revealing a low energy flow and a consistency of deposition. Since the banks that restrained the water were of human origin, it would seem that the moats were important artefacts, and their dating assumes prominence.

Fortunately, a series of four radiocarbon determinations has been obtained for Noen U-Loke. Two come from buried channels below the edge of the mound (81-339 cal. AD and 87 BC-114 cal. AD). The second pair derive from samples of rice grains found at a depth of 1.4 metres in the first moat, and result in dates of 405-600 and 543-798 cal. AD (McGrath and Boyd 2001). Further dates from other sites examined in the study area centred on Noen U-Loke agree that the banks were constructed within the period 200 BC - AD 600. This provides a good integration with the Iron Age occupancy of the mounds that these moats encircled.

By any measure, the amount of labour required to construct the banks, involving as it did, digging into the floodplain alluvium down to bedrock, would have been considerable. There must have been a major social imperative, prevalent across the entire Mun Basin, to undertake such work. In their geomorphological studies, Boyd and his associates have highlighted two vital issues. The first is that the large Iron Age sites were located adjacent to substantial rivers many of which no longer exist or have relocated their channel. This would have provided excellent conditions for an assured water supply and the provision of fish, shellfish, and other aquatic resources for the populace. Even the most superficial acquaintance with the area today will soon emphasise the importance of water in human settlement. The second important result is that during the course of the Iron Age, the water regime became less predictable. As a reaction, the Iron Age communities

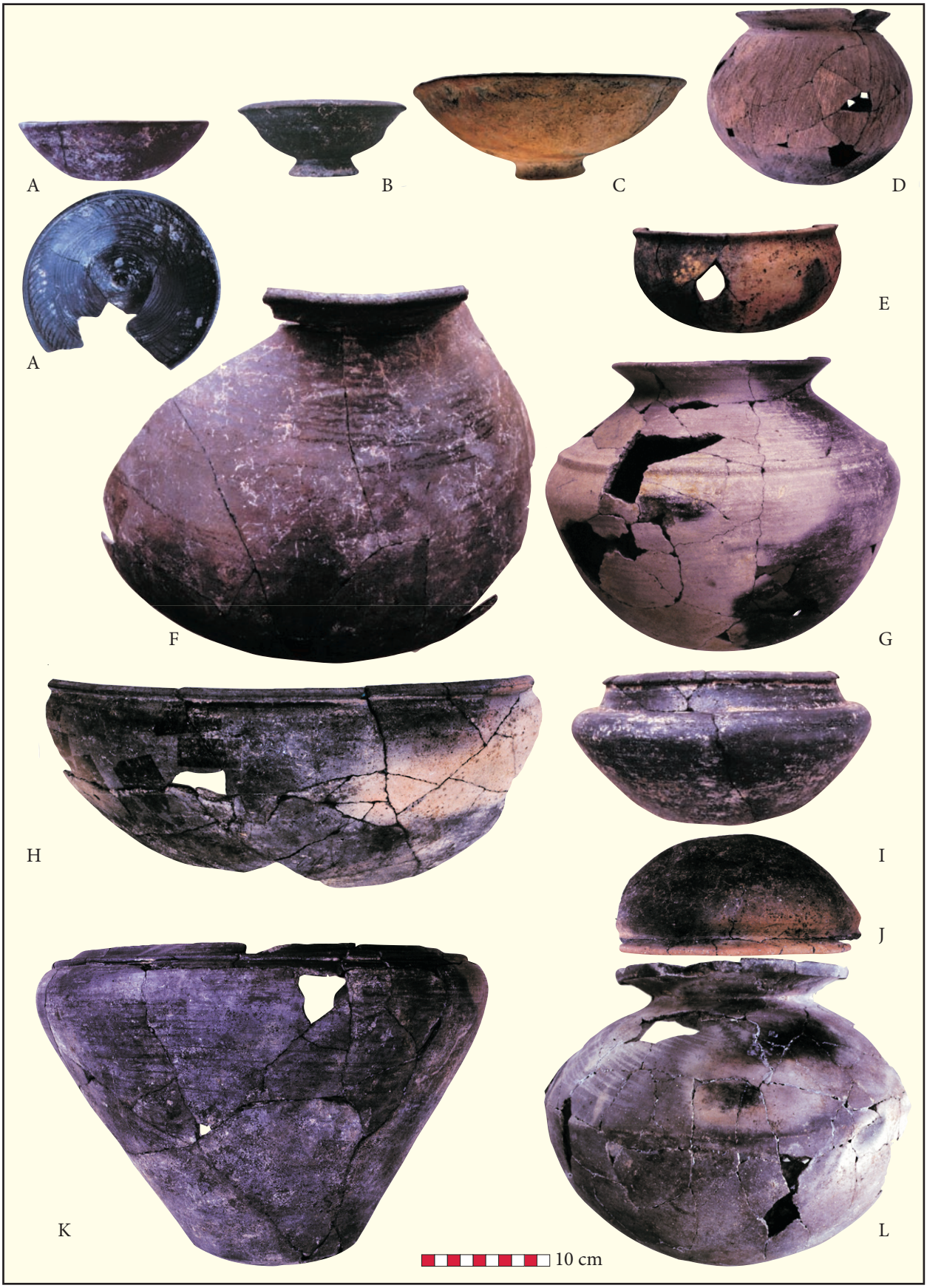


FIG. 37:9 Pottery vessel forms from the second Iron Age ceramic phase. A. cat. 1526, MP4A, B. cat. 1525, MP4A, C. cat. 1581, MP4A, D. cat. 1531, MP4A, E. cat. 1742, MP4A, F. cat. 1713, MP4A, G. cat. 1772, MP4A, H. cat. 1732, MP4B, I. cat. 1246, MP4A, J. cat. 490, MP4, K. cat. 1679, MP4B, L. cat. 491, MP4

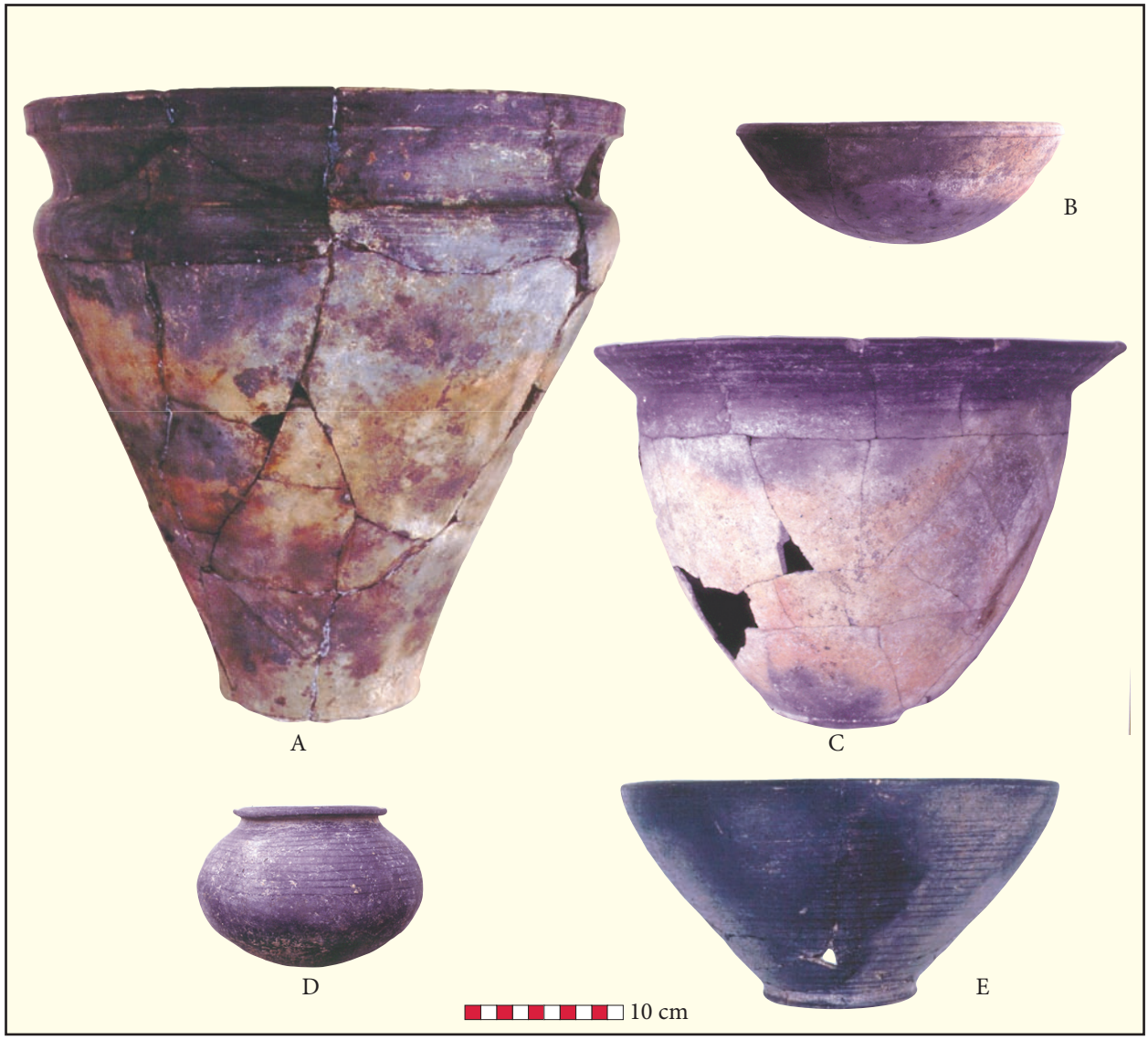


FIG. 37:10 Pottery vessels from Iron Age ceramic pase 3, all from Mortuary Phase 5. A. cat. 1399, B. cat. 79, C. cat. 115, D. cat. 974, E. cat. 1451

began to construct banks round their settlements in order to control and indeed, assure, their water supply. This has been dated within the period of 200 BC to AD 600.

Such hydraulic engineering poses the question of function. McGrath (2001), noting the absence of any form of defensive structure on the banks, favoured an agricultural purpose, suggesting that the wide and shallow moats would have been well suited to rice cultivation. On the other hand, it is noted that the period of construction of the banks also saw a rise in the forging of iron weaponry, and at least one man at Noen U-Loke was killed when an iron arrow severed his spine. While water remains vital for survival in this seasonally arid part of Southeast Asia, some purpose in addition to the provision of rice and doubtless, fish and shellfish, is favoured. However shallow, the presence of a water barrier up to two hundred metres deep, incorporating four or five banks at Noen U-Loke, would have provided more security for the inhabitants, than an open landscape.

THE BRONZE INDUSTRY

Bronze mortuary offerings are extremely rare in Bronze Age cemeteries. At Ban Lum Khao, no recognizable bronze artefact was found in any of the 111 burials excavated (Higham and Thosarat 2005). The extensive opening of the Bronze Age cemetery at Ban Non Wat revealed that only the very large and elaborate graves of the presumed social elite contained bronzes, mainly in the form of socketed axes and chisels rather than personal ornaments. This contrasts sharply with our findings at Noen U-Loke, where there was a surge in the availability and the range of mortuary offerings during all phases of the Iron Age. In the earliest contexts, we find bronze socketed

spearheads, torcs and bangles. Mortuary Phase 3 burials included bells, toe, ear and finger rings and bangles, together with a unique spiraliform ornament on the skull of burial 39 (Fig. 10:7). A burst in the quantity and range of mortuary bronzes came with Mortuary Phase 4. The man in burial 14 wore 150 bronze bangles and 61 finger rings, of which six were formed into spirals. There were two toe rings on each foot, but pride of place is accorded three circular bronze belts. Four such belts were found round the waist of another man in burial 69. He also wore bronze earcoils and 20 bangles, 126 finger rings and 33 toe rings. Four bimetallic (bronze and iron) rings had been interred, two on the left foot, one over the left femur and another under the chin. Nor was bronze confined to adult men. An infant who died before attaining a year of age in burial 63 wore 12 bangles, six anklets and an earring. Again, bimetallic rings had been strategically placed with the corpse. An infant of similar age in cluster 4A, burial 122, wore 35 bangles, a spiral ring on the toe, and a bronze earring.

This sheer weight of bronze fell in the succeeding Mortuary Phase 5, but numbers were still impressive. Burial 1, a young man, wore 22 bangles, 50 finger rings, earcoils and two bimetallic rings. A mid-aged adult in burial 59 more typically for this phase, had only one bimetallic ring, four finger rings and a bangle on each wrist.

It is clear that both copper and tin were more readily available through exchange than was the case during the course of the Bronze Age. Moreover, more sophisticated forms of ornament were cast, particularly into the form of spirals. Mass production was employed for the finger and toe rings. Open moulds for this purpose have been found at several sites in the Mun Valley, including nearby Ban Prasat.

THE IRON INDUSTRY

A total of 277 iron artefacts were found during the excavation of Noen U-Loke, as well as evidence for local smithing. Of these, 54 items were found as grave offerings, a figure rising to 104 when bimetallic rings are added. Iron offerings were present from Mortuary Phase 2. Burial 27 was accompanied by a large socketed iron spear. Intriguingly, iron was also employed in this early phase, for ornaments. The woman in burial 108 wore an iron torc and two bangles on each wrist. No iron was found in a Mortuary Phase 3 grave. With Mortuary Phase 4, iron offerings were again placed with the dead. Bimetallic rings and type 1A ridged knives dominated numerically, some of the latter still retaining vestiges of their sheaths. There was also a large socketed iron spade and hoe. Bimetallic rings continued to be favoured in the final burial phase, together with a new agricultural implement, the curved bladed sickle. One man was found with an arrowhead embedded in his spine, and a probable spearhead accompanied burial 5.

Iron from non-mortuary contexts provides intriguing contrasts when compared with that associated with the dead. The most abundant artefacts from the former, comprise knives and points. The iron points, which were probably associated with conflict, predominate numerically in upper layer 4 and layer 3. Complete knives are quite common in burials during later mortuary phases, but pieces of broken knives are also common in the occupation layers. In terms of change over time, it is possible to recognise four distinct developments. Early iron was forged into ornaments and weaponry. There was then a hiatus in the application of iron to mortuary rituals during Mortuary Phase 3. This was followed by the interment of knives principally, and bimetallic rings. One burial in Mortuary Phase 4 was accompanied by a spade, another with artefacts of flat, thin strips of no known purpose. During the final phase, sickles became frequent additions to burials, and the number of points rose sharply. Iron thus was deployed for ornaments, and conflict. Spades, hoes and sickles indicate its use in agriculture and doubtless, for major works involved in creating the banks that retained water in the moats.

SUBSISTENCE

In considering the evidence for subsistence, it is stressed that Noen U-Loke was occupied during the Bronze Age, although there was scant evidence for this in the area we excavated. Therefore, the natural environment round the site would already have been modified. At the nearby site of Ban Lum Khao, the Bronze Age faunal sample indicated that in the earlier layers, there was a preponderence of deer bones, but that these declined relatively over time. Pig were abundant throughout, and were preferred for inclusion in mortuary contexts. Cattle were also present in all layers, but were less prevalent than pigs. There were also domestic dogs and some water buffalo bones (Higham and Thosarat 2005). There were many fish bones.

The results of the pollen analyses undertaken by Boyd and McGrath confirm the suggestion that the Iron Age occupation followed considerable forest clearance undertaken during the preceding two millennia. They have identified six vegetation phases on the basis of the pollen present in Iron Age moat infill deposits. The earliest they assign to the early Iron Age, and it revealed a mosaic pattern of open land, where presumably rice could have been cultivated, and partially disturbed forest, which could have been refugia for the indigenous herbivores, such as deer, cattle and their predators. There were then two phases of significant further human impact, witnessed in further forest clearance and the creation of more open space. It is highly likely that such episodes coincided with the development on the site of rice rituals in the mortuary area, and the forging of iron spades, hoes and sickles.

The faunal spectrum of Noen U-Loke, beginning as it does in the early Iron Age, dovetails neatly with that from later Ban Lum Khao. Deer were never strongly represent-

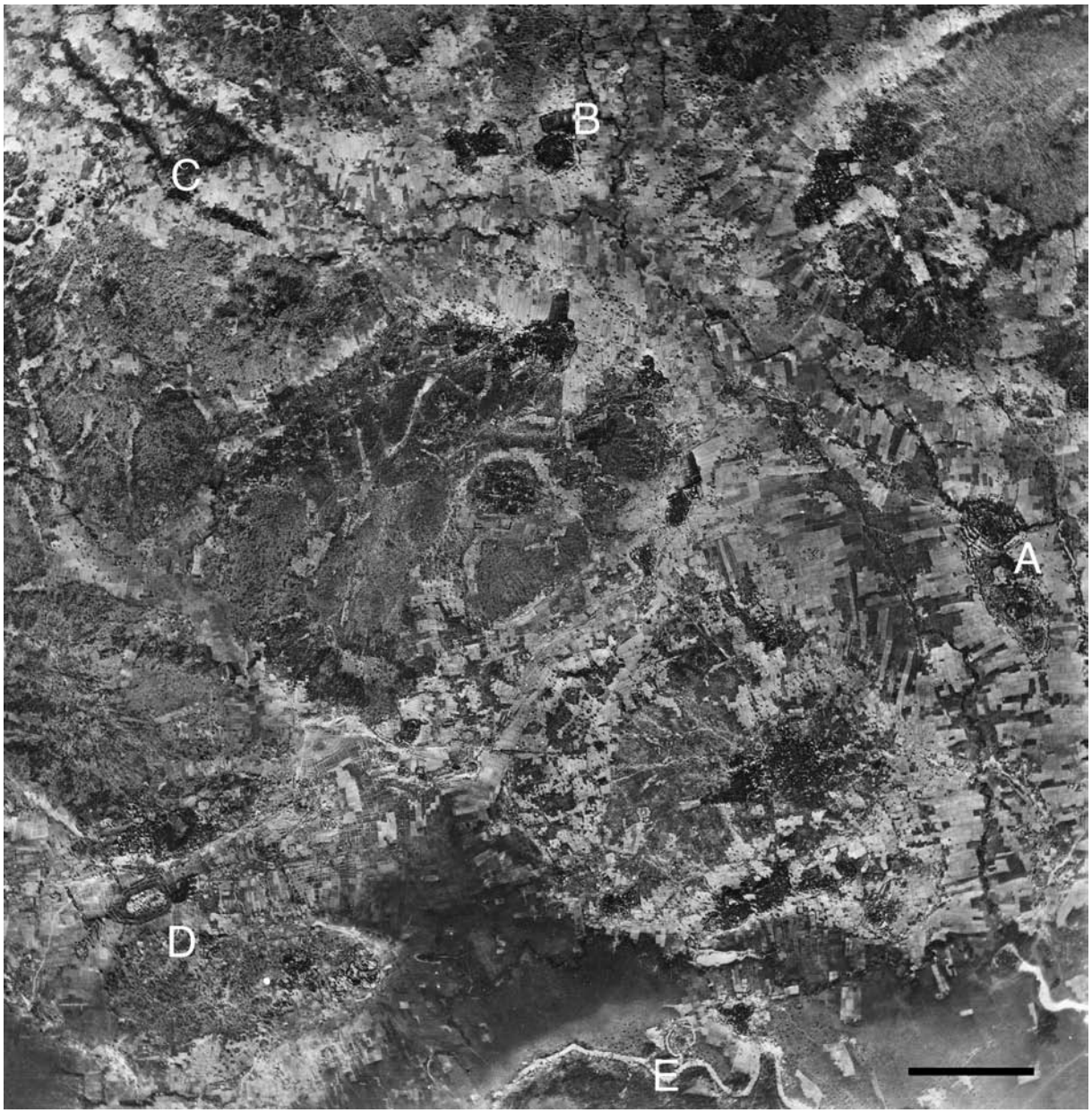


FIG. 37:11 Moated sites in the study area were densely distributed. This image, taken just west of Noen U-Loke, shows further sites in the valley of the Huai Don Kasak (stream). A. Ban Makham Thao, B. Ban Kriam, C. Ban Bu Mako, D. Ban Nong Khrua Chut, E. Ban Non Ngiu. The river seen south of Ban Non Ngiu is extinct. Scale 1 km.

ed, and this might indicate that already open conditions and earlier predation had thinned their numbers. The Eld's deer was consistently present throughout, but never in large numbers. Instead, domestic pigs and cattle predominated. The former were also preferred in mortuary rituals, both as the complete skeletons of young animals, and as part of the skeleton, usually the left fore limb, in Mortuary Phase 2. Dogs were present in small quantities, as were the remains of turtle. Where it is possible to distinguish between the domestic cattle and water buffalo, the former always dominate, while the latter rarely exceed 10% of animals represented.

The shell fish assemblage is dominated by *Filopaludina* and *Pila ampullacea*, both of which come from marshy or riverine habitats, including ricefields.

The mortuary rites from the third mortuary phase included the filling of graves with silicified rice. One of the pits from layer four also included many carbonised rice grains. The association of such large quantities of rice with the burials, which included filling at least one infant mortuary jar, is held to indicate considerable stress on rice both in terms of the diet and ritual. The necessary surpluses were doubtless obtained in part through the application of iron technology to cultivation, since we have recovered sickles, a spade and hoes, often again as mortuary offerings.

We were surprised that more fish were not recovered, despite our efforts through flotation to ensure the representatation of the small fraction of biological remains. Nevertheless, their importance might be judged from the numbers placed in ceramic vessels with the dead in Mortuary Phase 2. The presence of fish, shellfish and turtle indicate an aquatic habitat, which was presumably at its height during the rainy season.

TRADE AND EXCHANGE

Most evidence for exchange comes from the items interred with the dead. It is clear that there was a major change in availability and preferences between the Bronze Age of the area, and the occupants of Noen U-Loke during the Iron Age. During the Bronze Age at Ban Non Wat and Ban Lum Khao, most personal ornaments were fashioned from marine tridacna or trochus shell or imported marble. There were few bronze items, and these were found only with the richest individuals. Shell and marble are hardly represented as mortuary offerings at Noen U-Loke. There are shell ear ornaments in Mortuary Phase 2, and a few shell beads have been recovered: 50 have been identified as burial offerings, compared with the many thousands found with single individuals at nearby Ban Non Wat during the Bronze Age. In their place, we find a complete new range of jewellery. During Mortuary Phase 3, the first glass, agate and carnelian ornaments appeared. Glass and agate continued strongly into Mortuary Phases 4 and 5, but carnelian was only found in one further burial.

In the absence of any acceptable evidence for local manufacture, it is likely that most if not all the glass beads were imported. This does not imply a remote source, such as India, since it is known that glass beads were manufactured in peninsular Thailand not long after the establishment of regular trade contact with South Asia in the later first millennium BC. The carnelian beads concentrate in Mortuary Phase 3B, and most follow the same elongated form. It seems likely that they came to the site within a short time interval from a specific exotic source. Theunissen has suggested that they might have come from Central Thailand, where at least one possible source is known. He also suggests a lower Mekong origin for the agate beads and pendants.

Gold entered exchange networks during the early centuries AD. There is much evidence for the manufacture of gold ornaments at Oc Eo, on the Mekong Delta during this period, and some of the beads bear a reasonable resemblance to those found with burial 113 during Mortuary Phase 4. Gold was also found with burial 14 and 68, in former as a foil over silver earcoils and the latter as circular gold beads. Silver came into use at the same time as gold. Burial 113 in Mortuary Phase 4 contained a woman with silver toe and finger rings. Burial 105 in the same cluster wore a silver bangle, and burial 59, a silver ear ring.

There was clearly a surge in the availability of copper and tin during this period. Just one burial, 14, arguably carried more weight of bronze ornaments than in all the Bronze Age burials ever excavated in Southeast Asia. There remain the two major possible sources of copper ingots or finished artefacts: Phu Lon in Loei Province and the Khao Wong Prachan Valley in Lopburi (Piggot 1992). A closer source might also be located about 100 kilometres west of Noen U-Loke on the eastern slope of the Petchabun Range: we have sighted a sample of what looks like copper slag, but the owner of the property has refused access to explore this site. Tin could have come from the rich ore deposits of western Central Thailand, or from the Laotian sources.

The rarity of ceramic anvils for shaping clay into pottery vessels, and the very high quality of the Iron Age mortuary wares, particularly the variety known as "Phimai Black", might well indicate that there were regional specialist manufacturing centres involved in trade in ceramics. More information on this important issue is awaited from the project ceramicist.

Noen U-Loke was located in an environment devoid of the high quality hard stone and ores that constituted the main evidence for imports. It commanded low-lying terrain in which salt was the principal local resource that could have been a source of wealth through trade. To this day, salt is a major local export. The number of salt manufacturing mounds that cluster round Iron Age moated sites has been noted. While none has been excavated, it is highly likely that they date from the Iron Age, to judge from the prehistoric ceramics that are found on them. Woven fabrics might well have been another item that was exchanged from sites such as Noen U-Loke and Non Muang Kao.

THE CERAMIC INDUSTRY

The analysis of the ceramic remains is incomplete, and a separate monograph on the pottery vessels and other ceramic remains from all sites examined under the Origins of Angkor project is planned. At this juncture, the principal value of the assemblage lies in the possibility of contributing to the establishment of a well-documented and dated cultural sequence for the two sites under review.

Only one partial vessel, possibly belonging to the Bronze Age, was found with the Mortuary Phase 1 burial. The first Iron Age ceramic phase incorporated at least three forms with clear affinities in form to those from the latest Bronze Age graves of Ban Lum Khao and Ban Non Wat. They thus evidence continuity over the period when iron forging came into force. Most typical, is the globular cord marked vessel with a red-slipped cylindrical neck (Fig. 37:10D). The shallow dish seen in figure 37:10C is also typical of the Late Bronze Age in this region. Round cord-marked vessels with a small everted rim are found ubiquitously in the prehistoric sites of the Khorat Plateau, and one of these, figure 37:10G, a large version, was em-

ployed in Mortuary Phase 3A as an infant jar burial. The only form that is not seen elsewhere in the region thus far, is a plain rimless vessel of ovoid form, two of which were found with burial 107 in Mortuary Phase 2. This phase spans Mortuary Phases 2 and 3A,but surprisingly, no complete vessels were found with burials belonging to Mortuary Phase 3B.

The second Iron Age ceramic phase based on form saw a major innovation. Some vessels were now fired to a dark black colour, and burnished so as to form patterned lines (Fig. 37:9). This is typical of many sites in the upper Mun Valley, and is generally known as "Phimai Black". Some vessels are large, and thin, that they might well have come from specialised manufacturing centres. Analysis of their fabrics might illuminate this point. A common form was a shallow bowl, embellished on the interior with patterns in the form of a sunburst (Fig. 37:9A). Some of these were found with a lid of similar form, isolated from any burial or other feature. At Non Muang Kao, one such lidded vessel was found placed within a circular pit only marginally larger than the pots themselves. During this phase, the shallow dishes were also fitted with a ring foot (Fig. 37:9B, C). The round globular cord marked vessels continued to be placed with some of the burials (Fig. 37:9D). In the case of the vessel shown in figure 37:9E, the shallow bowl was given a deeper profile. Some large and elaborately decorated pots were placed as mortuary offerings, as seen in figure 37:9 F-I. Infant mortuary jars also took on a new form or mode of decoration compared with the preceding phase. One had a more pointed base, the other while retaining its more globular form, was pattern burnished (Fig. 37:9 K,L).

With the third Iron Age ceramic phase, Phimai Black vessels continued, with some new developments in terms of form. The infant jar burials now became markedly tapered towards the base, as seen in figure 37:10A. This form was precisely matched in the infant jar burials from later contexts at Ban Non Wat. Shallow lidded bowls continued from the previous phase, but we also now find globular pots with a small everted rim, and vessels with a wide flaring mouth decorated with pattern burnish.

CONFLICT

Noen U-Loke is one of many similar, moated settlements identified in the Mun Valley. These sites are densely distributed, and some cover an impressive area. The double-peaked mound of Non Muang Kao, one of the largest, extended over about 50 hectares. Competition and rivalry over resources in conjunction with a rising population engaged in exchange for valuables, are seen as conditions likely to stimulate conflict. From the earliest Iron Age burials at Noen U-Loke, we find evidence for weaponry. Burial 27 included a very large socketed iron spearhead and two socketed bronze spearheads. Iron points proliferated in Layer 3, and we know that a young man buried face down in Mortuary Phase 5, was killed when an iron arrowhead severed his spine. We take this evidence in conjunction with the provision of multiple banks and moats round these sites, to suggest that inter-community conflict rose during the Iron Age. The clear evidence for warfare century or two later, taken from the inscriptions of the Chenla period (AD 550-802), we feel, had prehistoric roots.

SOCIAL ORGANISATION AND STATUS

The social organisation of this Iron Age community can be assessed on the basis of at least five sources of information. Of these, the most valuable is the mortuary record. It is also possible to consider the size of the sites in question, and the construction of the surrounding earthworks. The likely organisation of production, and the evidence for trade in exotic valuables must also be incorporated into any overall review of this most vital subject.

Noen U-Loke occupies a unique position in Southeast Asian prehistory because of its long Iron Age sequence. The four mortuary phases date between about 300 BC and AD 500. This is a little-known period but a vital one as it immediately preceded the rise of small regional states. Talbot (chapter 18) has exhaustively considered all aspects of the changing mortuary behaviour. She has found first, that the samples are probably representative of the community: there is the expected high incidence of infant mortality, and the ratio of men to women is not far different from 1:1. Despite underlying continuity, there were deeply significant changes in the way the dead were treated, and what accompanied them to the grave. Thus, adults were usually interred in an extended position, on the back with the hands to the side. Infants were often found in lidded mortuary jars although some were also interred in the same manner as adults. In terms of the relative positions of the graves, we see a progression from widely spaced burials (MP2) to the presence of tight clusters (MP3-4) and then a reversion to wider spacing. The clusters include men, women, infants and children, and it is considered highly likely that relationships within each were consanguinal and affinal. These clusters seem to have been focussed on a particular founder-adult. The precise nature of the mortuary facility for such clusters is not clear based on archaeological remains, but in the case of cluster MP3B, there is some evidence for the presence of a clay floor over the graves that was severed by a late interment. For MP4, a line of large postholes might represent a mortuary structure. Burial 75 lies apart from the other members of MP cluster 4C, and the grave was surrounded by a clear set of postholes that again, might have been a mortuary structure.

The MP 3 and 4 configuration of graves probably represents represents episodic lineage sets of interments, each over a relatively brief period. The overall plan of MP4 takes the form of a chequer-board, and we do not know if

the sets were contemporary, or form a sequence. MP3A is almost certainly slightly earlier than MP3B.

There were marked changes in both the layout of burials and their contents with time. MP2 burials have the following characteristics. Iron was used for ornaments, weaponry and for tools in the form of a socketed hoe. Bronze was found as ornaments and weaponry. Exotic imports are represented by marine shell, copper and tin. Two men were interred adjacent to each other but on opposite orientations and each wore talismans that may well represent hunting prowess or personal bravery, tigers' canines for one, pig's tusks for other other. Many fish and pig bones accompanied the dead, some found in complete ceramic vessels that hearken back to the Late Bronze Age. Spindle whorls also link MP2 with the preceding burials at the nearby site of Ban Non Wat.

With MP3, we find several important new developments. MP3A saw the first glass and agate imports, both from exotic sources. Burials were now tightly clustered. Complete pig's skeletons were found with the dead, and bronze jewellery was worn. MP3B incorporated the earliest rice bed burials. This technique involved placing the corpse in a grave filled with silicified rice. The bones, when encountered, were covered in rice. Long, facetted carnelian beads were restricted to this cluster. Other jewellery included strings of glass beads, agate beads and pendants, and bronze toe and finger rings. There were no iron offerings, and very few pottery vessels.

The fourth MP probably dates within the period AD 200-400. This was a period by which sea-borne trade networks were fully developed. The inhabitants of Noen U-Loke were active participants in this growing exchange network for exotic goods. There was a sharp rise in quantity of grave goods, which tended to be concentrated in the burials of four individuals. These four, two men and two women, were accompanied by almost half of all the bronzes found with the dead. Moreover, the quality of the bronzes reached a new level, particularly the bronze belts favoured by the men. We also find many glass and agate beads, but only one carnelian ornament. Gold and silver jewellery was found (Fig. 37:12). Iron knives were often placed with the dead, and in one instance, an iron spade had been placed within a ceramic vessel. There is also evidence for the elaboration of the graves with clay linings and again, large quantities of rice. The contrast between the clusters is also challenging. MP4B, for example, lacked the gold, silver, bronze belts and bimetallic rings.

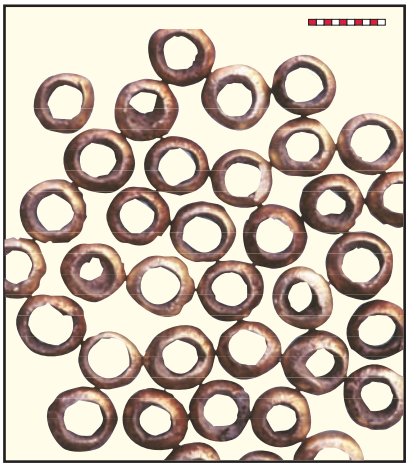


FIG. 37.12 Gold beads from burial 68, Mortuary Phase 5. Scale 5 cm

The stress on tight probably lineage clustering dissipated with MP5, and the quantity of bronzes fell. Iron tool sets included iron blades and sickles, gold was still imported and the same style of agate pendant remained in favour.

Talbot has suggested that the rise in aggrandized individuals during MP4 reflected developing stress in the community, stress involving the competitive indication of status through mortuary rites. The possible causes of such stress invoke other sources of information on the changing social order at these sites.

It is first noted, that the sharp rise in the wealth of individuals during MP4 took place at a time when long distance exchange in exotic goods expanded. This was expressed not only in the hardstone beads, gold and silver, but also in the weight of bronze. Participation could well have encouraged local production of, for example, salt or cloth, requiring in its turn, the organisation of labour. The burgeoning demand for high-quality bronzes would again have called on increasing craft specialisation. This trend has been noted already in the high quality of the Phimai Black ceramics which dominated with MP4. There is good evidence also, for increased rice production. The forging of iron tools, such as hoes, spades and sickles, linked with industrial production of salt, would it is proposed, have led to forest clearance. Given the increased size and the number of settlements, this too was probably a period of population growth.

Combining these factors, we propose a model of cultural change that also involved growing social friction, expressed in conflict. This receives archaeological expression in the presence of a young man with a spine severed by a tanged arrowhead, and a proliferation of iron points in later layers at Noen U-Loke. There is also the question of the banks and moats that encircle the large Iron Age sites, and which correspond in time, as far as we can judge, to the period when particularly rich individuals were being interred in the Noen U-Loke cemetery. As Boyd has shown, the water control measures were put in place, at considerable social cost, at a time when the water regime faltered and supply was under threat. This phenomenon, which might well have been partially due to deforestation and increased sedimentation, is seen as a potent influence on social relations which probably fostered competition and conflict over a precious resource.

And this returns us to the fall in mortuary wealth, and the end of putative lineage clusters. Is it possible, that by



FIG. 37:13 Towards the end of the excavation of Noen U-Loke

the end of the Iron Age sequence, one such group within the site achieved a level of pre-eminence that encouraged the establishment of an elite burial enclave? If so, then those represented on the MP5 mortuary area would represent a lower social level within an increasingly hierarchical establishment. This, however, like much else, can only be pursued with further excavations at a site of which we have uncovered less than 0.2% of the area once occupied. This figure falls to 0.03% for Non Muang Kao.

THE WIDER PERSPECTIVE

O'Reilly (chapter 35) has summarised the relationships between Non Muang Kao and Noen U-Loke and other sites in Northeast Thailand. He too, noted a consistent thread of evidence for intensified hierarchical structures during the Iron Age. On a broader perspective still, it has long been known that the late prehistoric people of Lingnan and Northern Vietnam were not only engaged in intergroup strife, but were also subjected to predatory Qin and Han expansion. The led to the strong development of militarism and investment in leadership. One artefact associated with this rise in overall cultural complexity was the large bronze drum, used in mortuary and other ritual occasions. Some of these drums were exported south, and they have been found in the lower Mun Valley, and Central and peninsular Thailand. The cowrie shells found in such abundance at such sites as Shizhaishan in Yunnan probably represent exchange in the opposite direction.

The long Iron Age sequence at Noen U-Loke has revealed when exotic imports became available in areas beyond the strategic coastal or riverine sites to the south. We find first glass and agate, soon followed by carnelian in graves dating from the second century BC. Bronze production showed a dramatic increase during the early centuries AD. Iron weapons were forged in greater quantities from 200 AD, and iron was also deployed in agriculture and surely also for construction. This was also the period when gold and silver were used for personal ornaments. There are several other sites in Southeast Asia which parallel these developments, albeit without the same lengthy sequence. Ban Don Ta Phet is central in any consideration of trade contact with India, and Woods (2002) has outlined the wide range of grave goods found there: iron weaponry and tools, glass, agate, carnelian and crystal beads, bronze bowls of probably Indian origin, and ceramic spindle whorls. Here statistical analyses of the burial assemblages indicate the presence as at Noen U-Loke, of a relatively small number of particularly rich individuals. The radiocarbon determinations suggest occupation during the fourth century BC.

Ban Wang Hi in Northern Thailand is a second important Iron Age cemetery (Pautreau *et al.* 2005a). A radiocarbon determination suggests that it predates the fifth century AD. More than thirty burials have been uncovered, revealing a quantity of glass beads and earrings, cowrie shells and bronze bangles embellished with bells. Perhaps the most surprising finding at this site, is the quantity and range of iron artefacts. A long sword was found with one adult, and there are also spearheads, heavy tanged knives and reaping implements.

This move towards iron weaponry and useful tools, in

conjunction with exotic jewellery, is likewise found as one moves further west into Burma. Hnaw Kan is one of several Iron Age in the Samon Valley of Central Burma, and here Pautreau *et al.* (2005b) have recovered dense clusters of burials associated with large iron spears. At Myo Hla, one cluster of burials appeared to be particularly rich in terms of burial offerings, which included iron arms and tools, bronze tools and ornaments, and agate, glass and carnelian beads. Pautreau finds in such societies the logical progenitors of the early Burman states.

This finding returns us to the ultimate objective of our work at Noen U-Loke, to understand the indigenous contribution to the genesis of states leading to Angkor. We have contributed, we feel, some new and relevant information. The moated sites of the Mun Valley and by inference, northern Cambodia, harboured large communities that were to become culturally more complex. The cemeteries suggest the presence of elite leaders. Their status was indicated by a considerable weight of bronze paraphernalia, by gold and silver, agate and glass. Iron was locally forged into a wide range of weapons and useful tools. The organised workforce put in place impressive water control systems. We suspect the presence of specialists in the production of ceramics and casting of bronzes. Rice cultivation and animal husbandry supplied the energy for communities that turned to salt as a major commodity to be deployed in exchange relations. Such competitive social conditions saw an increase in conflict. Iron Age groups are now documented at Angkor, Angkor Borei, Phimai and Phanom Wan, all subsequent religious and administrative centres. Noen U-Loke and Non Muang Kao have, we feel, shown that the late prehistoric communities of the Mun Valley were ready and able to make the transition to civilization.

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