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Complex hunter-gatherers and first farmers in southern China

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ABSTRACT

Our understanding of adaptation by hunter-gatherers in Southern China and Southeast Asia to one of the richest habitats known, has for long been dominated by the investigation of cave sites. These have provided a seriously biased interpretation that stressed transient occupation by small, mobile groups. We here provide the first Bayesian-modelled radiocarbon chronologies for three key sites in Guangxi Province, southern China. Yahuai was occupied thrice between ca. 44 ka and 16.2 ka. Jiangxi'an is an extensive settlement located on the bank of the Zuo River with two occupation phases dated between 9500 and 8300 BP. Ganzao, a second open site, lies nearby on the same river bank and extensive excavations have revealed nearly 100 burials, together with a rich assemblage of material and biological remains dated between 10,300–9500 BP. These river-bank settlements and contemporary coastal sites evidence a radically different adaptation to that derived from rock shelters alone, that coincided with the Holocene thermal optimum and provide a compelling image of the affluent, sedentary hunter-gatherer communities that encountered and were assimilated by the farmers who penetrated the region from their homeland in the Yangtze River region during the third millennium BCEE.

1. Introduction

With its subtropical climate, monsoonal rainfall pattern and strategic location bordering the South China Sea, Guangxi Province in southern China and adjacent areas of Vietnam comprise a key region for documenting.

the settlement of this region by Anatomically Modern Humans (AMH). In this paper, we follow the cultural sequence spanning the climatic transition between the late Pleistocene and the Holocene climatic optimum. This necessitates our construction of the chronological framework derived from three new series of radiocarbon determinations. In doing so, it is necessary to stress the importance of selecting appropriate material for dating. Zhang et al. (2024) have critically examined the dating procedures for the Guangxi riverside settlements that have hitherto largely been derived from freshwater shells or from bone. The problem with the former, is that these sites lie beside rivers that originate in limestone terrain that are highly likely to transport dissolved inorganic carbonates. On being absorbed by the shells, these provide spuriously early ages. Bone, unless treated with the necessary pretreatments, is likely to appear too young because of likely contamination by humic deposits. Zhang et al. have dated three open occupation sites on the Yong River: Baozitou, Shichuantou, and Nabeizui (Fig. 1). Resultant dates from canarium nuts and lotus roots are consistently and significantly later than those derived from shells by up to 1500 years. We have avoided dating shells because there is no consistent correction formula to account for the freshwater reservoir effect.

We first report on the first Bayesian modelling of radiocarbon determinations for the cultural sequence in southern China from Yahuai Cave, a site on the right bank of the You River (Fig. 1). It was occupied from at least 44 ka, a date that contributes to determining when AMHs penetrated this region. It is further significant for the recovery of plant remains associated with stone tools that span the cold of the later Pleistocene into the warmer conditions of the Holocene (Wu et al., 2020). The typology of the stone tools has revealed a flaked industry typical of northern China, and it is considered likely that there was a move to the warmer south during the cold of the late glacial maximum (Xie, 2020). The inhabitants brought to the site palms and bamboo that can be consumed or used for medicinal purposes, tool making and for shelter. From at least 16 ka, they also collected wild rice, this being the

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earliest evidence for consuming this plant yet identified for the region.

The later hunter-gatherer occupation of southern China and Southeast Asia has been dominated by the excavation of caves and rock shelters ascribed to the Hoabinhian "technocomplex". First identified in the 1920s by the pioneer fieldwork of Madeleine Colani in the Vietnamese province of Hoa Binh, these sites present brief periods of occupation, wherein small groups were broad spectrum foragers with a limited range of stone tools dominated by a unifacially worked chopper known as a "sumatralith" (Colani, 1927). With the sea level much lower than at present for most of this period (Hope, 2005; Sathiamurthy and Voris, 2006), no evidence for a coastal adaptation survives. However, when the sea rose higher than at present from ca. 4000 BCE, large settlements are known, as seen at Con Co Ngua (Oxenham et al., 2018). It is highly likely that their predecessors are now submerged.

In Mainland Southeast Asia south of Guangxi, hardly a single inland hunter-gatherer site has been identified on the broad flood plains of the major rivers, probably due to habitat modification. However, moving into southern China, many hunter-gatherer sites were located beside or near rivers. These inland open sites and their contemporary coastal settlements are now providing a more realistic interpretation of this period of prehistory than that presented by the transient occupation of rock shelters.

Chinese specialists equate the Neolithic period with the first occurrence of pottery and ground stone tools, dated between ca. 12–3.5 ka. To avoid confusion with the more widespread restriction of the term "Neolithic" to communities engaged in farming, we here follow Oxenham et al. (2018) in employing the descriptive term "complex hunter gatherers" (CHG). Although pottery and ground stone tools occurred at the start of this sequence, the first rice farmers, who originated in the Yangtze River region, penetrated into the plains of Guangxi and the Red River region only after 5000 BP, as is documented by the analysis of their DNA (Lipson et al., 2018; McColl et al., 2018). Prior to this ingress, the economic basis for the greater part of the period involved hunting and gathering. At least 400 CHG sites have now been identified in Guangxi Province alone (Xie, 2022). However, many of these lack a chronological context, especially from radiocarbon dating. This constrains comparison with other regional sites and crucially, with the documented and vital changes in the environment. Here we consider the Bayesian modelling of the cultural sequences of first the early site of Yahuai cave, and then for two open, riverine occupation sites, Jiangxi'an and Ganzao.

1.1. Yahuai cave

Located on a karst tower overlooking a broad plain (Fig. 2), four areas, A, B, C, and D, have been opened covering 50 m^2 (Fig. 3; SI Fig. 1). The excavation followed stratigraphic principles that divided the sequence into distinct layers rather than arbitrary spits of predetermined depth. Area A (12 m^2) was excavated down to the basal rock from the surface with a stratigraphic section more than 7.5 m deep, consisting of 55 layers with cultural remains only from the upper part of the deposits; Area B (17 m^2, not dug down to the basal rock) exposed a 4.2-m thick section with 24 layers; Areas C and D were only excavated down to about 1 m, and yielded 7 and 11 layers respectively. Areas A and C were seriously disturbed but the deposits of Area B were virtually complete. It is this sequence that has been fully dated (Fig. 3). It must, however, be stressed that the deposits are very complicated: there are many fallen rocks and some of the stratigraphic layers are present in only part of the excavated square. Therefore, not all of the stratigraphic layers occurred in a section of the square, and therefore some layers are missing in Fig. 3.

A burial and a complete human skull of the Palaeolithic period were discovered. Numerous stone artefacts were recovered, the majority being small quartzite, sandstone, chert, tektite, or crystal flakes. Ground stone, shell and bone tools and pottery were found and fire was used (Fig. 4). Red ochre, some in powder form, was found throughout the sequence (Xie et al., 2018). Faunal remains included both large and small vertebrate remains that are currently under study (Belmaker et al., 2018; Song et al., 2020). Phytoliths come from elm, bamboo, palms and

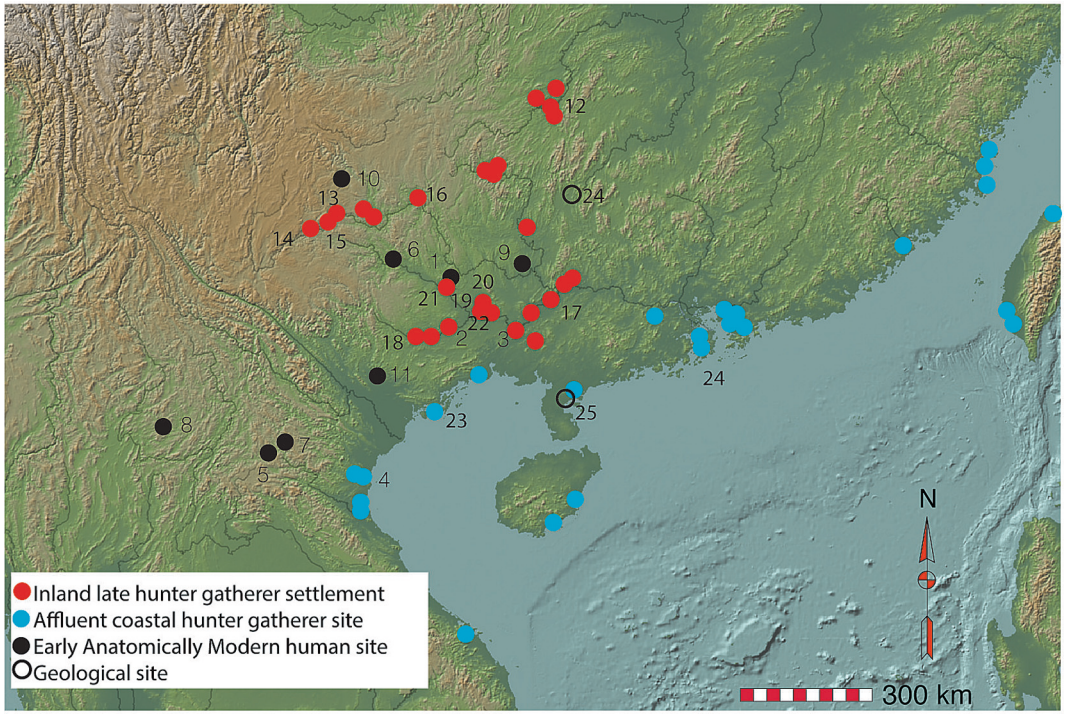

Fig. 1. The location of the key sites. 1. Yahuai, 2. Jiangxi'an, Ganzao, 3. Dingshishan, 4. Con Co Ngua, 5. Tam Ngu Hao, 6. Bose (Baise) Basin, 7. Tam Pa Ling, 8. Ngeubhinh Mouxeu, 9. Bailiandong, 10. Laoya, 11. Nguom, 12. Zengpiyan, 13. Gexinqiao, 14. Baida, 15. Kantun, 16. Beidaling, 17. Datangcheng, 18. Chongtang, 19. Baozitou, Shichuantou, Nabeizui. 20. Huiyaotian, 21. Liyupo, 22. Lingwu, 23. Cai Beo, 24. Dongge Cave, 25. Huguangyan Maar Lake. Map by C.F.W. Higham courtesy GeoMapApp (www.geomapapp.org), CC by Ryan et al.

Fig. 2. The location of the cave of Yahuai.

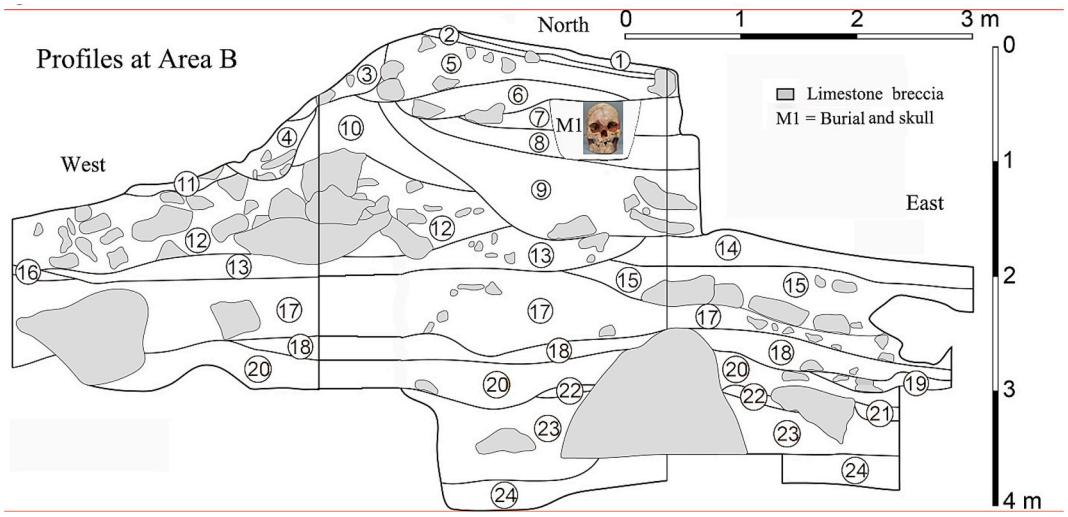

Fig. 3. The stratigraphic sequence from Yahuai cave area B, showing the location of radiocarbon samples.

wild rice (Wu et al., 2020).

We recognize three prehistoric phases in Area B. Phase 1, comprising layers 18–23, is characterized by the flaked stone tools and lack of perforated stones implements. Phase 2 incorporates layers 9–17 and contains numerous flaked stone tools, the occurrence of perforated stone implements and shell tools. Phase 3, found in layers 5–8, yielded many snail shells, burials and a human skull, and an increase of perforated stone tools and shell tools.

The remains of terrestrial and aquatic animals and plants suggest that hunting, fishing, and gathering were major subsistence strategies (Song et al., 2020). Several economically important plants were present throughout the sequence including Urticineae (cf. *Ulmus* sp.), which appears in the lower layers of the sequence (MIS 3 through to Heinrich 1); bamboo and palms which appear throughout the sequence, and wild rice dating to 16 ka, the earliest yet known in Southern China (Wu et al., 2020).

We have obtained 22 radiocarbon determinations, one from a charred nut and the rest from charcoal. Twelve come from Beijing University, three from Beta Analytic and six from the Oxford Radiocarbon Accelerator Unit (Table SI1). These have been analysed with Bayesian modelling (Fig. 5). Phase 1 occupation dates between 44 and 33 ka. The material culture between the first and second phase and the radiocarbon determinations suggest that there was then a gap of six millennia before the cave was reoccupied during phase 2, between 28 and 24 ka. Phase 3 dates between 16.3 and 16 ka. The first pot sherds were found in layer 3, and these on comparative grounds date to about 4 ka.

There were thus three distinct occupation phases dating to the later Palaeolithic at this site. As with many cave sites in this region, it is evident from the Bayesian analyses and the changes in material culture alike, that this site was occupied intensely but briefly on three occasions. This contrasts with the open settlements that were to ensue. One contributory factor, it is suggested, is that during the interval between the final phase of occupation of Yahuai and the settlement of Jiangxi'an and Ganzao, there was a major climatic change involving the Holocene thermal optimum (Oxenham et al., 2018). This is seen in the pollen cores

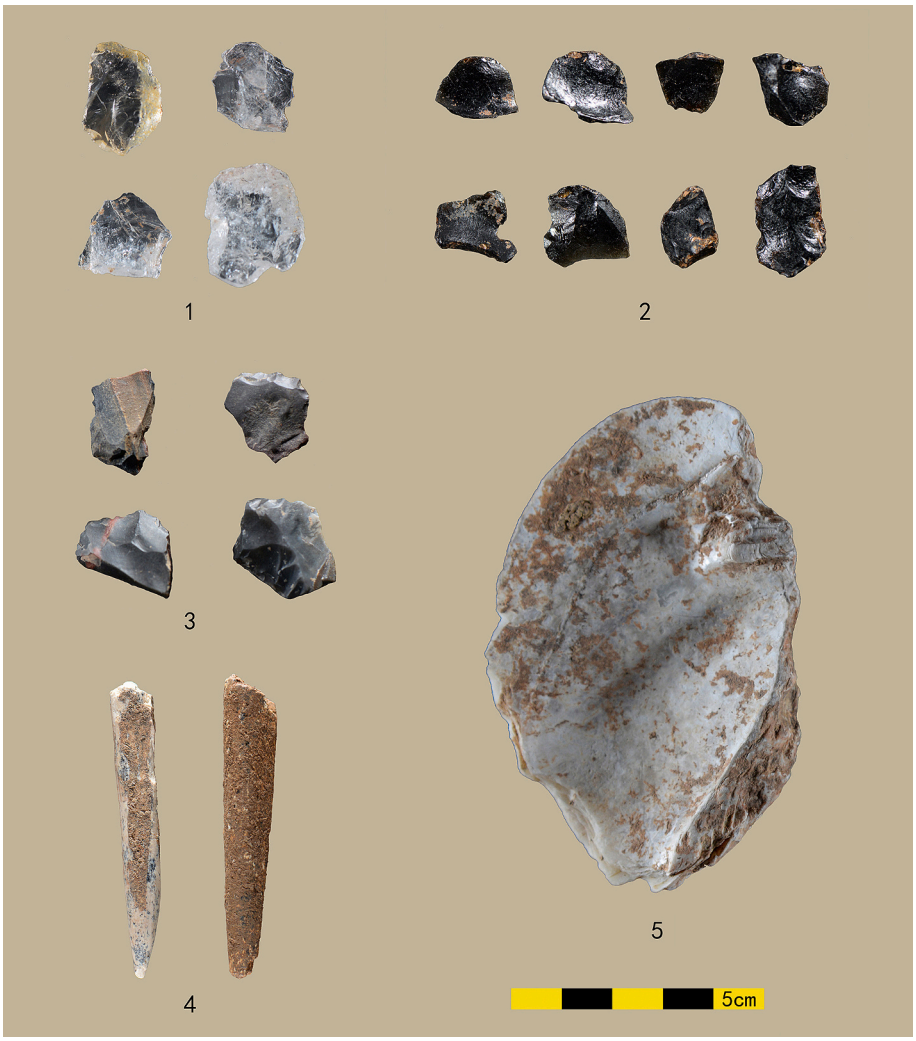

Fig. 4. Artefacts from Yahuai cave (Phase 2). 1. Crystal implements 2. Tektite implements, 3. Flint implements 4. Bone points 5. Shell tool.

from Huguangyan Maar Lake in Guangzhou, where three principal phases have been identified (Wang et al., 2007). Between 13 and 11.6 ka, there was a relatively cool period represented by temperate trees. This was followed by a significant increase in a tropical and sub-tropical flora that reached a climax at 9.5–8 ka that indicates a hot and wet environment. From 7.8 ka, the climate cooled considerably and drier conditions prevailed. This sequence is confirmed in the isotopic evidence from speleotherms in the Dongge Cave (Fig. 1; Dykoski et al., 2005).

1.2. *Jiangxi'an*

Jiangxi'an lies on the northern bank of Zuo River where it forms an alluvial terrace 1400 by 300 m in extent, with a high point of 87 m. To the north of the terrace is a hill 295 m in height. The site is located on the southern part of the terrace, covering an area of 3000 m^2.Two other sites are located nearby. Chonghe is 2.5 km upstream and Ganzao is 3.3 km downstream on the northern bank. All three are occupation and burial sites, and many more such settlements are located along the Zuo and Yong rivers.

The excavation of Jiangxi'an took place 2014, when about 2000 m^2 were exposed and divided into two areas. Nearly 1000 cultural remains were recovered, including stone artefacts, potsherds and shell and bone tools (Fig. 6). No burials were found, probably because part of the site has been removed by river erosion (Meng, 2015). Eight stratigraphic layers were identified and excavated as such, rather than as arbitrary spits. Each layer has a different distribution across the site and their thickness varies, so Fig. 7 covers just one part of the stratigraphic sequence. Layer 1 contains modern material; layer 2 dates to the Song dynasty and layer 3 is late Neolithic, containing a few lumps of burnt clay, cobbles, grinding stone tools, and ground stone axes. Layers 4 to 8 are the middle phase of the AHG sequence and comprise greyish to yellowish-brown clay (Fig. 7). Layers 6–8 lie at the northern end of the midden deposits, which are 60 m long and 3–9 m wide. Layer 7 comprises a rich midden of spiral and clam shells with clear boundaries. Artefacts include stone manuports, cores and flakes, perforated stone tools, grinding stones, ground stone axes and adzes, bone chisels, awls, hooks and bone needles, shell spades, pottery sherds, animal bones, charcoal and lumps of burnt clay. The pottery was tempered with calcareous sand and decorated with cord marks. Most of the pottery is red on the exterior and black or greyish-black on interior. The principal vessel form in the earlier phase had an everted rim with a globular body and round base, as seen in the Vietnamese site of Da But (Fig. 6 no.4), while in later phase the rim direction became direct. Faunal remains come from the water buffalo, rhinoceros, elephant, deer, wild pig, monkey, turtles, and fish. A possible butchering floor covering 4 by 2 m was found in layer 6, comprising mainly the mandibles of deer, muntjac, pigs and monkeys. Round pits were found at the bottom of layers 6 and 7.

According to the stratigraphy and artefact typology, there are two

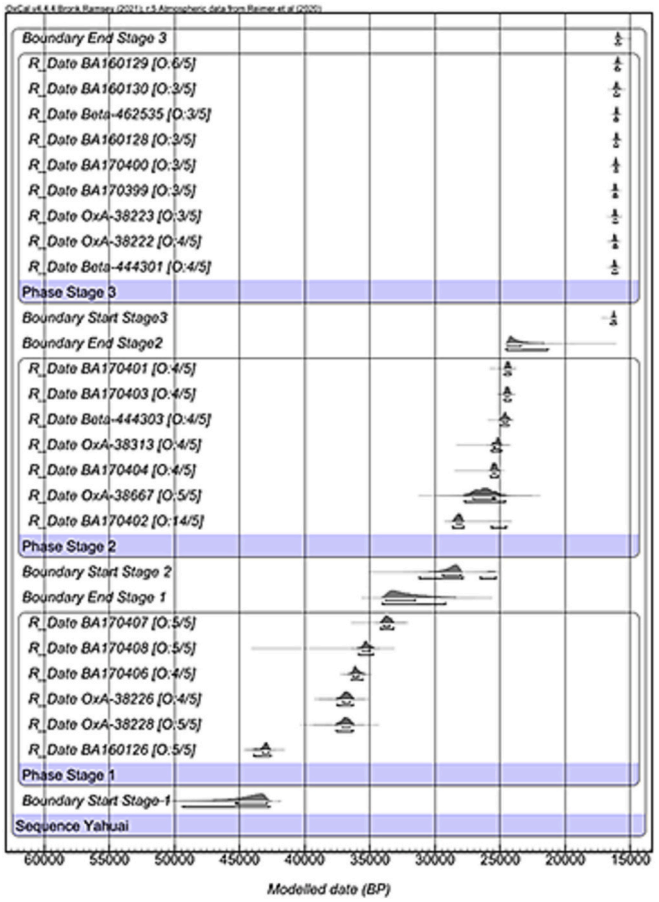

Fig. 5. Bayesian plot for the radiocarbon dates from Yahuai Cave, expressed as cal. BP and plotted using OxCal v4.4 and IntCal 2020 (Bronk Ramsey, 2021; Reimer et al., 2020; Dee and Bronk Ramsey, 2014).

phases of the middle AHG occupation at Jiangxi'an. The first comprises layers 8–6, and the second includes layers 5 and 4. We have included the 21 radiocarbon determinations from layers 8 to 4 in a Bayesian model (Table SI1). The results are in the main, consistent with the observed stratigraphic sequence. To account for the likely presence of old wood with inbuilt age we used a Charcoal Plus outlier model (Dee pers. comm.). In addition, with long-lived sites of this nature, with relatively shallow stratigraphy, it is to be expected that some samples will have been taphonomically-influenced through prehistoric activities. Seven of the radiocarbon determinations are derived from bone, depicted in red in Fig. 8. As may be seen, they harmonise with the charcoal dates.

The model suggests that the site was first occupied from 9490 to 9050 cal BP, a date corresponding to the onset of the Holocene thermal maximum. Phase 1 falls between 9300 and 8240 cal BP (95.4 % prob.) and the later occupation dates to 8420–7920 cal BP (Fig. 8).

1.3. Ganzao

Ganzao is an AHG settlement located on the northern bank of the Zuo River, about 3.3 km from Jiangxi'an. Discovered in 1963, it was test excavated in 1973. Fourteen burials and cultural remains were recovered. In 2014, a further excavation covering 1025 m^2 was undertaken and nearly 100 burials were identified together with many stone artefacts, including cores, flakes, chipped choppers and scrapers, ground axes and adzes and grinding tools. Potsherds, bone and shell tools as well as animal bones and human skeletons were also unearthed (Fig. 9, Chen, 2015, 2023). Nine layers were identified (Fig. 10). Layer 1 is greyish yellow clay, and the pits cut down from this layer contain stone spades

Fig. 6. Artefacts from Jiangxi'an, and the bone midden.1. shell adze, 2. ground stone adze, 3. bone point, 4. potsherd. The lower image shows a midden containing the mandibles of deer, pigs and monkeys.

and potsherds typical of late Neolithic (~4000BP). Layers 2–3 were distributed in the northern part and the southwest corner of the excavated area, the deposits becoming thinner from south to north. Numerous stone artefacts including cores, flakes, choppers, scrapers, ground stone axes and adzes were recovered. Layers 4–9 were found in the southeast part of the excavated area, where the deposits became thinner form south to north. Many shells, burials and pits were discovered, and stone and bone tools and pottery were found, but there were no shell tools.

There are four phases of cultural remains determined by stratigraphy rather than arbitrary spits of predetermined depth. Phase 1 comprises layer 9. Burials and pits were found together with stone, bone and shell tools and potsherds. Phase 2 comprises layers 8–4, which contain many shells, burials and pits. Stone and bone tools and pottery were found but there were no shell tools. Phase 3 is represented by layers 3–2. A large of stone artefacts and a few shell tools and potsherds were recovered. Pits and post-holes were also found at the bottom of this layer. Phase 4 includes pits cut down from layer 1 and the big stone spades and potsherds unearthed in these pits. Phases 1–3 belong to AHG period and phase 4 is in the age of late Neolithic.

Twenty-eight samples from occupation contexts (exclusive of phase 4)have been dated and subjected to Bayesian modelling, five from the University of Waikato, the rest from Beijing University (Fig. 11, Table SI1). The results suggest that the site was first occupied within the period 10,640–9070 cal BP. Phase 2 spans 9450–8460 cal BP, while Phase 3 ranges between 8700 and 8280 cal BP (all at 95.4 % prob.). It is noted that the determinations for phase 3 do not conform with those from phase 2, and might well reflect bioturbation within a relatively shallow accumulation of cultural remains that was disturbed by the excavation of graves and pits, a common characteristic of sites such as these.

The burials are divided into two phases, and included infants, young and mid-adult individuals (Fig. 9). All seven graves of Phase 1 were cut down from under Layer 8. The position of two burials was not clear because most bones were missing, others were found in side-flexed

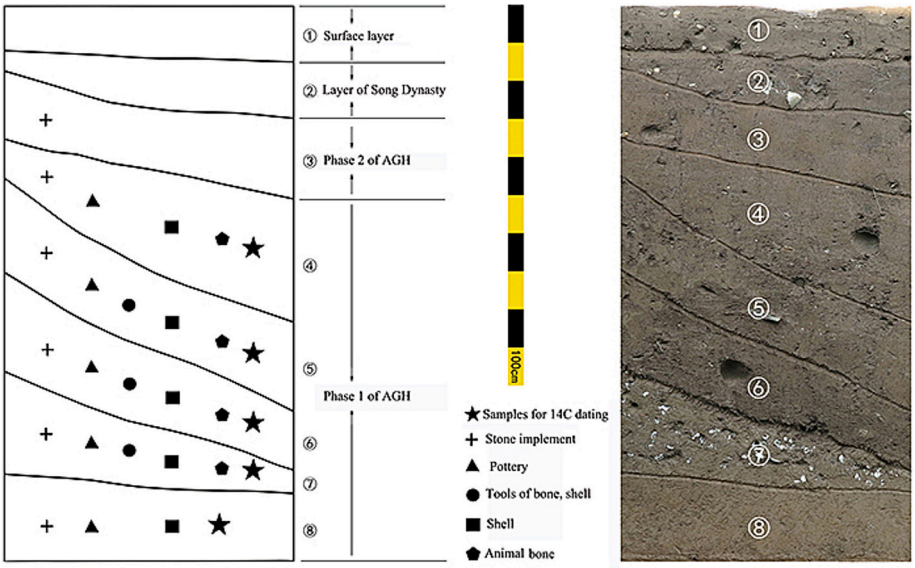

Fig. 7. The stratigraphic profile of Jiangxi'an, showing the location of the radiocarbon samples.

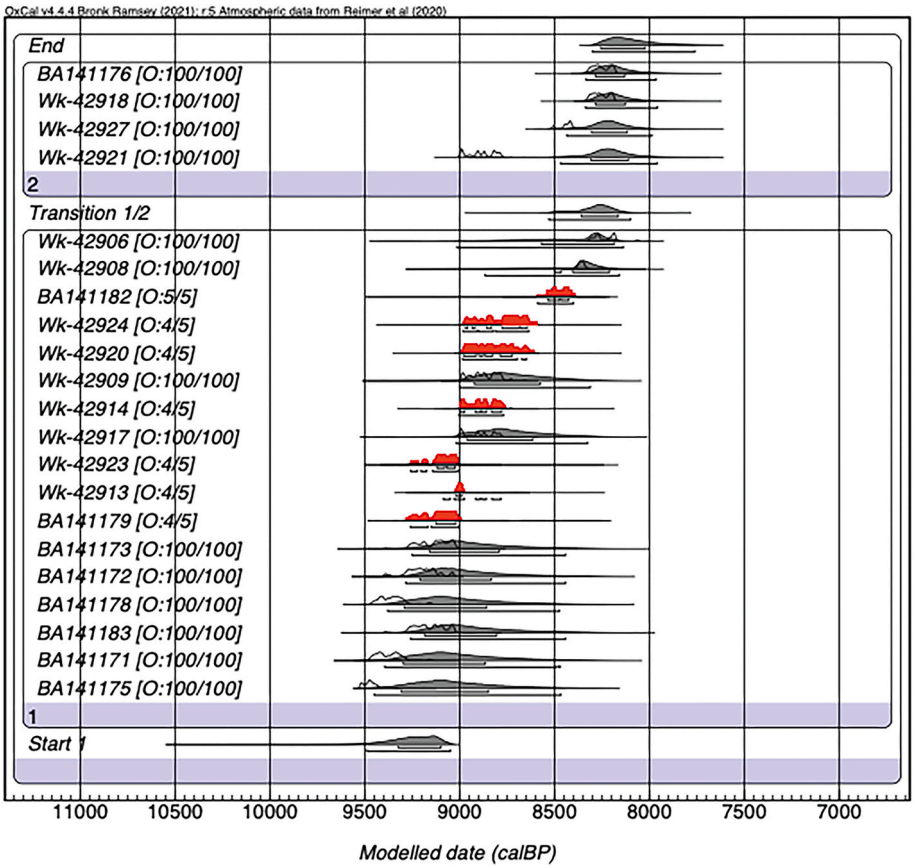

Fig. 8. The Bayesian plot for radiocarbon dates from Jiangxi'an, expressed as cal. BP and plotted using OxCal v4.4 and IntCal 2020 (Bronk Ramsey, 2021; Reimer et al., 2020; Dee and Bronk Ramsey, 2014). Dates in red derive from bone, all others are from charcoal. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

position typical of sedentary hunter-gatherer settlements in this region. No mortuary offerings were found other than blocks of stones in two graves. Phase 2 comprised 90 graves, half being cut from under Layer 4, others were cut from under layer 5, 6, or 7. Most of the dead had been interred in a side-flexed position, others flexed and lying on the back. Mortuary offerings were found in a third of the burials, comprising blocks of stone, whetstones, and shell and stone tools. Bayesian modelling of the determinations on human bone reveal that phase 1

Fig. 9. Artefacts and burials from Ganzao. 1. Grinding stone tool (Phase 4), 2. Stone adze (Phase 2), 3. Bone hook (Phase 2), 4. Burial 91 (Phase 1), 5. Burial 47 (Phase 2).

graves date between 10.4 and 9.4 ka, although date BA141112 looks very much as if it is intrusive from phase 2. Those from phase 2 fall between 9.4 and 8.2 ka (Fig. 12; Table SI1). These harmonise well with the results from occupation contexts (Chen, 2023).

2. Discussion and conclusions

At ca. 44 ka, Yahuai is one of the oldest cave sites in southern China and mainland Southeast Asia to yield a small flake-tool assemblage. Bailiandong cave, located in central Guangxi spans the late Palaeolithic to AHGS and has been dated between 37 and 7 ka. Five phases were identified, and the same small flake-tool assemblage were found in phases1–2 dated between 36 and 19 ka (Zhou, 2007; Jiang, 2009). Nguom rock shelter is located in Northern Vietnam and three assemblages from different stratigraphic layers were identified there. Stone artefacts from layer 2 and layer 3 belong to Hoabinhian and Son Vi cultures respectively, while those from layer 4 and layer 5 belong to a small flake-tool industry and has been dated between 40 and 23 ka (Ha, 1985; Quang, 1995; Hoang and Nguyen, 1998). Lang Rongrien, located in peninsular Thailand was occupied from 43 ka, the stone assemblage from the earliest phase being assigned to the small flake-tool industry (Anderson, 1990).

These cave sites, with thin occupation layers representing transient occupation, contrast markedly with the many large, usually river-bank settlements that are now being identified in the inland river flood plains and intermontane valleys of southern China and Southeast Asia (Higham, 2013). They present a set of integrated innovations that took hold as the climate warmed from ca. 12 ka. The interior plains would have presented ideal conditions for hunter gatherers. At Jiangxi'an and Ganzao, we find large occupation sites, extensive areas of stone tool manufacture and at the latter, a cemetery in which the dead were

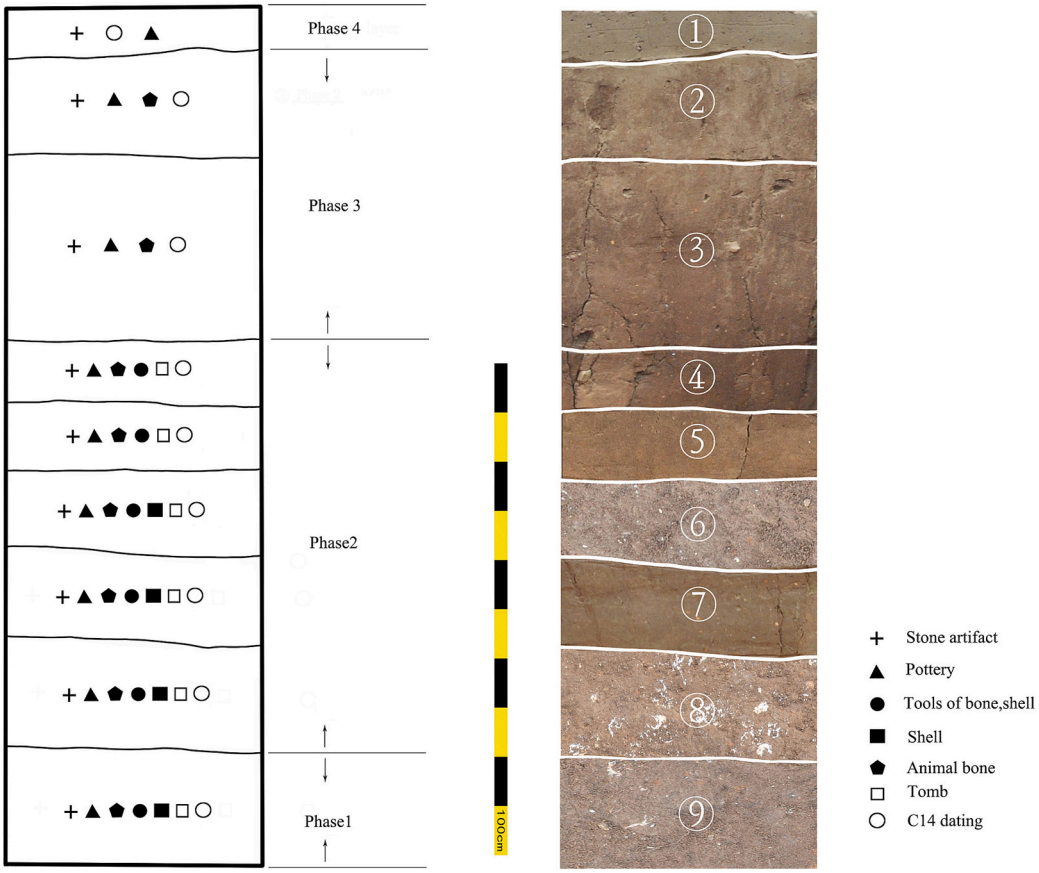

Fig. 10. The stratigraphic profile for Ganzao, showing the location of the radiocarbon dating samples.

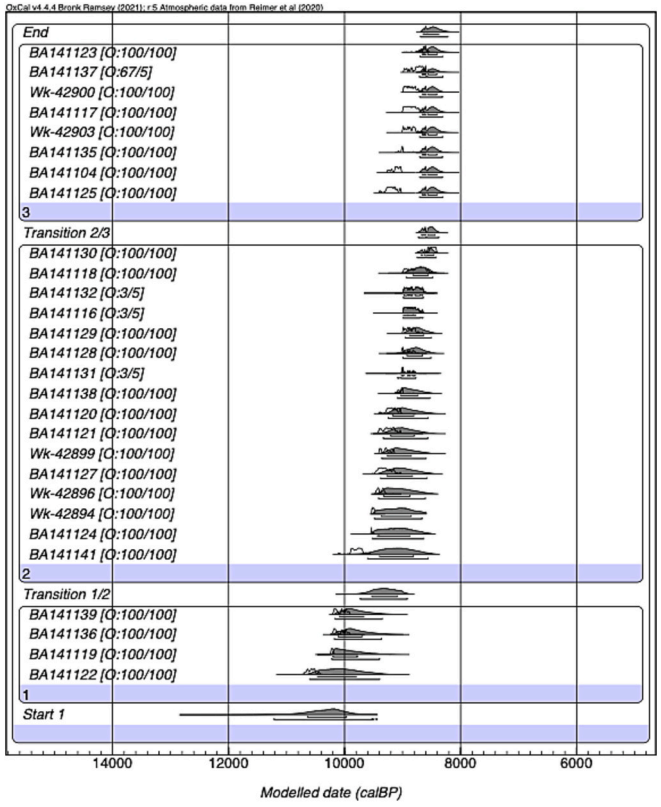

Fig. 11. The Bayesian plot for radiocarbon dates from occupation contexts at Ganzao, expressed as cal. BP and plotted using OxCal v4.4 and IntCal 2020 (Bronk Ramsey, 2021; Reimer et al., 2020; Dee and Bronk Ramsey, 2014).

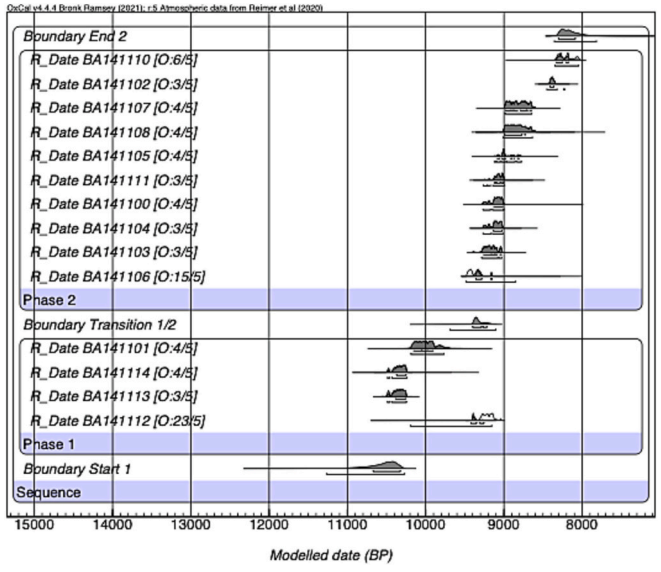

Fig. 12. Bayesian model of the radiocarbon determinations from human bone, for burials from Ganzao, expressed as cal. BP and plotted using OxCal v4.4 and IntCal 2020 (Bronk Ramsey, 2021: Reimer et al., 2020; Dee and Bronk Ramsey, 2014).

interred in tightly flexed positions with few mortuary offerings. It is important to note that our dating of these sites falls within the span, 10,000–8000 BP) obtained by Zhang et al. (2024) for the three sites he dated on the basis of lotus roots and canarium nuts. Beidaling is one of several similar sites located along the course of the Hongshui River. Here, an extensive stone workshop and eight burials were found in the lower part of the deposits, which are dated to ca. 8 ka. More than 50,000 stone artefacts were recovered, including hammer stones, anvils, whetstones, flaked choppers, points and scrapers, as well as polished adzes and axes. All stages of manufacture are represented, indicating an established stone workshop (Lin and Xie, 2005).

Jiangxi'an and Ganzao are two of many riverine settlements that date to the Holocene thermal optimum as documented by speleotherm and pollen and analyses respectively at Dongge Cave and Huguangyan Maar Lake. In eastern Guangxi, five sites have been found along the course of the Xun River. Datangcheng was a stone workshop with two periods of occupation, dated to 8 and 5 ka. There was a dense accumulation of stone flakes and artefacts in various stages of manufacture, including many adze rough outs, hammer stones and whetstones. Much pottery was also found, including large vessels with everted rims (Lin et al., 2007). There are several sites along the course of the Yong River in Southern Guangxi, and at Chongtang, a group of 26 human graves have been uncovered, in which the dead were interred in a tightly flexed position. Cowrie shells also provide evidence for exchange with distant coastal communities (He and Chen, 2008).

Huiyaotian, an open site next to the Yong River, has been dated on the basis of three radiocarbon determinations to 9.0–8.3 cal BP. A cemetery containing a group of at least 64 burials in flexed or squatting positions has been revealed. A multivariate analysis of cranial shape has placed the inhabitants in the Australo-Papuan group that predated the ingress of the first rice farmers (Matsumura et al., 2020). The closest relations are found in Hoabinhian sites across Southeast Asia, while they present a sharp contrast to the rice farmers of the lower Yangtze sites of Beidun and Hemudu (Matsumura et al., 2017). This site also incorporated rich shell middens, and covers at least 18,000 m^2. An analysis of the faunal remains has shown that the environment was forested, with abundant riverine resources including shellfish, turtles and fish (Table SI2, Zhen et al., 2017). The material culture included pottery vessels, polished stone adzes, bivalve shell knives and grinding stones (Wang, 2023). Liyupo has been dated by five radiocarbon determinations to 7700–6700 BP. Here, 43 flexed burials have been found along with a material culture again including pottery vessels, grinding stones, pestles and pounders. The starch grains from both sites have revealed the consumption of taro and yams, each representing 20 % and 15 % of the samples analysed. Panicoid grasses, such as Job's tears and green foxtail millet account for 37 %, while there are also acorns at 14 %. We conclude that these permanent and extensive CHG settlements had developed, during the Holocene thermal optimum, habitual and extensive exploitation of taro, yams, grasses and acorns. This trend towards the processing of aroids and grasses during the Holocene climatic optimum was widespread, as seen at Niah Cave (Barton et al., 2013). There is little doubt that it would have facilitated a greater degree of permanent settlement and associated social and technological changes. Indeed, the Guangxi riverside sites present consistent evidence for habitation, burials and manufacturing that accord with planning and the generational transfer of knowledge.

The similarities between these sites and those of the Da But group in northern Vietnam are so close that they must have been developing in tandem. Con Co Ngua is the exemplar of the Da But sites, where excavations in 2013 documented a complex, large, sedentary hunter-gatherer community dated to ca. 6.9 cal BP (Oxenham et al., 2018). Although now 30 km from the shore, Con Co Ngua would then have been close to the sea, with its rich marine resources reflected in the remains of estuarine and marine as well as fresh-water fish, turtles and otters. The inhabitants collected nutritious canarium nuts, and probably many other plant foods that have not survived. They also hunted and even managed wild water buffalo and deer, and in doing so probably exposed themselves to injuries seen in a number of healed fractures of the arm and leg bones (Scott et al., 2019). Proximity to the same water sources as wild bovids was probably the reason why 14 % of the population suffered from hydatids (Vlok et al., 2022). The sedentary nature of this

settlement favoured the manufacture of pottery vessels. These had rounded bases and were decorated with parallel impressions similar to the ceramics from the associated sites to the north. They also made shell and bone tools from deer long bones, including points and fishhooks. Coarse pottery vessels and ground stone adzes were recovered from Con Co Ngua. Cai Beo is a coastal settlement on the eastern shore of Cat Ba island in Ha Long Bay. Covering at least 18,000 m^2, the occupants, were able to exploit both the marine and the adjacent forested habitats. Wang et al. (2022) have recently analysed the many stone mortars, and found that palms, acorns, yams and taro were also intensively collected.

Jiangxi'an and Ganzao are thus the only Early and Middle AHG sites in southern China to have been dated with multiple samples and Bayesian modelling that reveal the likelihood of continuous occupation over centuries. The new 14C dates provide an important chronological framework for the study of these late Pleistocene and Holocene settlements in Guangxi, a region that was well populated with AMH groups when the first rice farmers arrived from the north. Vitally, the radiocarbon chronologies reveal that occupation coincided with a marked increase in both warmth and precipitation. Our appreciation of the subsistence economy of these communities during the thermal optimum has recently been illuminated by the analysis of human dental calculus and the starch grains from the virtually ubiquitous grinding tools and pestles that so characterize the new repertoire of stone artefacts from these sites (Wang et al., 2022). Subsistence incorporated not only the riverine and woodland resources, but also the harvesting and processing of a wide range of plants dominated by taro, yams and grasses.

In accounting for the sedentary occupation of these sites, it is important that the exploitation of root crops and other plants has now been identified, to complement that already evidenced at Niah Cave in Borneo during the late Pleistocene occupation (Barton et al., 2016). As Kubukcu et al. (2023) have shown, similar trends have recently been documented in harvesting and processing plant resources at Franchthi Cave in Greece and at Shanidar, leading to the conclusion for those sites that cultivation and domestication, the signal for the Neolithic Revolution, was preceded over many millennia by intensification of plant resource exploitation. The degree to which any or all of these plants in Southern China and Vietnam proceeded beyond the gathering of wild harvests is not yet known. Nevertheless, the very fact that these sedentary village communities saw occupation, probably continuous, for centuries, opens a new concept of their complexity when compared with the traditional dominance of the temporary occupation by small groups of rock shelters.

This raises two issues of widespread interest. The first adds to the growing list of complex hunter gatherers who maintained enduring settlements and cemeteries, a list that spans sub-tropical Southeast Asia to sub-Arctic Finland (Hakonen et al., 2023). the second involves the relationship between long-established complex hunter gatherers and incoming farmers. In Southeast Asia, this involved multiple prongs of riverine and coastal ingress. We have shown that the rice farmers would have encountered substantial, sedentary hunter gatherer settlements in which people had long-since made pottery vessels, polished and hafted their axes, ritually interred their dead in substantial cemeteries and exploited a wide range of both animal and plant resources. Man Bac, a Neolithic settlement on the southern margin of the Red River Delta, is the best site for assessing the meeting between these two groups. The cranial morphology and DNA of those interred at Man Bac have revealed that nine of the males comprise a cluster matching the inhabitants of Weidun, an agricultural community located in the lower Yangtze Valley. Five individuals, however, cluster with the earlier hunter gatherers of this region (Matsumura, 2010). The first two studies of ancient DNA from early rice farmers and hunter gatherers in Southeast Asia have likewise revealed a consistent pattern of introgression between the two (Lipson et al., 2018; McColl et al., 2018) that from all available evidence did not involve the violence seen in the same convergence in Western Europe (Fibiger et al., 2023). This is a widespread pattern of coalescence and assimilation that is best understood in the long term complex hunter-gatherer communities seen at Jiangxi'an and Ganzao.

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CRediT authorship contribution statement

Guangmao Xie: Writing – original draft. **Xiaoying Chen:** Investigation. **Zhangwang Meng:** Data curation. **Yan Wu:** Investigation. **Charles Higham:** Writing – review & editing, Funding acquisition.

Declaration of competing interest

We declare that we have no interest financial or otherwise.

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