Journal of World Prehistory (2019) 32:143–178
https://doi.org/10.1007/s10963-019-09130-3

Luobi Cave, South China: A Comparative Perspective on a Novel Cobble-Tool Industry Associated with Bone Tool Technology during the Pleistocene–Holocene Transition

Yinghua Li, et al. ***[full author details at the end of the article]***

Published online: 23 May 2019

Abstract
The nature of Paleolithic cultures in South China and their relationship with mainland Southeast Asia remains ill-defined. The lithic industry of South China has been characterized as a simple 'cobble-tool' industry, persisting from the early Pleistocene to the Holocene, while the most representative Southeast Asian industry was also marked by a pebble-tool techno-complex, the *Hoabinhian*, during the Late Pleistocene–Early Holocene. A possible cultural link between the two regions has been proposed by some scholars but the technological characteristics of the two industries remained elusive, as did the variability within them. In this paper we conduct technological analysis of a 'cobble-tool' industry associated with a bone tool technology from Luobi Cave, Hainan Island, dated to c. 11–10 ka, and compare it with the well-studied typical Hoabinhian site of Laang Spean in Cambodia. While there is a slight similarity in operational sequence (*chaîne opératoire*), a major difference is that the Luobi Cave site can be rejected as a potential Hoabinhian site. The excavated material indicates a high degree of innovation and demonstrates a new sort of variability in the tool-kit of modern human groups during the Late Pleistocene–Early Holocene transition in South China and Southeast Asia. This study represents an initial attempt to decipher the technological cultural variability in this region. We suggest that the emergence of behavioral modernity and cultural variability should be evaluated at both regional and sub-regional scales, instead of defining them as uniform, progressive and incremental, processes. Here we present, firstly, the variability of operational sequences (*chaînes opératoires*) within the lithic production of Luobi Cave, and then compare this assemblage with typical and well-studied Hoabinhian assemblages from Laang Spean Cave in Cambodia to make clear the regional variability or complexity of human technological behaviors. Secondly, we then discuss the role of these technological behaviors as strategies for adapting to diverse ecology and environments from the Late Pleistocene to the Holocene.

Keywords Cobble-tool industry · Luobi Cave · South China · Hoabinhian · Hunter-gatherers · Late Pleistocene–Holocene transition · Southeast Asia

Introduction

During the Late Pleistocene to Holocene, South China and Southeast Asia shared a similar climate, ecology and environment on a macroscopic scale, resulting in closely linked population and continuous cultural development. A number of paleoanthropological and archaeological discoveries suggest that this region was extensively occupied by anatomically modern humans (AMH) by the time of the Late Pleistocene–Holocene transition (Aubert et al. 2014; Cao 1982; Curnoe et al. 2016; Demeter et al. 2012; Forestier et al. 2015; Gorman 1970; Jiang 2009; Liu et al. 2015; Song et al. 1983; Yi et al. 2008; Zeitoun et al. 2008, 2012; Zhang 1995). However, uncertainty remains about the cultural trajectory with respect to other parts of the world, and about cultural variability within this vast region.

For the prehistoric archaeology of China, as for that of the Old World more generally, a subject matter distinction can be perceived, dividing Paleolithic from Neolithic archaeologists: the former have tended to focus on knapped stones of the Pleistocene (> 10 ka) while the latter have concentrated on pottery and polished stone artefacts normally attributed to the Holocene (< 10 ka). However, in South China lithic industries predominantly consisting of knapped stones persisted for a long time, extending from the Pleistocene into the Holocene (Bar-Yosef and Wang 2012; Qu et al. 2012; Wang 1998; Zhang 2002), while pottery was not commonly made and used until the Middle Holocene (Jiao 1994; Zhang and Hung 2012). As a result, the lithic industries of South China, characterized by knapped stones and dated to the Late Pleistocene–Holocene transition, have received little attention, and we have little knowledge about human technological behaviors and cultural variability or homogeneity in this region during this transitional period.

In fact, the transition from the Late Pleistocene to the Holocene (c. 13–8 ka) represents an important global climate shift from fully glacial to fully interglacial conditions, resulting in a great transition in the culture, technology and subsistence patterns of humans in most parts of the world (Straus 1996). However, as in South China and Southeast Asia, the frequent and remarkable paleoclimatic change, combined with diverse ecology and environments, generated significantly different landscapes for human evolution, associated with great sub-regional variability in human cultures and behaviors, which should not be ignored (Aikens and Akazawa 1996; Barton et al. 2007; Eriksen 1996; Gao et al. 2010; Li et al. 2014a; Moore and Hillman 1992; Pookajorn 1996; Wang 1998).

As to variability within Chinese Paleolithic cultures, two traditions/industries—the core-and-flake industry in North China and the cobble-tool industry in South China—persisted for a long time, from the Pleistocene into the Holocene (Bar-Yosef and Wang 2012; Qu et al. 2012; Wang 1998; Zhang 2002). In Southeast Asia, the transition from the Late Pleistocene to the Holocene was marked by a widely-distributed pebble-tool techno-complex, the *Hoabinhian*, with a well-established tradition of scholarship stretching back nearly a hundred years (Colani 1927, 1929; Gorman 1969, 1971; Ha 1997; Pautreau 1994; Pookajorn 1990). Since its first discovery and definition in North Vietnam (Colani 1927, 1929), the

Hoabinhian has become the most important techno-complex for our understanding of Late Pleistocene–Holocene hunter-gatherer subsistence on the Southeast Asian mainland, and on several islands including Sumatra (Bacon 2012; Boriskovsky 1969; Forestier 2000; Forestier et al. 2005, 2015, 2017; Gorman 1971; Ha 1980, 1997; Heekeren and Knuth 1967; Higham 2013; Kamaruzaman 2002; Marwick 2007; Matthews 1966; McKinnon 1991; Meijaard 2003; Moser 2001; Mourer and Mourer 1970a; Nguyen 2000; Rabett 2012; Shoocongdej 2006; Taha 2000; Yi et al. 2008; Zeitoun, Bourdon et al. 2019; Zeitoun, Auetrakulvit et al. 2019).

The Hoabinhian sites, mostly located on the Southeast Asian mainland, are associated with an ecology of humid, tropical hunter-gatherer subsistence, which persisted until the transition to the Neolithic, emerging between 8 ka and 6 ka (according to region), when plant domestication or 'proto-agriculture' was adopted (Glover 1977; Gorman 1969, 1970, 1971; Reynolds 1989). Hoabinhian tools, according to the initial definition by Colani (1927, 1929) comprise hammer stones, implements of sub-triangular cross-section, discs, characteristic short axes and almond-shaped artefacts, all consistently shaped on cobbles or pebbles. One common, representative tool-type in these lithic assemblages is the *sumatralith*. Sumatraliths display unifacial flaking, usually around the circumference of a unifacial blank with a consistent plano-convex cross-section (Forestier 2000; Gorman 1970; Marwick 2008a; White and Gorman 2004). In recent years, a new lithic technological analysis has been applied so that three major *chaînes opératoires* involving cobbles can be identified for defining the Hoabinhian as a techno-complex: (i) choppers and chopping tools; (ii) unifacial tools (sumatraliths); and (iii) split cobbles (Forestier et al. 2005, 2013, 2015; Marwick 2008b, 2013; Zeitoun et al. 2008). This has laid the foundation for new analysis and comparison of Hoabinhian tools on a sub-regional scale. Regarding the relationship between the cobble-tool industry of South China and that of Southeast Asia, the probable presence of Hoabinhian tools (i.e. sumatraliths) in South China has been suggested by some researchers (Bowdler 2006; Dai 1988; Deng 1992; Zhang and Qiu 1998), but this has not been discussed in any detail, and we are left with only an obscure understanding of variability in the lithic industries of these two adjacent regions.

Over a deep time and evolutionary perspective, cobbles and pebbles were the most widely used raw materials in hominin lithic production, stretching from the most ancient East African assemblage at Lomekwi 3 (Harmand et al. 2015) through the Late Pleistocene–Holocene transition in South China (Bar-Yosef and Wang 2012; Qu et al. 2012; Wang 1998; Zhang 2002), Southeast Asia (Forestier et al. 2005, 2013, 2015; Gorman 1969, 1971; Pookajorn 1990; Zeitoun et al. 2012) and South America (Boëda et al. 2014). Technological and techno-functional analysis indicates two major operational schemes applied to pebble/cobble industries: flaking (*débitage*) and shaping (*façonnage*) (Inizan et al. 1999). Yet the variability within these two knapping schemes remains unclear, especially for the cobble-tool industry of South China and pebble-tool of the Hoabinhian techno-complex in Southeast Asia.

In addition to the recent discovery of a Hoabinhian assemblage at the site of Xiaodong, Yunnan Province, southwest China (Ji et al. 2016), Luobi Cave was another site thought to have yielded sumatraliths (Hao and Huang 1998), but uncertainty remained as to the nature and position of its industry with respect to the Hoabinhian of Southeast Asia. In this paper we first present the variability of operational sequences (*chaînes opératoires*) within lithic production of Luobi Cave. We then compare this assemblage with typical and well-studied Hoabinhian assemblages from Laang Spean Cave in Cambodia to demonstrate the regional variability and complexity of technological behaviors present in this time period and region. Finally, we discuss these patterns in terms of humans' strategies for adapting to diverse ecology and environments from the Late Pleistocene to the Holocene.

Luobi Cave, Hainan Island

Luobi Cave (also called Luobidong in Chinese) is located in the northeast of Sanya City, Hainan Island (18°19′42.4″N, 109° 32′50.6″E). Hainan lies about 170 nautical miles from Da Nang in Vietnam across the western margin of the South China Sea, off the southernmost tip of the Chinese mainland. The site (Fig. 1) was discovered in 1983 and excavated for two successive seasons in 1992 and 1993 by archaeologists from the Museum of Hainan Province, Sanya City, and the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) (Chinese Academy of Sciences). The exposed area of about 120 m^2 yielded human and faunal remains, and stone-, bone- and antler tools.

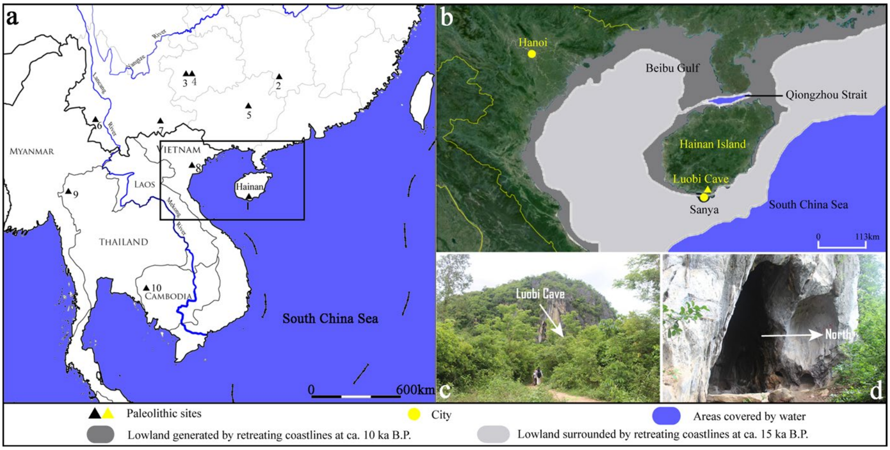

Fig. 1 **a** Distribution of the sites mentioned in this paper from South China and SE Asia: *1*. Luobi Cave; *2*. Fuyan Cave (Daoxian); *3*. Maomaodong; *4*. Chuandong; *5*. Bailian Cave; *6*. Xiaodong Rockshelter; *7*. Maludong; *8*. Hang Boi cave; *9*. Tham Phaa Can Rockshelter; *10*. Laang Spean Cave; **b** Location of Luobi Cave in Hainan Island and lowlands generated by retreating coastlines (c.15–10 ka. B.P.) (redrawn after Yao et al. 2009, base map from Google Earth 2013); **c** photograph of Luobi Cave at the foot of Luobi Hill; **d** photograph of the entrance of Luobi Cave, facing north (Photograph: Yuduan Zhou)

Geology and Stratigraphy

Luobi Cave is situated at an elevation of 98 m above sea level at the southern foot of the isolated Luobi Hill, formed by the uplift of local strata in the Yanshan Movement. Three geological platforms developed in this region during the Quaternary period, numbered 1, 2, 3 from bottom to top, and Luobi Cave stands on the first platform. Long-term geological processes have resulted in the cave taking the form of a vertical cavern with a chamber 9 m wide, 12.5 m high and 16 m deep (Fig. 2).

The excavation zone was divided into 28 2 m × 2 m grids with a further investigation area of around 20 m^2 at the entrance. The deposits in Luobi Cave were mostly packed sediments from outside the cave, which vary in color and composition, and vary greatly in both horizontal and vertical section. The cave deposits were divided into three units according to their components and the characteristics of associated animal remains. The stratigraphy in the three units may be described as follows (see Fig. 2), from bottom to top:

Unit 1 consists of a yellow sandy clay, with a small amount of breccia, coarse sand and iron bulk, containing some carbonated cementation of hard texture, without horizontal stratification, 2–4 m thick, yielding a number of mammalian remains. A calcareous plate of 5–10 cm thickness developed on the top of this unit. The deposits in the southeast of the cavern were thicker than in other parts, becoming increasingly thin to the northwest of the chamber. An erosion surface was present between Units 1 and 2.

Unit 2 consists of grey or greyish–yellow sandy clay, poorly sorted and without clear horizontal stratification, yielding a large quantity of human fossils, stone artifacts and animal remains, 3–4 m thick. As in Unit 1, the deposits become thinner from southeast to northwest. Several phenomena characterized the sediments of this unit:

- Gravels and breccia on limestone were both present in the deposits. Gravels were usually smaller than breccia, reaching a maximum of 80 × 40 cm.

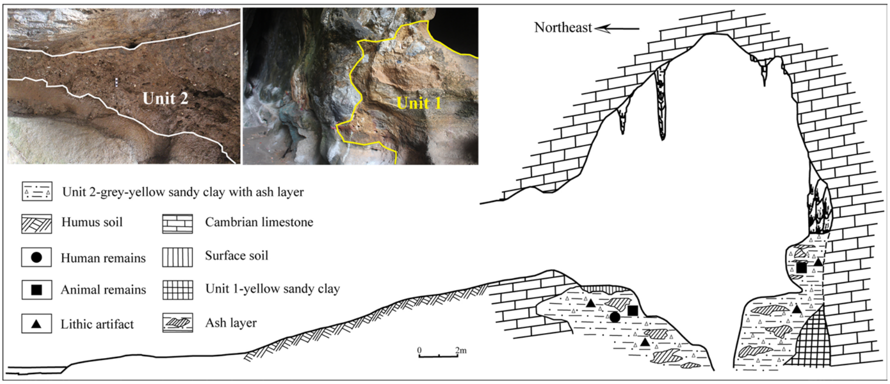

Fig. 2 The stratigraphy of Luobi Cave (redrawn after Hao and Huang 1998; Photograph: Yuduan Zhou)

- The deposits were partially consolidated, especially close to the east wall of the cavern, where there developed a calcareous plate of 40–125 cm thick in the shape of a rock shelter after weathering. Numerous mollusc shells, other well-fossilized animal bones, some stone artifacts and several human teeth fossils were discovered in this plate.
- Some concentrations of ash were unearthed. It appeared that closer to the ash more breccia was present. Distributed around the ash were a large number of mammalian fossils and mollusc remains. There was considerably less ash sediment and breccia near the wall of the cavern than in other parts. In addition, some charcoal, burnt stone and bones were found.

Unit 3 consists of a black or black–grey layer (surface soil), non-consolidated, composed of recent sediments and collapsed limestone, containing a large amount of bat feces and numerous historical relics, less than 30 cm in thickness.

Dating and Chronology

As most of the deposits were removed in previous excavations, and more systematic dating analysis using different methods will be conducted in the near future, we here determine the time frame of Luobi Cave on the basis of three radiocarbon dates (uncalibrated) obtained from organic remains from Unit 2. The first is from a mollusc shell (93SL D4 VIII; BK94122), giving an age of 10,890±100 years BP (Chen 1998); the second is on mollusc, dated to 10,642 ± 207 years BP (Huang and Hao 1995); the third was provided by AMS ^{14}C on a bone fragment (D3:93:114, BA95061), attributed to 4520 ± 200 years BP (Chen 1998). The third sample was thought to be interfused from the upper unit (Chen 1998). The first sample was possibly from the lower part of Unit 2; its stratigraphic position is recorded as 'D4 VIII' (the eighth layer of grid D4), and the second one was from the upper part of this unit (the second layer) (Huang and Hao 1995). Although there is a possible reservoir effect for mollusc shells and complicated geological action in Unit 2, considering that the sediments of Unit 1 (containing animal fossils of Late Pleistocene and without mollusc shells) underlay those of the Unit 2 (containing mollusc shells and human teeth), and that the earliest Neolithic remains in Hainan Island can be attributed to c. 6000 years BP (Fu et al. 2016; Wang 1990), the age of about 11,000 ~ 10,000 (Late Pleistocene to Early Holocene) appears a plausible timeframe for the human activity in this cave. In addition, biostratigraphic analysis suggested that nearly all the mammalian species discovered in Luobi Cave were extant—even the civet cat, *Viverricula* cf. V. *malaccensis fossilis*, was clearly similar to recent species, indicating that these animals probably lived during the Late Pleistocene–Holocene transition period (Hao and Huang 1998), corresponding well to the radiocarbon dates. We are confident that detailed systematic dating analysis will be able to construct a more reliable time framework for Luobi Cave in future.

Human and Animal Remains

A total of 12 human teeth and one left talus were unearthed from Unit 2. Among the human teeth, seven specimens were fossilized and five were not; all are attributed to AMH (*Homo sapiens sapiens*). The features of these teeth were similar to those from Neolithic humans of North China and modern humans of Yunnan Province (Gu 1998).

The animal remains found in Luobi Cave were composed of mammalian species, avifauna and invertebrate species. The mammalian bones were attributed to 45 species, none from North China but mainly tropical/subtropical types of South and Southeast Asia, such as the common tree shrew (*Tupaia glis*), Hainan black gibbon (*Hylobates concolor hainanus*), various civet cats (*Paguma* sp.; *Paradoxurus* cf. *P. hermaphrodites*; *Viverricula* cf. *V. malaccensis*), otter (*Lutra* sp.), tiger (*Panthera tigris amopyensis*), elephant (*Elephas maximus indicus*), and tapir (*Tapirus* sp.). The avifaunal remains belonged to 14 genera, including fossilized species such as peacock pheasant (*Polypleclron bicalcaratum*), green peafowl (*Pavo mulicus*) and the red jungle fowl (*Gallus gallus*), which were classified as components of the Oriental zone and differed greatly from Pleistocene avifauna in North China and the Sichuan region. In addition, 70,000 mollusc shells, representing a total of 24 species of aquatic mollusc, were unearthed in Unit 2 (Hao and Huang 1998).

Archaeological Contexts and Material Remains

The archaeological contexts and material remains found in the Unit 2 of Luobi Cave included several ash layers 20–35 cm in thickness containing burnt stones, bone and antler tools, burnt mammalian bones, mollusc shells and charcoal, and a 'hearth' made up of three irregular cobbles forming a 40 × 45 × 20 cm triangular zone with burnt red soil within it along with blackened mollusc shells and black consolidated charcoals. The cultural remains unearthed in the cave consisted of stone artifacts, bone and antler tools, charcoal, burnt stones and bones and a putative lump of ochre (Hao and Huang 1998). In this paper our focus is on the lithic assemblage, the bone tools, antlers, marine mollusc shells and animal teeth.

Lithic Assemblage

A total of 200 stone artifacts were recovered, of which 90 bore identifiable characteristics (Hao and Huang 1998). The raw materials are mostly cobbles, locally available from a nearby riverbed. The majority of raw materials are volcanics and obsidians, which make up 86% of the whole assemblage; limestone, crystal, flint, quartz and other materials are present in small quantities (Hao and Huang 1998). The knapping technique is mainly direct percussion with hard hammer, accompanied by a grinding technique which is applied to a few perforated tools. We re-analyzed 34 pieces held in the Museum of Hainan Province, including one core, two normal products of bipolar débitage, two unworked half-cobbles, one half-cobble used as an anvil, 11 flakes, nine shaped tools, one retouched fragment, three retouched chunks, one burnt stone, two hammers and one anvil. Table 1 summarizes the composition of the lithic assemblage in terms of artifact category and raw material.

Due to the incompleteness of the assemblage, we were not able to make a fully comprehensive analysis, but rather a qualitative one for the purpose of clarifying the operational sequences involved in lithic production and of constructing a basis for comparison with the lithic industries of mainland Southeast Asia. From a technological perspective, the operational sequences of débitage and façonnage (shaping) coexisted in this assemblage. The products of débitage were relatively few; products of façonnage predominated.

Two major operational sequences of débitage were identified:

1. *Débitage of Type C* (also called orthogonal débitage, see Forestier 1993). The worked volume of Type C (i.e. part of a block intentionally selected to be flaked) possesses a natural surface of débitage with predetermined technical characteristics such as lateral and distal convexity. The initialization consists of selecting a natural surface of débitage which is favorable for immediately removing the desired flakes without intentional preparation. Once the platform, which may be a natural surface or a negative of previous removal, is suitable for knapping, it is possible to obtain one flake or a series of flakes (three in most cases) in a recurrent way (Boëda 2013). In Luobi Cave only one core was identified, which was of small size (3.8 × 4.5 × 3.8 cm), on obsidian. Approximately four débitage series were obtained, each containing one to two useful flakes. For the first series, the striking platform was natural; for the remaining series, the striking platforms were negatives of removals from previous series. The biggest negative thus produced was 2.4 cm long and the smallest was 1.8 cm long.
2. *Type F: bipolar débitage on anvil* (Boëda 2013). Within this sequence, two types of product were present: one (n = 2) was of large size (> 9 cm in length) and resembled flakes knapped in two opposed directions along the longitudinal axis (referred to as 'Normal product' in Table 1); products of the other type (n = 3) were obtained from long and ovoid cobbles which were put on an anvil and directly fractured along the longitudinal axis, exclusively producing half-cobbles, in which one piece presents concavities on the dorsal face, probably used as an anvil (Fig. 3).

Four operational sequences of façonnage were identified, each corresponding to a representative techno-type of macro-tool on cobble. The size (length, width and thickness) is given in Table 2.

1. *Unifacial tool with transversal cutting-edge (choppers, classical on matrix of simple bevel)* (Li et al. 2014) (n = 2) made on cobbles of volcanic and limestone. The operational sequence involved a degree of predetermination and could be divided into two or three steps: firstly, blank preparation, which consists in knocking a cobble (possibly splitting it on an anvil) to obtain a relatively flat surface

Table 1 Inventory of the Stone Artifacts and Raw Materials of Luobi Cave

Artifact category		Volcanics	Obsidians	Limestone	Flint	Quartz	Total
Type C: orthogonal débitage	Core		1				1
Type F: Bipolar débitage on anvil	Normal product[a]	2					2
	Unworked half-cobble	2					2
	Half-cobble used as anvil	1					1
Flake[b]		4	5		1	1	11
Façonnage	Unifacial tool with transversal cutting-edge (chopper) (OS 1)	1		1			2
	Unifacial tool with longitudinal cutting-edge (OS 2)	1					1
	Bifacial tool (OS 3)	1		1			2
	Donut stone (OS 4)	4					4
Retouched fragment		1					1
Retouched chunk			3				3
Burnt stone		1					1
Hammer		2					2
Anvil		1					1
Total		21	9	2	1	1	34

[a]indicates that these products resembled flakes knapped in two opposite directions along the longitudinal axis, but they were different from split half-cobbles; [b]indicates that some of these flakes were produced by Type C/orthogonal débitage and the others were probably removed during production of shaped tools. ‘OS’ refers to ‘operational sequence’

Fig. 3 Type F- Bipolar débitage on anvil: half-cobble used as anvil. The white line and dotted line show the concavities formed on the surface of the cobble

Table 2 Descriptive data for shaped tools unearthed from Unit 2 of Luobi Cave

Tool types	Number	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)
Chopper	D4 VII:2	9.7	8.7	4.8	540
	D3VIII:22	11.7	7.5	5.1	490
Unifacial tool	D4VII:6	13.6	8.7	5.8	850
Bifacial tool	B3II:16	8.6	8.3	3.1	280
	C3IV:1	13.4	10.2	4.8	760
Donut stone	A2IV:5	8.6	8.5	4.5	420
	A2II:32	9.6	9	5.7	530
	A3II:12	8.7	8.4	3	220
	C4V:5 (broken)	10.1	5.3	2	160

(termed a 'ventral face') and a high cortical back on the proximal part, which forms a potential prehensive techno-functional unit (UTF-P) to be grasped (see Boëda 2013 for interpretation of UTF-T). The blank thus obtained presents a near-rectangular transversal section on the mesial part and a simple-beveled profile on the sagittal view. If the distal part on the ventral face was not sufficiently flat, a series of removals would be knapped to produce an appropriate flat surface (Fig. 4); secondly (if necessary), shaping on one side purposefully to produce an abrupt periphery with an angle of nearly 90° (Fig. 5); thirdly, retouch from the flat ventral face to produce a transversal cutting-edge, that is, transformative techno-functional unit (UTF-T) predetermined to contact with materials with a plano-convex section and an angle of 60°–75° (see Boëda 2013 for interpretation of UTF-P).

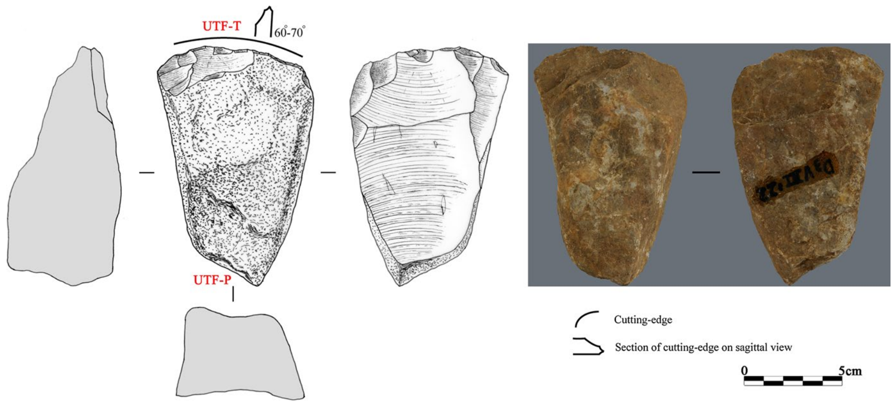

Fig. 4 Operational sequence 1 of façonnage for macro-tool on cobble with artificial flat ventral face: Chopper (UTF-T: Transformative techno-functional unit; UTF-P: Prehensive techno-functional unit)

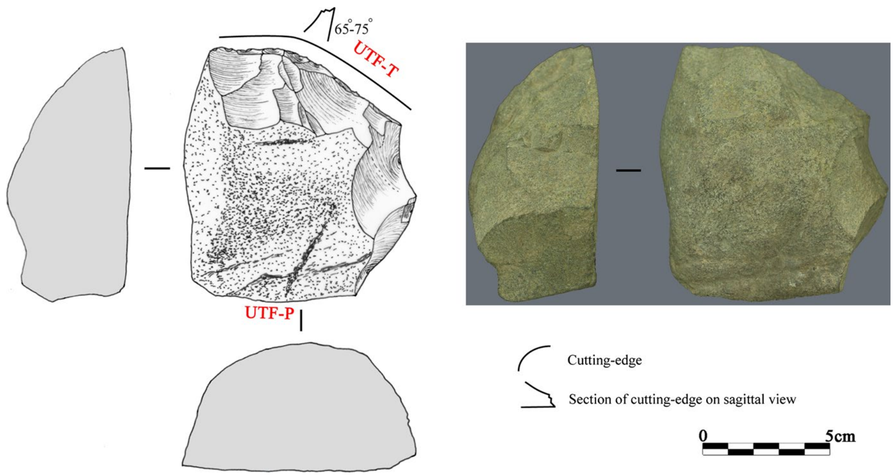

Fig. 5 Operational sequence 1 of façonnage for macro-tool on cobble with ventral face formed by a fissuring: Chopper (UTF-T: Transformative techno-functional unit; UTF-P: Prehensive techno-functional unit)

2. *Unifacial tool with longitudinal cutting-edge* (n = 1) made on a cobble of volcanic provenance. The operational sequence was divided into three steps: firstly, blank preparation which consists in fracturing a long and thick cobble to obtain a flake with a flat ventral face and a high cortical back on the left side and a central area which forms a potential prehensive techno-functional unit (UTF-P); secondly, shaping on the proximal and distal part of the flake from the flat ventral face to get two macro-denticulate and abrupt edges with an angle of 90°–100°and to make the longitudinal cutting-edge (the right side of the flake) protrude; thirdly, retouch on the right side of the flake to produce one transformative techno-functional unit

(UTF-T) which is macro-denticulate with a plano-convex section and an angle of 80° (Fig. 6).

3. *Bifacial tools* (n = 2) made on both volcanic and limestone cobbles. The operational sequence was divided into three steps: firstly, blank preparation, which consists in selecting a cobble with a round rhombic transversal section and a round rectangular profile on sagittal view; secondly, shaping bifacially on the left and right side of the blank to form two abrupt edges with an angle of nearly 90° and to make the transversal cutting-edge protrude. The removals of the shaping sequence were all far-reaching and virtually no cortex was left on the surface. The proximal part is abrupt, being a potential prehensive techno-functional unit (UTF-P); thirdly, retouch on the distal part of the blank to obtain a transformative techno-functional unit (UTF-T). Some differences exist between the two pieces analysed here.

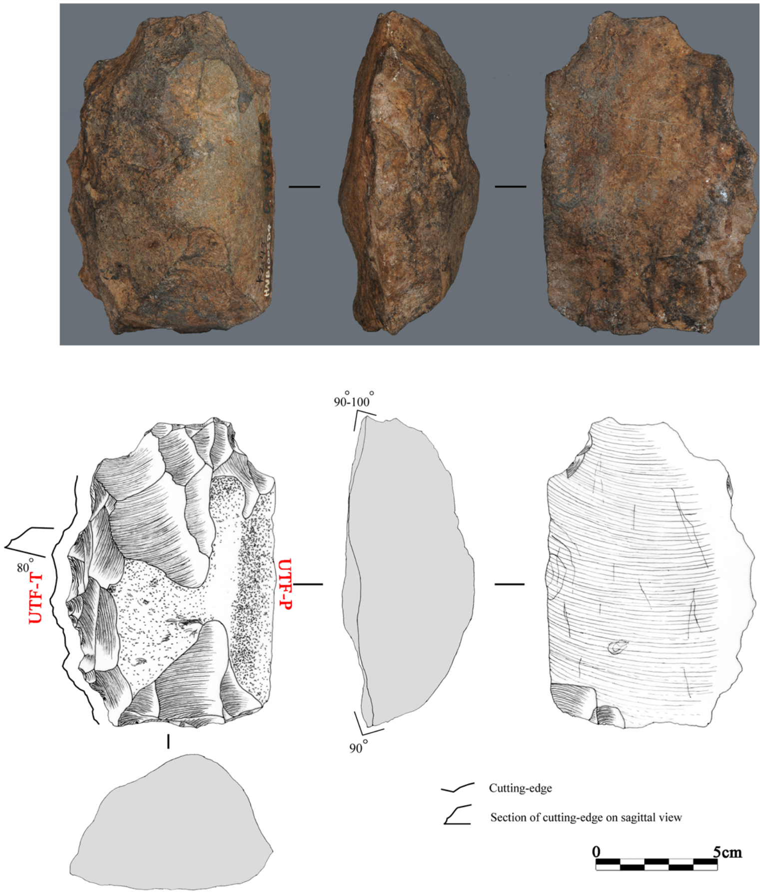

Fig. 6 Operational sequence 2 of façonnage for macro-tool on cobble: Unifacial tool with longitudinal cutting-edge (UTF-T: Transformative techno-functional unit; UTF-P: Prehensive techno-functional unit)

Piece C3IV:1: on one face the percussion was carried out in a direction perpendicular to the morphological axis of the cobble. On the other face the first flake was knapped in a direction perpendicular to the morphological axis, yet several subsequent removals seemed to be knapped along the morphological axis of the cobble. Then retouch was conducted around the periphery of the volume in such a way that most of the periphery exhibited an abrupt and thick edge with an angle of 90°–100°, except the distal part, which was convex on frontal view, of concave-convex section on sagittal view, and with an angle of 70°. As a result, the transversal section on the mesial part became asymmetric biplane/convex, especially on the left side which became abrupt. The profile on sagittal view was also of asymmetric biplane/convex shape, and one face was more convex than the other with a thick and abrupt butt due to the presence of fissuring (Fig. 7).

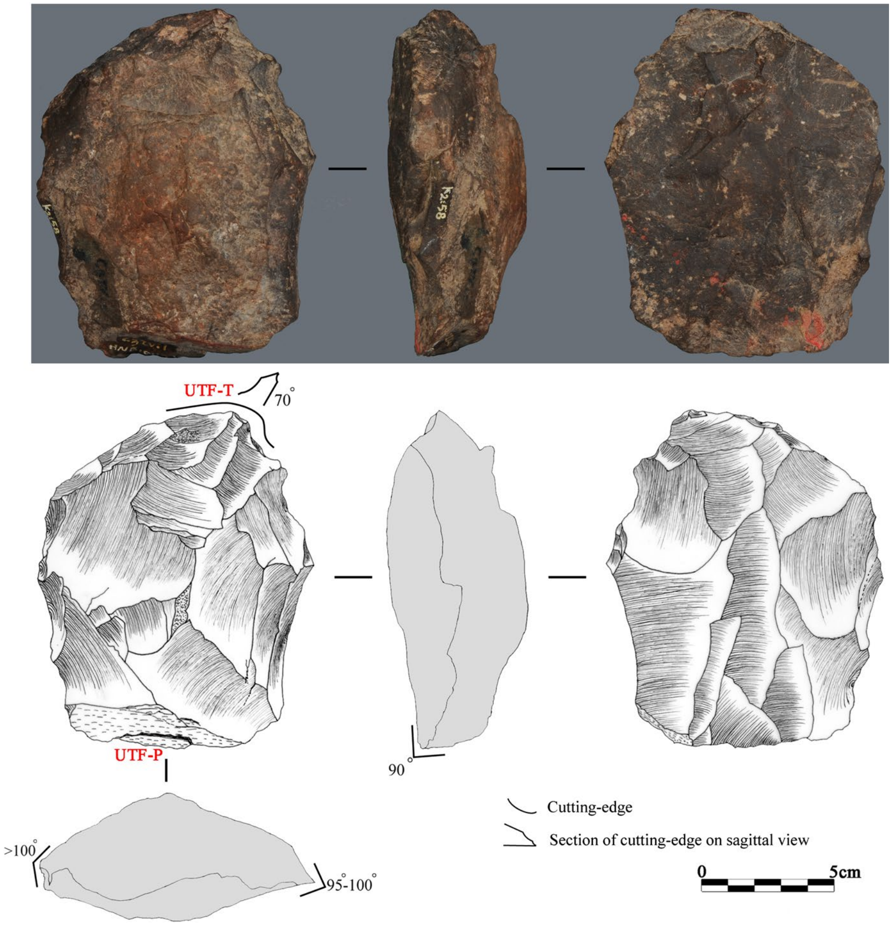

Fig. 7 Operational sequence 3 of façonnage for macro-tool on cobble: Bifacial tool (UTF-T: Transformative techno-functional unit; UTF-P: Prehensive techno-functional unit)

Piece B3II:16: the volume was thin and the two faces both exhibited bifacial knapping but the negatives were all flat, nearly parallel to the transverse axis of the volume. Then retouch was conducted around the periphery of the volume in such a way that the left and right side exhibited an abrupt and thick edge with an angle of >90°, except the distal part which was relatively convex on frontal view, of plano-convex section on sagittal view, and with an angle of 50°–60°. The butt was broken, forming a thick and abrupt structure. As a result, the transverse section on the mesial part was irregularly rectangular, especially on the left and right side, which became abrupt. The profile on sagittal view was also irregularly rectangular with a distal and proximal part (butt) which was abrupt and thick (Fig. 8).

4. *Donut stone* (n=4). These are ground perforated tools made on cobbles of volcanic rocks. The operational sequence may consist of three steps: firstly, the oblate and round (or oval) cobbles were selected; secondly, the center point of the cobble was perforated in an opposed direction to form a hole, which was large at both ends and small in the middle; thirdly, the surface was struck and some pieces were

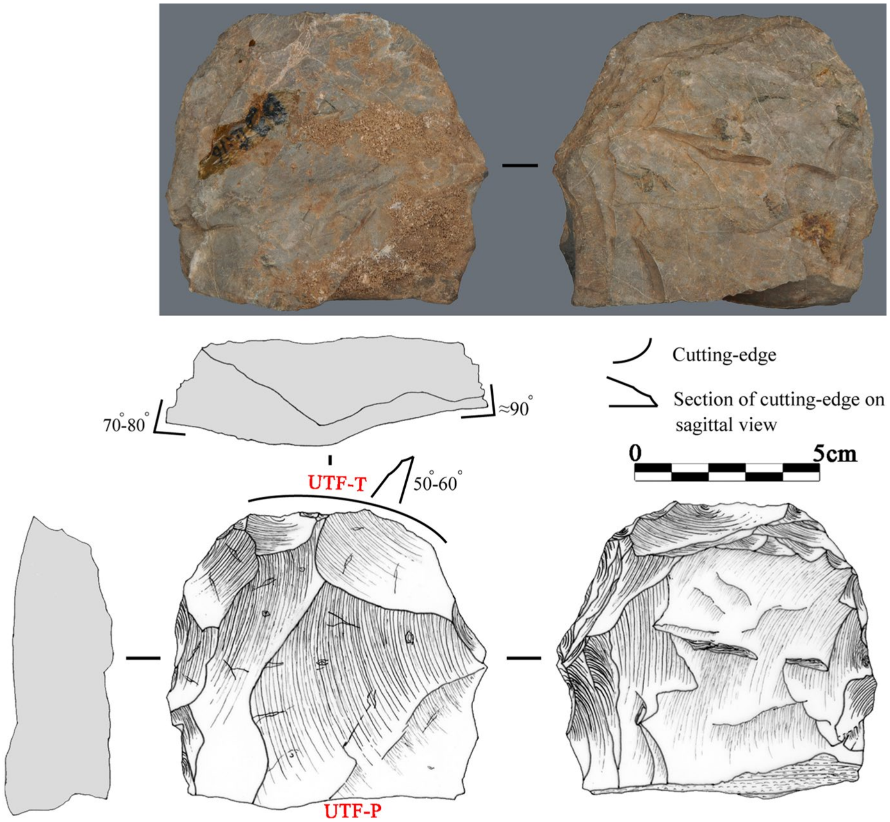

Fig. 8 Operational sequence 3 of façonnage for macro-tool on cobble: Bifacial tool (short axe) (UTF-T: Transformative techno-functional unit; UTF-P: Prehensive techno-functional unit)

partially ground. The second and third steps might be interchangeable. The wall of the inner hole is usually very smooth, apparently as a result of frequent friction during utilization; in contrast, the perimeter of the tool is quite pitted (Fig. 9).

Several formal tools retouched on fragments of volcanic (n = 1) and chunks of obsidians (n = 3) were identified. The tool types are mainly notches and scrapers with rectilinear or convex cutting edges and an angle of 70°–80° (Fig. 10). The lengths of the retouched pieces range from 3.3 to 6.7 cm.

Some flakes were also present (n = 11), none of which bore clear evidence for retouch. It could be inferred that the flakes on obsidians (n = 5) might be products of *Type C– orthogonal débitage* and the flakes on volcanic rocks (n = 4) might result from shaped tools which were manufactured on the same material. Due to the small quantity collected, it was difficult to determine the origin of other flakes (one piece on flint and one on quartz).

One burnt stone, two hammers and one anvil were also discovered, all made on large pieces of volcanic rock, with the length ranging from 8.6 to 15.1 cm. The hammers and anvil were of oblate and round/rectangular shape or of thick and irregular prismatic structure presenting dense scars of knocking and knapping on the surface. For the anvil,

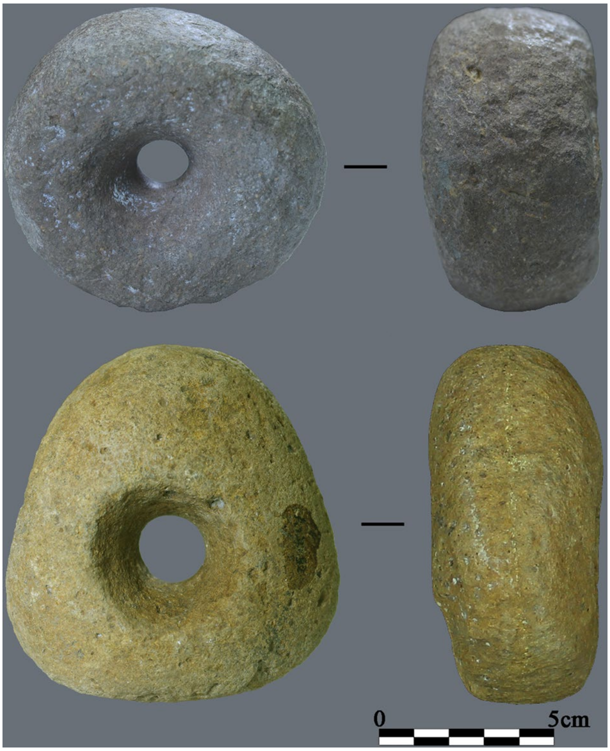

Fig. 9 Operational sequence 4 of façonnage for macro-tool on cobble: donut stone

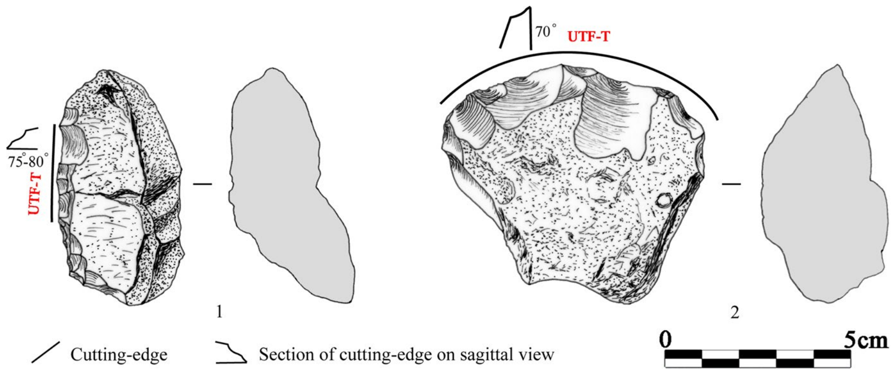

Fig. 10 Retouched pieces on chunks of obsidians. 1.Scraper with a rectilinear outline on frontal view and a plano-convex section on sagittal view; 2. Scraper with a convex outline on frontal view and a plano-convex section on sagittal view (UTF-T: Transformative techno-functional unit)

besides the knocking scars on the surface and border, there are two connected concavities at the center of two faces. The concavities are about 3 cm long and 1.5 mm deep, which is indicative of concentrated percussion for an extended time.

Tools Made on Bone, Antler, Clam Shells and Animal Teeth

A total of 51 bone tools were excavated; they are mostly made on bone elements sourced from the appendicular skeleton of large mammals (e.g. *Bovidae* and *Cervidae*). The manufacturing technique consisted of knapping and cutting associated with scraping and grinding. Some tools were totally ground. A small number of tools were of regular morphology and could be classified into several identifiable types, including spade, awl, spear-like implement, point, arrowhead and dagger (Fig. 11).

A total of 39 antler tools were obtained, which were made on the antler branch of *Cervus* and *Muntjac* deer. The manufacturing technique was mainly grinding, and for some tools only the antler tip was used and exhibited some traces of utilization. The identifiable tool types included spade, hammer, awl and point.

Several tools made of clam shells (n = 2) and animal teeth (n = 4) were also discovered; these are mostly of small size and bear a pointed or convex cutting edge (Fig. 12). The traces left on these tools suggest manufacturing techniques including cutting and engraving.

Comparison of Luobi Cave with the Representative Hoabinhian Technocomplex of Laang Spean Cave

In Southeast Asia, the Hoabinhian is an archaeological phenomenon and episode occurring from the late Late Pleistocene to the Middle Holocene. The term represents a pre-agricultural occupation and subsistence pattern (Bellwood 1993)

Fig. 11 Bone and antler tools. 1. Antler spade; 2. Bone spear-like implement; 3. Bone spade; 4. Antler point/hammer; 5,6. Antler awls

Fig. 12 Tools made of clam shell and animal teeth (edited after Hao and Huang 1998). 1 and 3. Tools made of clam shells; 2. Tool made of animal teeth (wild boar)

prevailing in Southeast Asia, and partially in Southwest China and/or surrounding regions (Ji et al. 2016), during the Late Pleistocene–Holocene transition. Despite a level of homogeneity, there was variability on a large spatio-temporal scale and in multiple aspects (e.g. lithic technology, bone tool technology, culture, ecology, social organization (Forestier et al. 2013; Marwick 2013; Shoocongdej 2000).

The Hoabinhian was initially defined as a Southeast Asian pebble tool culture characterized by the presence of unifacial tools and associated tool types, including implements of triangular section, hammer stones, discs, short axes and almond-shaped artifacts recovered from North Vietnamese karstic infillings almost a century ago (Colani 1927, 1929; Collectif 1932). Subsequently, the Southeast Asian Hoabinhian sites were usually defined simply by the presence of the representative unifacial tool, the sumatralith (Boriskovsky 1969; Gorman 1970; Hayden 1977; Heekeren and Knuth 1967; Matthews 1966; Mourer and Mourer 1970a, b), a criterion that was so broadly employed that it was always a principal focus in every debate concerning whether *Hoabinhian* denoted a culture, a tradition, a chronological period, an industry, a pebble-tool complex or a pebble-tool technocomplex. This overemphasis on lithic artifacts such as the sumatralith in defining the Hoabinhian was questioned by Gorman (1969) in defining the Hoabinian as an early technocomplex that reflected common ecological adaptations to the Southeast Asian humid tropics (Gorman 1970). This definition of the Hoabinhian as a lithic technocomplex (Pookajorn 1990)—one that with its preferential use of a specific knapping method on pebbles could be regarded as highly adapted to a forest environment (Anderson 1990; Bannanurag 1988; Pope 1989; Zeitoun et al. 2008)—was adopted in subsequent research (Bowdler 2006; Forestier 2000; Higham 1989, 2013, 2014; Marwick 2007; Moser 2001; Stark 2004; Yi et al. 2008; Zeitoun et al. 2008). Recently, arguing on the basis of technological and techno-functional observation rather than on purely typological grounds, the Hoabinhian was re-defined as a technocomplex that includes three major operational sequences (*chaînes opératoires*) made on pebble/cobble: (i) chopper and chopping tools; (ii) uniface; and (iii) split cobble (Forestier et al. 2013, 2015; Zeitoun et al. 2008). In short, this technocomplex focused on a preferential exploitation of cobbles and pebbles by shaping or by split fracture. Peripheral shaping on split cobbles predominates, with choppers being the principal cobble tools found in Southeast Asia, particularly in North Vietnam (as, for example, in Hang Chô cave, Mai Da Dieu, Hang Boi, Xom Trai Cave and Con Moong Cave, dated back to around 20,000–7,000 BP: Ha 1980, 1997; Nguyen 2000, 2005; Rabett 2011, 2012; Tan 1976; Yi et al. 2008). Furthermore, the Hoabinhian technocomplex is fully represented at various cave sites in Cambodia and Thailand, although with some common technological features that were based on an original pebble/cobble shaping process, as indicated by the lithic industry of Laang Spean Cave, Cambodia. So the analysis we present in this paper has helped in the construction of a coherent framework for the study of Hoabinhian lithic industry and associated elements, and provides an important basis for our comparison between South China and Southeast Asia (Fig 13).

The bone tools were mainly found in the Southeast Asian archipelago (Philippines, Indonesia), where they are associated with flakes and small flake tools; by contrast, the Hoabinhian assemblages of the Southeast Asian mainland exhibit a paucity of bone tools (Rabett 2012). Hang Boi Cave site (inland shell midden), recently dated between 13,000 and 10,000 BP (Rabett et al. 2009; Rabett 2011; Rabett et al. 2011; Rabett 2012), shows interesting data on the possible existence of bone points (Rabett 2012; Rabett and Piper 2012). Other tool types, such as ground perforated tools ('donut stones'), are sporadically represented in Hoabinhian assemblages in Northern Thailand at Tham Phaa Can rockshelter site (Sørensen 1975; White 2011; White and Gorman 2004).

From a comparative perspective, the industry of Luobi Cave and the Hoabinhian industries represented by Laang Spean Cave present both similarities and differences (Table 3). The similarity is perceived only in two aspects: one is the operational

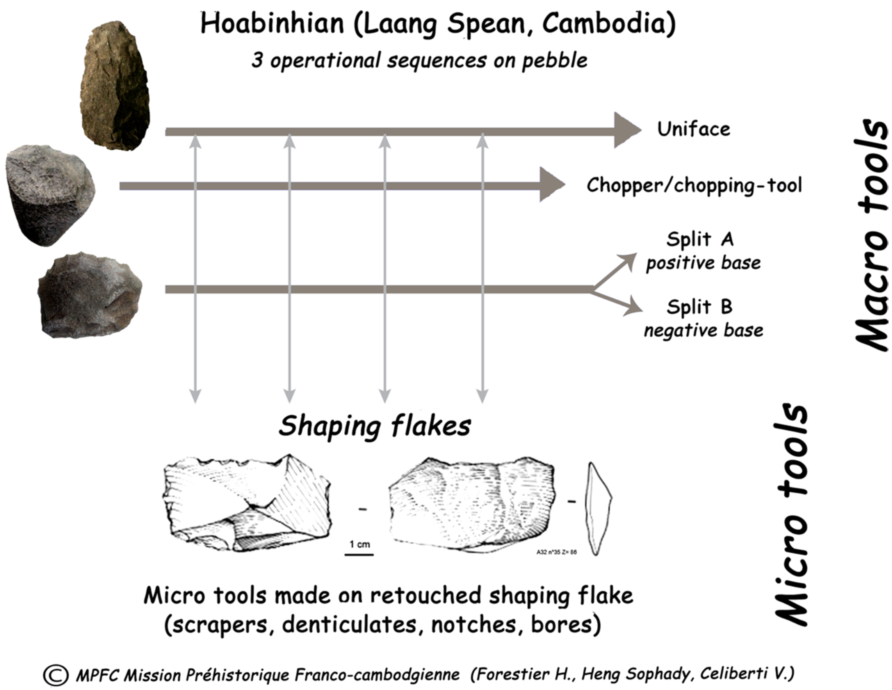

Fig. 13 Three operational sequences on pebbles represented by a typical Hoabinhian pebble industry unearthed in Laang Spean Cave, Cambodia (accomplished by H. Forestier, H. Sophady and V. Celiberti)

sequence of choppers classically based on a matrix of simple bevel, and the other is the retouched micro-tool types, including scrapers and notches.

Six Aspects Display Difference

(a) The raw materials of the stone tools used by humans at Luobi Cave mainly consisted of volcanic rocks and obsidians, and those used by humans at Laang Spean Cave were hornfels, limestones and sandstones (Forestier et al. 2015).
(b) The operational sequence of débitage (orthogonal, i.e. Type C débitage) was applied in the lithic industry of Luobi Cave in association with shaping (façonnage), yet no typical products of Type C (orthogonal) débitage coexisted with the operational sequence of shaping in archaeological strata of the majority of the Hoabinhian sites (including Laang Spean).
(c) Typical retouched tools on split-pebble/cobble are scarce in Luobi Cave but are common among the tool types of Laang Spean Cave, where they comprise about 10% of the total lithic artifacts.
(d) The four operational sequences of shaping (macro-tools) typically differed between Luobi Cave and Laang Spean Cave. For the first sequence, only two choppers (i.e. on a matrix of simple bevel) were unearthed in Luobi Cave, but both choppers and chopping-tools (i.e. on a matrix of double bevel) were found

Table 3 Comparison of tool types and lithic operational sequences between Luobi Cave and Laang Spean Cave. (Laang Spean Cave data after Forestier et al. 2015)

Category		Luobi cave	Laang spean cave	
Raw materials		Volcanic rocks, obsidians, limestone, quartz, flint	Hornfels, sandstone, limestone	
Débitage	Type C (orthogonal débitage)	A few	None	
	Type F/bipolar débitage (or split)	Small quantity	Large quantity	
Façonnage (shaping)		OS1: chopper with an artificial flat ventral face	Chopper with a natural flat ventral face and chopping-tool	Macro-tools
		OS2: unifacial tool with a longitudinal cutting-edge and an artificial flat ventral face	Unifacial tool with multiple cutting-edges and a natural flat ventral face (sumatralith)	
		OS3: bifacially shaped tool	None	
		OS4: donut stone	None	
Retouched tools	On split pebble	None	Scrapers, denticulates on split pebble	
	On flakes of Type C débitage	Notches, scrapers retouched on flakes of Type C (orthogonal débitage) and shaping flakes	Scrapers, denticulates, notches, bores retouched on shaping flakes	Micro-tools
Tools made on bone, antler, clam shells and animal teeth		Spade, awl, spear-like implement, point, etc.	None	

in Laang Spean Cave. Moreover, the ventral face of the choppers in Luobi Cave is either artificial or formed by fissuring, yet that of the choppers in Laang Spean Cave is a natural flat pebble surface. For the second operational sequence, what was unearthed in Luobi Cave were unifacial tools displaying an artificial flat surface (ventral face) and a longitudinal cutting-edge, but those in Laang Spean Cave were shaped unifaces on pebble with a naturally flat face (i.e. sumatralith). In other words, no sumatraliths were identified in Luobi Cave. The third operational sequence (bifacial tools, including bifaces and short axes) identified in Luobi Cave were either absent or scarce at most Hoabinhian sites, and this was true of the fourth operational sequence (donut stones) too.

(e) As for retouched tools (micro-tools), the blanks for the tools of Luobi Cave included flakes of Type C/orthogonal débitage and shaping, while the blanks for the tools of Laang Spean Cave were mainly shaped flakes.

(f) Tools made on bone, antler, clam shell and animal teeth are found in relatively large quantity and high quality in Luobi Cave, but they are poor in many Hoabinhian sites of mainland Southeast Asia. Some types were only unearthed in the Southeast Asian archipelago (Philippines, Indonesia), where they were associated with flakes and small flake tools.

Overall, despite minor similarities between the industry of Luobi Cave and Laang Spean Cave, the archaeological assemblage of Luobi Cave is quite different from the pebble-tool assemblage of Hoabinhian sites of Southeast Asia. Firstly, the operational sequences of façonnage (shaping) indicate that the typical sumatralith characterizing Hoabinhian assemblages was absent from Luobi Cave and that the typical retouched tools on split-cobble (macro-tools) were very few in Luobi Cave, forming a striking contrast with Laang Spean Cave, which is characterized by a high proportion of macro-tools made on split pebbles (Forestier et al. 2015).

Secondly, at Luobi Cave the association of the bone tools with cobble tools is particularly interesting because such an association is mostly found in the Southeast Asian archipelago (Philippines, Indonesia), yet the Hoabinhian assemblages in mainland Southeast Asia are lacking in bone tools (Rabett 2012). The Hang Boi Cave, recently dated to about 13,600 years BP, reveals interesting data on the possible existence of bone points (Rabett et al. 2009; Rabett 2011; Rabett et al. 2011; Rabett 2012; Rabett and Piper 2012), but actually it is impossible to generalize this observation to the majority of Hoabinhian sites (Rabett 2012) (see further discussion below).

Thirdly, a particular knapping method called Type C/orthogonal débitage (see Forestier 1993; Boëda 2013) was applied to the lithic production of Luobi Cave, yet in Laang Spean Cave and other Southeast Asian Hoabinhian sites the products of débitage were very rare in those layers which yielded Hoabinhian assemblages.

Discussion and Conclusion

Throughout the twentieth century the Hoabinhian was known as a pebble-tool assemblage deriving from the northern Vietnamese province of Hoa Binh, where numerous caves and rockshelters had been discovered and excavated (Colani 1927, 1929; Collectif 1932). Many more Hoabinhian sites were subsequently found, excavated or re-excavated in mainland Southeast Asia and on several islands, including Sumatra in Indonesia (Bacon 2012; Bellwood 2007; Bronson and Glover 1984; Forestier et al. 2005, 2015; Higham 2013, 2014; Marwick 2007; McKinnon 1991; Moser 2001; Zeitoun et al. 2008; Zeitoun and Bourdon et al. 2019; Zeitoun and Auetrakulvit et al. 2019, among others). The Hoabinhian technocomplex and Hoabinhian-like tools were also reported to occur as far north as Xiaodong, southwest China (Ji et al. 2016), as far west as the southern fringes of the Himalayas (Gaillard et al. 2010, 2011; Soni and Soni 2010), and also in Burma (Thaw 1971), and even as far afield as Australia (Bowdler 1994). In terms of chronological context, except for a few Vietnamese Hoabinhian sites recently dated to uncalibrated 33 ka ± 1500 (Pham Thanh Son, personal communication), the oldest Hoabinhian site in Southeast Asia is probably Tham Lod rockshelter in northern Thailand, dated to 26,580 ± 250 (Beta-17222, MHSTLAR2-918) (Shoocongdej 2006). At another important site, Spirit Cave in Thailand, the earliest Hoabinhian levels have been attributed to c. 13–14 ka, with the lithic assemblage persisting until c. 7 ka, when a sedentary Neolithic culture with pottery and edge-ground stone tools appeared (Gorman 1970, 1971). In the heartland Hoabinhian region of North Vietnam, most sites were occupied between 20 and 7 ka, with the rare exception of the basal level of Hang Cho Cave, which probably dates to around 29 ka (Ha 1980, 1997; Yi et al. 2008). Overall, the majority of Hoabinhian occupations in mainland Southeast Asia and on islands such as Sumatra can be dated to the Last Glacial Maximum (< c. 20 ka) during the Late Pleistocene–Holocene transition (Bacon 2012; Higham 2013, 2014; Moser 2001; Rabett et al. 2009; White 2011), persisting until 3.7 ka with the Neolithic period (Forestier et al. 2013) on the border of Burma and Thailand, where a transitional industry appears to be associated with early agriculture (Glover 1977; Gorman 1969, 1971; Reynolds 1989). In Southwest China, the newly-discovered Hoabinhian site of Xiaodong Rockshelter has been dated to 43.5 ka. This currently represents the earliest recorded presence of the Hoabinhian in Asia (Ji et al. 2016), although the technological and cultural relationship between Xiaodong and other sites of Southeast Asia and South China remains to be studied.

Briefly, based on its spatio-temporal frame, the features of its lithic industries, and the composition of the archaeological remains, the Hoabinhian has been considered to represent late hunter-gatherer groups (Higham 2014; Rabett 2012). Such groups have been considered to have pursued a specific subsistence pattern, as viewed from an economic and ecological perspective (Marwick 2008b, 2013). Current data suggests that subsistence can be generally understood by studying various interrelated aspects of human life such as tool production, hunting, plant collection, spatial organization and mobility. Firstly, Hoabinhian hunter-gatherers tended to knap stone tools and flakes on cobbles/pebbles collected from river terraces (Colani 1927; 1929), to obtain edge-ground stones and perforated stones (Shoocongdej 2006; White and Gorman 2004), and also to produce tools on bone, antler, clam shells (Rabett and Piper 2012) and possibly on bamboo (Bar-Yosef et al. 2012; Xhauflair et al. 2016). Secondly, they hunted animal species in the surrounding biotopes of tropical rainforest and/or forest swamp (Francis 2008) canopied evergreen forest, and along river margins (Shoocongdej 2006). The animals targeted included gibbons, macaques, squirrels, fish, shellfish (Endicott 1999) and local wild cattle, pig and deer (Shoocongdej 2006). Thirdly, botanical evidence recovered at Spirit Cave, Thailand, indicates that the Hoabinhian hunter-gatherers did not just exploit wild or cultivated nuts purely for basic nutritional purposes: betel nut was probably used as a stimulant, and pepper as a condiment; candlenut, although possibly consumed, was used for lighting. Beyond these, plants such as the bottle gourd, *Cucumis*, leguminous beans and possibly the pea suggested economic development beyond simple food-gathering (Gorman 1969). Although botanical remains were not observed at all Hoabinhian sites, it can be inferred that the use and consumption of plants from the surrounding biotope was widespread at this time. Fourthly, small groups of Hoabinhian hunter-gatherers in western Thailand seemingly practised residential mobility using a generalized subsistence technology during the wet season (although logistic mobility during the dry season has not been demonstrated) (Shoocongdej 2000). In addition, some hunter-gatherers hunted intentionally in zones containing water sources where some species came to drink, as observed, for example, at Tham Lod rockshelter (Piper and Rabett 2014; Shoocongdej 2006) which indicates spatial management by small groups of foragers. Fifthly, Hoabinhian hunter-gatherers tended to prepare food at their site of habitation, as revealed by stone-lined hearths, charcoal concentrations and food residues at some sites (Higham 2013). In summary, Hoabinhian hunter-gatherers applied a broad-spectrum subsistence pattern involving manufacturing tools on a variety of raw materials; hunted fauna and gathered plants (Higham 2013) and perhaps carried out small-scale plant cultivation in the later period (Gorman 1969) while employing a residential mobility strategy responsive to seasonal and environmental change (Shoocongdej 2000).

The population who occupied Luobi Cave also practised a broad-spectrum subsistence pattern as suggested by most Hoabinhian sites (Hao and Huang 1998), but detailed comparison of Luobi Cave and Laang Spean Cave suggests differences not only in lithic technology but also in bone tool technology and other aspects of resource prospection and procurement. This indicates a high level of innovation and a new level of diversity in the subsistence of modern human groups during the Late Pleistocene–Holocene transition in South China and Southeast Asia. There is significant new complexity and variability in the cobble/pebble tools and their associated elements such as the 'donut stone' and also in tools made on bone, antler, clam shells and animal teeth.

However, as stated in the introduction, uncertainty persists as to the definition and characterization of different tool types, their operational sequences and associated technical elements, and about the possible relationship between the archaeological assemblages of South China and the Hoabinhian of Southeast Asia. The analysis of Laang Spean Cave suggests that the toolkit of the Hoabinhian population at this site involved three main production sequences generating three pebble tool types (sumatralith, split-pebble tool, chopper and chopping-tool, as discussed above, and see Forestier et al. 2015), similar to those found at the Huai Hin site in Thailand (Forestier et al. 2013). The operational sequences of lithic production in Luobi Cave were confirmed by our analysis to be markedly different from those of Laang Spean Cave. Thus, in this sense our technological comparison between the Luobi Cave and a representative Hoabinhian site (Laang Spean Cave, Cambodia) marks a necessary first step towards deciphering and evaluating the cultural variability in South China and the Hoabinhian techno-complex of Southeast Asia from a technological perspective.

The 'donut stone'—also named 'perforated disk', 'weight stone' or 'stone ring' (Adams 2014)—is an interesting tool type recovered from Luobi Cave. The term refers to a cylindrically shaped ground/ground-struck stone, in the center of which a hole was formed by biconical drilling. The wall of the inner hole is usually very smooth, seemingly as a result of frequent friction during utilization, in contrast with the perimeter of the disk, which is quite pitted. Because archaeological contextualization that might provide information about the tool's use is rare, various suggestions for its use have been advanced based on the ethnographic record. Possibilities suggested by analogy include tools for shelling corn; weights for digging-sticks; gaming stones (Adams 2014); thigh-supported spindle whorls for household yarn and cordage production (Tomasic 2012); fly-wheels for perforating; tools for making fire; and sinkers and/or anchor-stones for fishing (Zhou 2007). The range of potential uses could support the idea of multifunctionality and would explain why it is one of the most widely-used tool forms in both prehistory and the recent past. Due to issues with data accessibility and the fact that synthetic accounts of such tools are rare in China, we must limit ourselves in this paper to a global observation about chronological position and distribution. Current data suggest that this kind of tool is common at a number of archaeological sites in the Americas, such as the Santa Cruz River Basin sites, and the sites of Clearwater, Tucson Presidio, Point of Pines (Adams 1998), and Snaketown (Haury 1976) (North America); the sites of Cerén (Sheets and Simmons 2002) and Kaminaljuyú (Kidder et al. 1946) (Mesoamerica); Manchan barrio and Quebrada Sta. Cristina (Moore 1991) (South America). It is also found in India (Misra 2001); on the island of New Guinea (Watson and Cole 1977; Gorecki and Gillieson 1989 [for Papua]); and at Matupi Cave (Van Noten 1977) and Border Cave in Africa (Beaumont et al. 1978). Its occurrence in Africa can be traced back to c. 20 ka BP in Matupi Cave (Van Noten 1977) and 33–45 ka BP in Border Cave (Beaumont et al. 1978). Finds from the Americas appear to be much later than those from Africa, South China and Southeast Asia. Although the donut stones occur widely around the world, current data appear insufficient to shed light on their origin, evolution and dispersal route, and they cannot be used as a type fossil in the definition of archaeological cultures or prehistoric populations.

The donut stone type is found at more than forty archaeological sites distributed across South China (Zhou 2007), such as Luobi Cave, Pengtoushan (Cao 1989); Bailian Cave (Jiang 2009); Dingshishan (Fu 2002); Huangyan Cave (Song et al. 1983); Dongwangzibei (Zou et al. 1999); Liyuzui (He et al. 1983); Dushizai (Qiu et al. 1982); Xianrendong (Guo and Li 1963); Shangshan (Zhao et al. 2004); Wuming Cave A (Pei 1935); and Zengpiyan (Collectif 2003; Wu and Yang 1976). This tool type is also documented at archaeological sites in Southeast Asia. In Thailand it was present in Tham Phaa Can (Sørensen 1975; White 2011; White and Gorman 2004); Tham Lod rockshelter (Shoocongdej 2006); Tam Taew cave (Imdirakphol 2012); Tham Pra cave (Prichanjit et al. 1996); Doi Pha Kan (Imdirakphol et al. 2017); and in surface deposits at many localities including Ban Tha Si (Zeitoun et al. 2013), Mae Moh (Imdirakphol 2012), Ban Tha Han and Ban Hang Hung (Sørensen 1975). It has been found in Vietnam (Ha 1995; Nguyen 2005; Saurin 1962; Zhou

2007); Laos (Fromaget and Saurin 1936); and Myanmar (Thaw 1971); and is known from Taiwan, Korea and Japan (Solheim 1996). Typically, southern Chinese donut stones are recovered out of stratigraphic context. Only a very few were excavated from a well-defined stratigraphy that can be dated. These include Bailian Cave (c. > 17 ka BP) (Zhou 2007); Luobi Cave (c. 11–10 ka BP) (Chen 1998); Dingshishan (~ 10 ka BP) (Fu 2002; Fu and Li 1998); Dushizai (> 10 ka) (Qiu et al. 1982); and Zengpiyan (c. 12–11 ka BP) (Collectif 2003). A new discovery in Southeast Asia suggests that donut stones uncovered from burials that intercut 'Hoabinhian' layers may be dated to c. 13 ka (Imdirakphol et al. 2017).

In summary, the sporadic, non-ubiquitous presence of donut stones globally may suggest a complex picture, with regional variability including South China and Southeast Asia during the Pleistocene–Holocene transition. This variability likely stemmed from multiple factors, including environment, food resources, functional requirements, subsistence patterns, adaptive strategies, human lifeways and cultural traditions. Our current analysis is not sufficient to explore this issue in detail and we anticipate that more systematic research will be conducted in future on this tool type and its technological origin and evolution in this region.

As with the donut stones, there is also abundant archaeological evidence for the use of bone tools in many regions of the world. The presence of such technology prior to 45 ka was convincingly recorded at several South African Middle Stone Age (MSA) sites, including Blombos Cave (D'Errico and Henshilwood 2007; Henshilwood et al. 2001); Sibudu Cave (Backwell et al. 2008; D'Errico et al. 2012); Klasies River (D'Errico and Henshilwood 2007); and Border Cave (Backwell et al. 2008; D'Errico et al. 2012; Yellen et al. 1995; Pletser and Huylebrouck 1999; Shipton et al. 2018). In Europe and some adjacent regions there is also evidence for production of bone tools from 44 to 35 ka, for example in Proto- and Early Aurignacian, Uluzzian, and Châtelperronian sites (Conard and Bolus 2006; D'Errico et al. 2003, 2012; D'Errico and Banks 2015; Tartar 2012), and in Üçağızlı Cave (Hatay, Turkey) (Baykara et al. 2015; Kuhn et al. 2009). Evidence of bone tool technology was also found at a handful of Asian sites attributed to the early Upper Pleistocene–Early Holocene, including Denisova Cave in Siberia (Derevianko 2010); Jwalapuram Locality 9 in southern India (Clarkson et al. 2009); and Batadomba-lena rockshelter in Sri Lanka (Perera et al. 2011). In Southeast Asia, bone tool technology was evidenced at some sites dated to the end of the Pleistocene, including five sites in mainland Southeast Asia—namely Lang Rongrien (Anderson 1988, 1997), Moh Khiew (Pookajorn 1996), Xom Trai (Nguyen 2000), Hang Boi (Rabett and Piper 2012), and Con Moong (Nguyen 2000)—and a number of sites from the Southeast Asian archipelago, including Niah Cave ('Hell Trench') (Barker et al. 2007); Niah Cave (Area A) (Pritchard et al. 2009); Niah Caves (Lobang Hangus) (Piper and Rabett 2009); Liang Lemdubu (O'Connor 2006); Gua Balambangan (Majid et al. 1998); Gua Braholo (Simanjuntak and Asikin 2004); Gua Musang (Thiel 1990); Agop Atas (Madai 1/28); Agop Sarapad (Madai 2) (Bellwood 1988); and Matja Kuru 2 (O'Connor et al. 2014).

Detailed observation suggests that during the Late Pleistocene, the Southeast Asian mainland and archipelago differed in its bone tool utilization in three distinct respects. Firstly, although the bone tool technology apparently occurred on the mainland before 40 ka BP, in a similar way to what is observed at Niah Cave ('Hell Trench') in Borneo, no bone-based composite projectile tools from this early phase have yet been found on the mainland (Rabett et al. 2006). Secondly, until the Pleistocene–Holocene transition the incidence of any bone-tool technology on the mainland continued to be low in contrast to the technological innovation in the archipelago (Rabett and Piper 2012). Thirdly, in comparison to the archipelago, the majority of Hoabinhian sites from the mainland yielded only a very few bone tools associated with pebble/cobble and/or flake tools. This is seen at Con Moong Cave where a few sharp-pointed bone tools and some hard, large-sized freshwater mollusc shell (scrapers or containers) were recovered (Thong 1980); Hang Boi midden contained a single fragment exhibiting several areas of deliberate modification (Rabett et al. 2009, Rabett et al. 2011); finally, Moh Khiew yielded a small numbers of bone tools in the early Holocene levels (dated to 12,893 ± 128 cal. BP: Pookajorn 1996; Rabett 2012).

The reasons for these differences might be explored further, but they do represent interesting intra-regional variability, which could serve as a reference point for the comparison of human behavior and subsistence in South China and the Hoabinhian sites of Southeast Asia during the Pleistocene–Holocene transition. In China, bone implements associated with stone tools were recovered from dozens of sites, including (in North China): Xiaogushan (Huang et al. 1986; Zhang et al. 1985, 2010); Shuidonggou locality 2 (Chen et al. 2012; Li et al. 2014) and 12 (Yi et al. 2013); Shizitan site (Song et al. 2016); Lingjing site (Li and Shen 2010); Zhoukoudian Upper Cave (Chen et al. 1992); and (in South China) Luobi Cave (Hao and Huang 1998); Chuandong Cave (Mao and Cao 2012; Zhang 1995); Maomaodong Cave (Cao 1982); Bailian Cave (Jiang 2009); Zhadong (Chen et al. 2004); and Ma'anshan Cave (Zhang et al. 2016). Associated with variable lithic industries within China, the bone tool technology appears to also exhibit regional variability, but this has not been firmly established because the majority of the bone artifacts have not yet been described in detail nor analyzed in terms of technological and functional method.

We have observed that in addition to stone tools, the other tool technologies on variable perishable raw materials such as bone, wood, bamboo or ivory also presented a marked difference in the complexity of the production procedure and in the overall rate of technological innovation on an inter- and intra-regional scale in South China and Southeast Asia. Specifically, not only is there perceivable variability of bone tool technologies between the Southeast Asian mainland and the archipelago, but there is also a remarkable difference in both the quantity and quality of bone tool technology as between Luobi Cave and most of the classic Hoabinhian sites of the Southeast Asian mainland. Thus, in a broader sense, the complex picture of human technological behaviors across the world could result from demographic and social events themselves partially associated with climatic elements rather than representing some uniform progressive and incremental process (Backwell et al. 2008; D'Errico and Banks 2013; Hovers and Belfer-Cohen 2006). The plentiful evidence of bone tool technology showing extreme spatio-temporal variability suggests that we should perhaps reconsider the use of this technology as an indicator of behavioral innovation in terms of human cognition (Conard and Bolus 2003, 2006; Henshilwood and Marean 2003; Klein 2008, 2009).

Luobi Cave is the earliest archaeological assemblage so far recovered on Hainan Island. The occupation was pre-agricultural, since the earliest Neolithic sites yielding ceramics, settlement traces and burials were dated to c. 6 ka (Fu et al. 2016; Wang 1990). Genetic research suggests that the early Hainan Islanders originated from either Southeast Asia (Li et al. 2008, 2013) or southern China and dispersed into the island before the end of the Pleistocene (Peng et al. 2011). Archaeological research indicates that the AMH who occupied Luobi Cave were similar to the Neolithic humans of North China and modern humans of Yunnan Province (Gu 1998), and that the essential cultural parameters—lithic and bone technology—resembled most of the cobble-tool industries of South China but differed from those of the Southeast Asian Hoabinhian assemblages. In other words, it seemed that Hainan Island showed a closer affiliation with South China than with the Hoabinhian sites of Southeast Asia. Nevertheless, geographically speaking, Hainan Island occupied a position just off the Vietnamese coast which is of the greatest importance in relation to the closure of the Bac Bo (Tonkin) Gulf ('Beibu Gulf' in Chinese). This remained physically connected with mainland China until c. 8.5 ka, when the Qiongzhou Strait formed and separated Hainan Island from the Leizhou Peninsula (Yao et al. 2009). During the late Late Pleistocene, neither the Beibu Gulf nor the Qiongzhou Strait presented an obstacle to migration by modern humans, and the North Vietnam area may have been a logical entry point for the migration of Hoabinhian and other groups from or to mainland Southeast Asia. Thus, the possibility of exchange and communication between humans of Luobi Cave and Hoabinhian hunter-gatherers of Southeast Asia cannot be excluded.

Further analysis of ancient DNA and more systematic morphological comparison between Luobi Cave and other sites in this region is needed in order to clarify the diversity or affinity of different populations, Hoabinhian or non-Hoabinhian. Additionally, dating analysis at Luobi Cave and other sites needs to be strengthened, and more detailed and integrative research should be conducted to reconstruct what emerges as a complex picture of culture, technology, subsistence, society, communication and dispersal. The study of lithic industries is indispensable in this. Our comparison between Luobi Cave and the representative Hoabinhian site of Laang Spean Cave suggests that cultural diversity and complexity during the Late Pleistocene–Holocene transition in South China and mainland Southeast Asia may have been much greater than previously imagined. It would therefore be appropriate to uncover cultural variability at a regional scale through a thorough consideration of the multiple adaptive responses linked to local needs, cultural traditions and technological knowledge (Rabett 2012), rather than to define the Late Pleistocene humans of South China and mainland Southeast Asia simply as behaviorally modern. In this connection, the comparative analysis presented here raises the problem of cobble/pebble tool diversity and technological evolution and dispersal, and provides new data and ideas about the variability of archaeological assemblages that were previously unknown in the cobble/pebble-tool industry of East and Southeast Asia. We expect that deeper, more extensive comparisons will be made in the future on a larger scale in South China and mainland Southeast Asia to help reveal in greater resolution the variability of cultures not only between Hoabinhian and non-Hoabinhian, but also within the so-called 'Hoabinhian'.

Acknowledgements This research has been supported by National Social Science Project (18BKG003). We thank Gang Qiu, curator of Provincial Museum of Hainan Island for his permission to restudy the collection of the Luobi Cave and Wenjie Gao, Huiyang Chen of the Museum for their help in observing the materials and taking photos of specimens. We also thank two anonymous reviewers and editors, Prof. Timothy Taylor and Sarah Wright for their comments, suggestions and help in improving the manuscript of this study. Our gratitude is extended to Dr. Kathryn Lee Ranhorn, Department of Anthropology, Harvard University for her help in correcting the final version of this manuscript.

References

Adams, J. L. (1998). Ground stone artifacts. In J. B. Mabry (Ed.), *Archaeological investigations of early village sites in the middle Santa Cruz Valley: Analysis and synthesis. Anthropological Papers No. 19* (pp. 357–422). Tucson: Center for Desert Archaeology.

Adams, J. L. (2014). *Ground stone analysis* (2nd ed.). Salt Lake City: University of Utah Press.

Aikens, C. M., & Akazawa, T. (1996). The Pleistocene–Holocene transition in Japan and adjacent Northeast Asia. In L. G. Straus, B. V. Eriksen, J. M. Erlandson & D. R. Yesner (Eds.), *Humans at the end of the Ice Age: The archaeology of the Pleistocene–Holocene transition. Interdisciplinary contributions to Archaeology* (pp. 215–227). New York: Plenum Press.

Anderson, D. D. (1988). Excavations of a Pleistocene rockshelter in Krabi and the prehistory of southern Thailand. In P. Charoenwongsa & B. Bronson (Eds.), *Prehistoric studies: The Stone and Metal Ages in Thailand* (pp. 43–59). Bangkok: Thai Antiquity Working Group.

Anderson, D. D. (1990). *Lang Rongrien rockshelter: A Pleistocene-Early Holocene archaeological site from Krabi, southwestern Thailand*. Philadelphia: University Museum, University of Pennsylvania.

Anderson, D. D. (1997). Cave archaeology in Southeast Asia. *Geoarchaeology: An International Journal*, *12*(6), 607–638.

Aubert, M., Brumm, A., Ramli, M., Sutikna, T., Saptomo, E. W., Hakim, B., et al. (2014). Pleistocene cave art from Sulawesi, Indonesia. *Nature, 514,* 223–227.

Backwell, L., D'Errico, F., & Wadley, L. (2008). Middle Stone Age bone tools from the Howiesons Poort layers, Sibudu Cave, South Africa. *Journal of Archaeological Science, 35*(6), 1566–1580.

Bacon, A. (2012). *Les sites de Tam Hang, Nam Lot et Tam Pà Ling au nord du Laos: Des gisements à vertébrés du Pléistocène aux origines des Hommes modernes*. Paris: CNRS Editions.

Bannanurag, R. (1988). Evidence for ancient woodworking: A microwear study of Hoabinhian stone tools. In P. Charoenwongsa & B. Bronson (Eds.), *Papers in Thai antiquity* (pp. 60–79). Bangkok: Thai Antiquity Working Group.

Barker, G., Barton, H., Bird, M., Daly, P., Datan, I., Dykes, A., et al. (2007). The 'human revolution' in lowland tropical Southeast Asia: The antiquity and behavior of anatomically modern humans at Niah Cave (Sarawak, Borneo). *Journal of Human Evolution, 52*(3), 243–261.

Barton, L., Brantingham, P. J., & Ji, D. (2007). Late Pleistocene climate change and Paleolithic cultural evolution in northern China: Implications from the Last Glacial Maximum. *Developments in Quaternary Sciences, 9,* 105–128.

Bar-Yosef, O., Eren, M. I., Yuan, J., Cohen, D. J., & Li, Y. (2012). Were bamboo tools made in prehistoric Southeast Asia? An experimental view from South China. *Quaternary International, 269,* 9–21.

Bar-Yosef, O., & Wang, Y. (2012). Paleolithic archaeology in China. *Annual Review of Anthropology, 41,* 319–335.

Baykara, S., Mentzer, S. M., Stiner, M. C., Asmerom, Y., Güle, E. S., & Kuhn, S. L. (2015). The middle Paleolithic occupations of Üçağızlı II Cave (Hatay, Turkey): Geoarcheological and archeological perspectives. *Journal of Archaeological Science: Reports, 4,* 409–426.

Beaumont, P., de Villiers, H., & Vogel, J. (1978). Modern Man in sub-Saharan Africa prior to 49,000 years BP: A review and evaluation with particular reference to Border Cave. *South African Journal of Science, 74,* 409–419.

Bellwood, P. S. (1988). *Archaeological research in south-eastern Sabah. Sabah Museum Monograph No. 2*. Sabah: Sabah Museum and State Archives.

Bellwood, P. (1993). Cultural and biological differentiation in Peninsular Malaysia: The last 10,000 Years. *Asian Perspectives, 32*(1), 37–60.

Bellwood, P. (2007). The Hoabinhians and their inland contemporaries. *Prehistory of the Indo-Malaysian archipelago* (pp. 155–200). Canberra: ANU Press.

Boëda, E. (2013). *Techno-logique & technologie: Une paléo-histoire des objets lithiques tranchants.* France: @rchéo-editions.com.

Boëda, E., Clemente-Conte, I., Fontugne, M., Lahaye, C., Pino, M., Felice, G. D., et al. (2014). A new Late Pleistocene archaeological sequence in South America: The Vale da Pedra Furada (Piauí, Brazil). *Antiquity, 88*(341), 927–955.

Boriskovsky, P. (1969). Vietnam in primeval times (Part IV). *Soviet Anthropology and Archeology, 8*(3), 214–257.

Bowdler, S. (1994). The Hoabinhian in Australia: A retrospective review. *Vietnam Social Sciences, 43*(5), 87–94.

Bowdler, S. (2006). The Hoabinhian: Early Evidence for SE Asian trade networks?. In E. A. Bacus, I. C. Glover, & V. Piggott (Eds.), *Uncovering Southeast Asia's past: Selected papers from the 10th Annual Conference of the European Association of Southeast Asian Archaeologists* (pp. 355–359). NUS Press, Singapore.

Bronson, B., & Glover, I. (1984). Archaeological radiocarbon dates from Indonesia: A first list. *Indonesia Circle, 12*(34), 37–44.

Cao, Z. (1982). On the Palaeolithic artefacts from Maomaodong (rockshelter site), Guizhou Province. *Vertebrata PalAsiatica, 20*(2), 155–164 **(in Chinese)**.

Cao, C. (1989). Archaeological survey report on the early Neolithic sites in Lixian County, Hunan Province. *Archaeology, 10,* 865–875 **(in Chinese)**.

Chen, T. (1998). The age of Luobi Cave, Sanya City. In S. Hao & W. Huang (Eds.), *The Luobi Cave site of Sanya City* (pp. 113–114). Haikou: Nanfang Press **(in Chinese)**.

Chen, T., Hedges, R. E. M., & Yuan, Z. (1992). The second batch of accelerator radiocarbon dates for the Upper Cave site of Zhoukoudian. *Acta Anthropologica Sinica, 11*(2), 112–116 **(in Chinese)**.

Chen, F., Li, F., Wang, H., Pei, S., Feng, X., Zhang, S., et al. (2012). A preliminary report on excavations at Shuidonggou Locality 2 in Ningxia Hui Autonomous Region, North China. *Acta Anthropologica Sinica, 31*(4), 317–333 **(in Chinese)**.

Chen, Q., Wang, S., & Zhang, D. (2004). *A study of the faunal remains from the Qingjiang River*. Beijing: Science Press **(in Chinese)**.

Clarkson, C., Petraglia, M., Korisettar, R., Haslam, M., Boivin, N., Crowther, A., et al. (2009). The oldest and longest enduring microlithic sequence in India: 35 000 years of modern human occupation and change at the Jwalapuram Locality 9 rockshelter. *Antiquity, 83*(320), 326–348.

Colani, M. (1927). L'âge de pierre dans la province de Hoa Binh (Tonkin). *Mémoire du service géologique de l'Indochine*, *13*. Hanoi.

Colani, M. (1929). Quelques paléolithes hoabiniens typiques de l'Abri sous roche de Lang-Kay. *Bulletin de la Société préhistorique de France, 26*(6), 353–384.

Collectif, (1932). *Praehistorica Asiae Orientalis: 1, Premier Congrès des préhistoriens d'Extrême-Orient, Hanoi.* Hanoi: Imprimerie d'Extrême-Orient.

Collectif. (2003). *The Zengpiyan site in Guilin*. Beijing: Cultural Relics Publishing House **(in Chinese)**.

Conard, N. J., & Bolus, M. (2003). Radiocarbon dating the appearance of modern humans and timing of cultural innovations in Europe: New results and new challenges. *Journal of Human Evolution, 44*(3), 331–371.

Conard, N. J., & Bolus, M. (2006). The Swabian Aurignacian and its place in European prehistory. In O. Bar-Yosef & J. Zilhão (Eds.), *Towards a definition of the Aurignacian: Proceedings of the Symposium held in Lisbon, Portugal, June 25–30, 2002* (pp. 211–239). Lisbon: Instituto Português de Arqueologia.

Curnoe, D., Ji, X., Shaojin, H., Taçon, P. S. C., & Li, Y. (2016). Dental remains from Longtanshan cave 1 (Yunnan, China), and the initial presence of anatomically modern humans in East Asia. *Quaternary International, 400,* 180–186.

Dai, G. (1988). On the relationship between 'Hoabinhian cultures'of Southeast Asia and cultures of South China. *Southeast Asia, 1,* 52–60 **(in Chinese)**.

Demeter, F., Shackelford, L. L., Bacon, A., Duringer, P., Westaway, K., Sayavongkhamdy, T., et al. (2012). Anatomically modern humans in Southeast Asia (Laos). *Proceedings of the National Academy of Sciences of the United States of America, 109*(36), 14375–14380.

Deng, C. (1992). Main points for archaeological reconstruction of aboriginal cultural circles in South China. In C. Deng & C. Wu (Eds.), *Archaeological research on Southeast China (Volume 2)* (pp. 83–94). Xiamen: Xiamen University Press **(in Chinese)**.

Derevianko, A. P. (2010). The Middle to Upper Palaeolithic transition in southern Siberia and Mongolia. In K. V. Boyle, C. Gamble, & O. Bar-Yosef (Eds.), *The Upper Palaeolithic revolution in global perspective: Papers in honour of Sir Paul Mellars* (pp. 103–113). Cambridge: McDonald Institute for Archaeological Research.

D'Errico, F., Backwell, L. R., & Wadley, L. (2012). Identifying regional variability in Middle Stone Age bone technology: The case of Sibudu Cave. *Journal of Archaeological Science, 39,* 2479–2495.

D'Errico, F., & Banks, W. E. (2013). Identifying mechanisms behind Middle Paleolithic and Middle Stone Age cultural trajectories. *Current Anthropology, 54*(S8), S371–S387.

D'Errico, F., & Banks, W. E. (2015). Tephra studies and the reconstruction of Middle-to-Upper Paleolithic cultural trajectories. *Quaternary Science Reviews, 118,* 182–193.

D'Errico, F., & Henshilwood, C. S. (2007). Additional evidence for bone technology in the southern African Middle Stone Age. *Journal of Human Evolution, 52*(2), 142–163.

D'Errico, F., Henshilwood, C., Lawson, G., Vanhaeren, M., Tillier, A., Soressi, M., et al. (2003). Archaeological evidence for the emergence of language, symbolism, and music: An alternative multidisciplinary perspective. *Journal of World Prehistory, 17*(1), 1–70.

Endicott, K. (1999). The Batek of peninsular Malaysia. In R. B. Lee & R. Daly (Eds.), *The Cambridge encyclopaedia of hunters and gatherers* (pp. 298–302). Cambridge: Cambridge University Press.

Eriksen B. V. (1996). Resource exploitation, subsistence strategies, and adaptiveness in Late Pleistocene–Early Holocene northwest Europe. In L. G. Straus, B. V. Eriksen, J. M. Erlandson, & D. R. Yesner (Eds.), *Humans at the end of the Ice Age: The archaeology of the Pleistocene–Holocene transition. Interdisciplinary contributions to archaeology* (pp. 101–128). New York: Plenum Press.

Forestier, H. (1993). Le clactonien: Mise en application d'une nouvelle méthode de débitage s'inscrivant dans la variabilité des systèmes de production lithique au Paléolithique ancien. *Paléo, 5,* 53–82.

Forestier, H. (2000). De quelques chaînes opératoires lithiques en Asie du Sud-Est au Pléistocène supérieur final et au début de l'Holocène. *L'Anthropologie, 104,* 531–548.

Forestier, H., Simanjuntak, T., Guillaud, D., Driwantoro, D., Wiradnyana, K., Siregar, D., et al. (2005). Le site de Tögi Ndrawa, île de Nias, Sumatra nord: Les premières traces d'une occupation hoabinhienne en grotte en Indonésie. *Comptes Rendus Palevol, 4*(8), 727–733.

Forestier, H., Sophady, H., & Celiberti, V. (2017). Le techno-complexe hoabinhien en Asie du Sud-est continentale: L'histoire d'un galet qui cache la forêt. *Journal of Lithic Studies, 4*(2), 1–45.

Forestier, H., Sophady, H., Puaud, S., Celiberti, V., Frère, S., Zeitoun, V., et al. (2015). The Hoabinhian from Laang Spean Cave in its stratigraphic, chronological, typo-technological and environmental context (Cambodia, Battambang province). *Journal of Archaeological Science: Reports, 3,* 194–206.

Forestier, H., Zeitoun, V., Winayalai, C., & Métais, C. (2013). The open-air site of Huai Hin (Northwestern Thailand): Chronological perspectives for the Hoabinhian. *Comptes Rendus Palevol, 12*(1), 45–55.

Francis, C. M. (2008). *A field guide to the mammals of Thailand and South-East Asia*. Bangkok: Asia Books.

Fromaget, J., & Saurin, E. (1936). Note préliminaire sur les formations Cénozoiques et plus récentes de la chaîne Annamitique septentrionale et du Haut-Laos (stratigraphie, préhistoire, anthropologie). *Bulletin du Service géologique de l'ndochine, 22,* 1–48.

Fu, X. (2002). The Dingsishan site and the prehistory of Guangxi, South China. *Bulletin of the Indo-Pacific Prehistory Association, 22,* 63–71.

Fu, X. G. F., & Li, X. (1998). The excavation of Dingshishan site in Yongning County, Guangxi. *Archaeology, 11,* 11–33 **(in Chinese)**.

Fu, X., Wang, M., Liu, Y., Fu, Y., & Shou, J. (2016). Important advancement in prehistoric archaeology of southeast coastal regions, Hainan Island. *Weekly of Chinese Cultural Relics*, *2016.01.15*, 8 **(in Chinese)**.

Gaillard, C., Mishra, S., Singh, M., Deo, S., & Abbas, R. (2010). Reply: Do not confuse large cutting tool types. *Quaternary International, 223,* 245–247.

Gaillard, C., Singh, M., & Malassé, A. D. (2011). Late Pleistocene to Early Holocene lithic industries in the southern fringes of the Himalaya. *Quaternary International, 229,* 112–122.

Gao, X., Zhang, X., Yang, D., Shen, C., & Wu, X. (2010). Revisiting the origin of modern humans in China and its implications for global human evolution. *Science China Earth Sciences, 53*(12), 1927–1940.

Glover, I. C. (1977). The Hoabinhian: Hunter–gatherers or early agriculturalists in Southeast Asia? In J. V. S. Megaw (Ed.), *Hunters, pastoralists and early agriculturalists in South Asia* (pp. 145–166). Leicester: Leicester University Press.

Gorecki, P. P., & Gillieson, D. S. (1989). *A crack in the spine: Prehistory and ecology of the Jimi-Yuat Valley, Papua New Guinea*. Division of Anthropology and Archaeology, School of Behavioural Sciences, James Cook University of North Queensland.

Gorman, C. F. (1969). Hoabinhian: A pebble-tool complex with early plant associations in Southeast Asia. *Science, 163*(3868), 671–673.

Gorman, C. F. (1970). Excavations at Spirit Cave, North Thailand: Some interim interpretations. *Asian Perspectives, 13,* 79–107.

Gorman, C. (1971). The Hoabinhian and after: Subsistence patterns in Southeast Asia during the Late Pleistocene and early recent periods. *World Archaeology, 2*(3), 300–320.

Gu, Y. (1998). Human remains found in Luobi Cave. In S. Hao & W. Huang (Eds.), *The Luobi Cave site of Sanya City* (pp. 9–10). Haikou: Nanfang Press **(in Chinese)**.

Guo, Y., & Li, J. (1963). Test excavation at the Xianrendong Cave, Dayuan Basin, Wannian County, Jiangxi Province. *Acta Archaeologica Sinica, 1,* 1–16 **(in Chinese)**.

Ha, V. T. (1980). Nouvelles recherches préhistoriques et protohistoriques au Vietnam. *Bulletin de l'Ecole française d'Extrême-Orient, 68,* 113–154.

Ha, V. T. (1995). Différentes lignes de développement du post-hoabinhien à l'âge de la pierre au Vietnam. *L'Anthropologie, 99*(4), 652–656.

Ha, V. T. (1997). The Hoabinhian and before. *Bulletin of the Indo-Pacific Prehistory Association, 16,* 35–41.

Hao, S., & Huang, W. (Eds.). (1998). *The Luobi Cave site of Sanya City*. Haikou: Nanfang Press (**in Chinese**).

Harmand, S., Lewis, J. E., Feibel, C. S., Lepre, C. J., Prat, S., Lenoble, A., et al. (2015). 3.3-million-year-old stone tools from Lomekwi 3, West Turkana. *Kenya. Nature, 521,* 310–315.

Haury, E. W. (1976). *The Hohokam: Desert farmers and craftsmen, excavations at Snaketown, 1964–1965*. Tucson: University of Arizona Press.

Hayden, B. (1977). Sticks and stones and ground axes: the Upper Palaeolithic in Southeast Asia. In J. Alen, G. Golson, & R. Jones (Eds.), *Sunda and Sahul: Prehistoric studies in Southeast Asia, Melanesia and Australia* (pp. 73–109). New York: New York Academic Press.

He, N., Huang, Y., & Liu, W. (1983). The Neolithic shell-midden site of Liyuzui at Dalongtan in Liuzhou city. *Archaeology, 9,* 769–774 **(in Chinese)**.

Heekeren, H., & Knuth, E. (1967). *Archaeological excavations in Thailand. 1. Sai-Yok: Stone-Age settlements in the Kanchanaburi Province*. Copenhagen: Munksgaard.

Henshilwood, C. S., D'Errico, F., Marean, C. W., Milo, R. G., & Yates, R. (2001). An early bone tool industry from the Middle Stone Age at Blombos Cave, South Africa: Implications for the origins of modern human behaviour, symbolism and language. *Journal of Human Evolution, 41*(6), 631–678.

Henshilwood, C. S., & Marean, C. W. (2003). The origin of modern human behavior. *Current Anthropology, 44*(5), 627–651.

Higham, C. (1989). *The archaeology of mainland Southeast Asia*. Cambridge: Cambridge University Press.

Higham, C. (2013). Hunter-gatherers in Southeast Asia: From prehistory to the present. *Human Biology, 85*(1–3), 21–44.

Higham, C. (2014). *Early mainland in Southeast Asia: From first humans to Angkor*. Bangkok: River Books.

Hovers, E., & Belfer-Cohen, A. (2006). Now you see it, now you don't: Modern human behavior in the Middle Paleolithic. In E. Hovers & S. Kuhn (Eds.), *Transitions before the transition: Interdisciplinary contributions to archaeology* (pp. 295–304). New York: Springer.

Huang, W., & Hao, S. (1995). A survey in Tianya Haijiao. *Wenwu Tiandi, 6,* 27–30 **(in Chinese)**.

Huang, W., Zhang, Z., Fu, R., Chen, B., Liu, J., Zhu, M., et al. (1986). Bone artifacts and ornaments from Xiaogushan site of Haicheng Liaoning Province. *Acta Anthropologica Sinica, 5*(3), 259–266. **(in Chinese)**.

Imdirakphol, S. (2012). *Donut stone in Thailand*. Master thesis. Silpakorn University: Bangkok.

Imdirakphol, S., Zazzo, A., Auetrakulvit, P., Tiamtinkrit, C., Pierret, A., Forestier, H., et al. (2017). The perforated stones of the Doi Pha Kan burials (Northern Thailand): A Mesolithic singularity? *Comptes Rendus Palevol, 16*(3), 351–361.

Inizan, M. L., Reduron-Ballinger, M., & Roche, H. (1999). *Technology and terminology of knapped stone*. Paris: Cercle de Recherches et d'Etudes Préhistoriques.
Ji, X., Kuman, K., Clarke, R. J., Forestier, H., Li, Y., Ma, J., et al. (2016). The oldest Hoabinhian technocomplex in Asia (43.5 ka) at Xiaodong rockshelter, Yunnan Province, southwest China. *Quaternary International, 400,* 166–174.
Jiang, Y. (Ed.). (2009). *The Bailian Cave of Liuzhou City*. Beijing: Science Press (in Chinese).
Jiao, T. (1994). The prehistoric culture in Lingnan area during terminal Pleistocene to Early Holocene. *Acta Archaeologica Sinica, 1,* 1–24 **(in Chinese)**.
Kamaruzaman, A. R. (2002). The Hoabinhian site at Taat Hill cave, upper Terengganu, Malaysia. *Jebat, 29,* 69–78.
Kidder, A. V., Jennings, J. D., & Shook, E. M. (1946). *Excavations at Kaminaljuyú, Guatemala.* Publication 561. Washington D.C.: Carnegie Institution of Washington.
Klein, R. G. (2008). Out of Africa and the evolution of human behavior. *Evolutionary Anthropology: Issues, news, and reviews, 17*(6), 267–281.
Klein, R. G. (2009). *The human career: Human biological and cultural origins*. Chicago: University of Chicago Press.
Kuhn, S. L., Stiner, M. C., Güleç, E., Özer, I., Yılmaz, H., Baykara, I., et al. (2009). The early Upper Paleolithic occupations at Üçağızlı Cave (Hatay, Turkey). *Journal of Human Evolution, 56*(2), 87–113.
Li, F., Chen, F., & Gao, X. (2014a). 'Modern behaviors'of ancient populations at Shuidonggou Locality 2 and their implications. *Quaternary International, 347,* 66–73.
Li, D., Li, H., Ou, C., Lu, Y., Sun, Y., Yang, B., et al. (2008). Paternal genetic structure of Hainan aborigines isolated at the entrance to East Asia. *PLoS ONE, 3*(5), e2168.
Li, Z., & Shen, C. (2010). Use-wear analysis confirms the use of Palaeolithic bone tools by the Lingjing Xuchang early human. *Chinese Science Bulletin, 55*(21), 2282–2289.
Li, Y., Sun, X., & Bodin, E. (2014b). A macroscopic technological perspective on lithic production from the Early to Late Pleistocene in the Hanshui River Valley, central China. *Quaternary International, 347,* 148–162.
Li, D. N., Wang, C. C., Lu, Y., Qin, Z. D., Yang, K., Lin, X. J., et al. (2013). Three phases for the early peopling of Hainan Island viewed from mitochondrial DNA. *Journal of Systematics and Evolution, 51*(6), 671–680.
Liu, W., Martinón-Torres, M., Cai, Y., Xing, S., Tong, H., Pei, S., et al. (2015). The earliest unequivocally modern humans in southern China. *Nature, 526,* 696–699.
Majid, Z., Ignatius, J., Tjia, H. D., & Koon, P. (1998). Some interesting Late Pleistocene–Early Holocene finds from excavations in Balambangan Island, Sabah, Malaysia. *Sabah Society Journal, 15,* 29–40.
Mao, Y., & Cao, Z. (2012). A preliminary study of the polished bone tools unearthed in 1979 from the Chuandong site in Puding County. *Guizhou. Acta Anthropologica Sinica, 31*(4), 335–343.
Marwick, B. (2007). Approaches to flaked stone artefact archaeology in Thailand: A historical review. *Silpakorn University International Journal, 7,* 49–88.
Marwick, B. (2008a). Three styles of Darwinian evolution in the analysis of stone artefacts: Which one to use in mainland Southeast Asia? *Australian Archaeology, 67,* 79–86.
Marwick, B. (2008b). What attributes are important for the measurement of assemblage reduction intensity? Results from an experimental stone artefact assemblage with relevance to the Hoabinhian of mainland Southeast Asia. *Journal of Archaeological Science, 35*(5), 1189–1200.
Marwick, B. (2013). Multiple optima in Hoabinhian flaked stone artefact palaeoeconomics and palaeoecology at two archaeological sites in Northwest Thailand. *Journal of Anthropological Archaeology, 32*(4), 553–564.
Matthews, J. M. (1966). A review of the 'Hoabinhian'in Indo-China. *Asian Perspectives*, *IX* 86–95.
McKinnon, E. E. (1991). The Hoabinhian in the Wampu/Lau Biang Valley of northeastern Sumatra: An update. *Bulletin of the Indo-Pacific Prehistory Association, 10,* 132–142.
Meijaard, E. (2003). Mammals of southeast Asian islands and their Late Pleistocene environments. *Journal of Biogeography, 30,* 1245–1257.
Misra, V. N. (2001). Prehistoric human colonization of India. *Journal of Biosciences, 26*(4), 491–531.
Moore, J. D. (1991). Cultural responses to environmental catastrophes: Post-El Niño subsistence on the prehistoric north coast of Peru. *Latin American Antiquity, 2*(1), 27–47.
Moore, A. M. T., & Hillman, G. C. (1992). The Pleistocene to Holocene transition and human economy in Southwest Asia: The impact of the Younger Dryas. *American Antiquity, 57*(3), 482–494.

Moser, J. (2001). *Hoabinhian: Geographie und Chronologie eines steinzeitlichen Technokomplexes in Südostasien*. Koln: Linden Soft.
Mourer, C., & Mourer, R. (1970a). The prehistoric industry of Laang Spean, province of Battambang, Cambodia. *Archaeology & Physical Anthropology in Oceania, 5*(2), 128–146.
Mourer, C., & Mourer, R. (1970b). Note préliminaire sur la présence d'une industrie préhistorique dans la grotte de Laang spean, province de Battambang, Cambodge. In Endo, B., Hoshi, H., & Masuda, S. (Eds.), *Proceedings of the VIIIth International Congress of Anthropological and Ethnological Sciences.* vol. Prehistory and Archaeology (pp. 141–142). Tokyo.
Nguyen, V. (2000). *Homeland of the Hoabinhian in Vietnam*. Sarteano: Paper presented at the European Southeast Asian Archaeologists Association **(unpublished)**.
Nguyen, V. (2005). The Da But Culture: Evidence for cultural development in Vietnam during the Middle Holocene. *Indo-Pacific Prehistory Association Bulletin (Taipei Papers, Vol.3) 25*, 89–93.
O'Connor, S. (2006). Unpacking the Island Southeast Asian Neolithic cultural package, and finding local complexity. In E. A. Bacus & I. Glover (Eds.), *Uncovering Southeast Asia's Past: Selected papers from the 10th International Conference of the European Association of Southeast Asian Archaeologists.* (pp. 74–87). NIAS Press, Singapore.
O'Connor, S., Robertson, G., & Aplin, K. P. (2014). Are osseous artefacts a window to perishable material culture? Implications of an unusually complex bone tool from the Late Pleistocene of East Timor. *Journal of Human Evolution, 67,* 108–119.
Pautreau, J. (1994). Le Hoabinhien, 60 ans après Madeleine Colani. *Bulletin de la Société préhistorique française, 91*(3), 175.
Pei, W. (1935). On a Mesolithic (?) industry of the caves of Kwangsi. *Acta Geologica Sinica, 14*(3), 393–414.
Peng, M., He, J., Liu, H., & Zhang, Y. (2011). Tracing the legacy of the early Hainan Islanders: A perspective from mitochondrial DNA. *BMC Evolutionary Biology, 11,* 46.
Perera, N., Kourampas, N., Simpson, I. A., Deraniyagala, S. U., Bulbeck, D., Kamminga, J., et al. (2011). People of the ancient rainforest: Late Pleistocene foragers at the Batadomba-lena rockshelter, Sri Lanka. *Journal of Human Evolution, 61*(3), 254–269.
Piper, P. J., & Rabett, R. J. (2009). Hunting in a tropical rainforest: Evidence from the Terminal Pleistocene at Lobang Hangus, Niah Caves Sarawak. *International Journal of Osteoarchaeology, 19*(4), 551–565.
Piper, P. J., & Rabett, R. J. (2014). Late Pleistocene subsistence strategies in Southeast Asia and their implications for understanding the development of modern human behavior. In R. Dennell & M. Porr (Eds.), *Southern Asia, Australia and the search for human origins* (pp. 118–134). New York: Cambridge University Press.
Pletser, V., & Huylebrouck, D. (1999). The Ishango artefact: The missing base 12 link. *Forma, 14,* 339–346.
Pookajorn, S. (1990). Hoabinhian cave excavations in Ban Kao district, West Thailand. In E. Glover & I. Glover (Eds.), *Southeast Asian Archaeology 1986. Proceedings of the First Conference of the Association of Southeast Asian Archaeologists in Western Europe* (pp. 11–28). Oxford: BAR.
Pookajorn, S. (1996). Human activities and environmental changes during the Late Pleistocene to Middle Holocene in Southern Thailand and Southeast Asia. In L. G. Straus, B. V. Eriksen, J. M. Erlandson & D. R. Yesner (Eds.), *Humans at the end of the Ice Age: The archaeology of the Pleistocene–Holocene transition. Interdisciplinary contributions to archaeology* (pp. 201–213). New York: Plenum Press.
Pope, G. G. (1989). Bamboo and human evolution. *Natural History, 98*(10), 48–57.
Prichanjit, S., Disayadej, P., & Phommanoj, S. (1996). *Town and ancient communities in Lanna*. Bangkok: Idea Square publishing.
Pritchard, P. C. H., Rabett, R. J., & Piper, P. J. (2009). Distinguishing species of Geoemydid and Trionychid turtles from shell fragments: Evidence from the Pleistocene at Niah Caves, Sarawak. *International Journal of Osteoarchaeology, 19*(4), 531–550.
Qiu, L., Song, F., & Wang, L. (1982). The excavation of the Neolithic site of Dushizai Cave, Guangdong Province. *Achaeology, 5,* 456–459 **(in Chinese)**.
Qu, T., Bar-Yosef, O., Wang, Y., & Wu, X. (2012). The Chinese Upper Paleolithic: Geography, chronology, and techno-typology. *Journal of Archaeological Research, 21*(1), 1–73.
Rabett, R. J. (2011). Techno-modes, techno-facies and palaeo-cultures: Change and continuity in the Pleistocene of Southeast, Central and North Asia. In B. W. Roberts & M. V. Linden (Eds.),

Investigating archaeological cultures: Material culture, variability, and transmission (pp. 97–135). New York: Springer.
Rabett, R. J. (2012). *Human adaptation in the Asian Palaeolithic: Hominid dispersal and behaviour during the late Quaternary*. Cambridge: Cambridge University Press.
Rabett, R. J., Appleby, J., Blyth, A., Farr, L., Gallou, A., Griffiths, T., et al. (2011). Inland shell midden site-formation: Investigation into a Late Pleistocene to Early Holocene midden from Tràng An. *Northern Vietnam. Quaternary International, 239*(1–2), 153–169.
Rabett, R., Barker, G., Hunt, C. O., Naruse, T., Piper, P., & Raddatz, E. (2009). The Trang An project: Late to post Pleistocene settlement of the Lower Song Hong Valley, North Vietnam. *Journal of the Royal Asiatic Society Series 3, 19*(1), 83–109.
Rabett, R. J., & Piper, P. J. (2012). The emergence of bone technologies at the end of the Pleistocene in Southeast Asia: Regional and evolutionary implications. *Cambridge Archaeological Journal, 22*(1), 37–56.
Rabett, R. J., Piper, P. J., Barker, G. (2006). Bones from Hell: Preliminary results of new work on the Harrison faunal assemblage from the deepest part of Niah Cave, Sarawak. In E. A. Bacus, I. C. Glover, & V. C. Pigott (Eds.), *Uncovering Southeast Asia's past: Selected papers from the 10th International Conference of European Association of Southeast Asian Archaeologists.* (pp. 46–59) National University of Singapore Press, Singapore.
Reynolds, T. (1989). Techno-typology in Thailand: A case study of Tham Khao Khi Chan. *Indo-Pacific Prehistoriy Association Bulletin, 9,* 33–43.
Saurin, E. (1962). La station préhistorique de Hang gon près Xuan-Loc (Viêt-nam). *Asian Perspectives, 6*(1/2), 163–168.
Sheets, P., & Simmons, S. E. (2002). Household production and specialization at Cerén. In P. Sheets (Ed.), *Before the Volcano erupted: The ancient Cerén village in Central America* (pp. 178–183). Austin: University of Texas Press.
Shipton, C., Roberts, P., Archer, W., Armitage, S. J., Bita, C., Blinkhorn, J., et al. (2018). 78,000-year-old record of Middle and Later Stone Age innovation in an East African tropical forest. *Nature Communications, 9,* 1832.
Shoocongdej, R. (2000). Forager mobility organization in seasonal tropical environments of western Thailand. *World Archaeology, 32*(1), 14–40.
Shoocongdej, R. (2006). Late Pleistocene activities at the Tham Lod rockshelter in highland Pang Mapha, Mae Hong Son Province, Northwestern Thailand. In: E. A. Bacus, I. C. Glover & V. Piggott (Eds.), *Uncovering Southeast Asia's past: Selected papers from the 10th Annual Conference of the European Association of Southeast Asian Archaeologists,* (pp. 22–37). Singapore: National University of Singapore Press.
Simanjuntak, T., & Asikin, I. N. (2004). Early Holocene human settlement in Eastern Java. *Indo-Pacific Prehistory Association Bulletin. Taipei papers,* vol *2*, *24*, 13–19.
Solheim, W. G., II. (1996). The Nusantao and north–south dispersals. *Bulletin of the Indo-Pacific Prehistory Association, 15,* 101–109.
Song, Y., Li, X., Wu, X., Kvavadze, E., Goldberg, P., & Bar-Yosef, O. (2016). Bone needle fragment in LGM from the Shizitan site (China): Archaeological evidence and experimental study. *Quaternary International, 400,* 140–148.
Song, F., Qiu, L., & Wang, L. (1983). The Huangyan Cave site in Fengkai County of Guangdong Province. *Archaeology, 1,* 1–3 **(in Chinese)**.
Soni, V. S., & Soni, A. S. (2010). Large size cleaver-like flakes and Hoabinhoidal elements from terminal Pleistocene to mid-Holocene epoch sites. *Quaternary International*, *223–224* (Supplement C), 242–244.
Sørensen, P. (1975). A note on perforated stones. *Asian Perspectives, 18*(2), 166–176.
Stark, M. (2004). Pre-Angkorian and Angkorian Cambodia. In I. Glover & P. Bellwood (Eds.), *Southeast Asia: From prehistory to history* (pp. 89–119). London: Routledge Curzon.
Straus, L. G. (1996). The world at the end of the Ice Age. In L. G. Straus, B. V. Eriksen, J. M. Erlandson & D. R. Yesner (Eds.), *Humans at the end of the Ice Age: The archaeology of the Pleistocene–Holocene transition. Interdisciplinary contributions to archaeology* (pp. 3–9). New York: Plenum Press.
Taha, A. T. (2000). *Archaeological investigation in Ulu Kelantan, Peninsular Malaysia*. PhD thesis. Canberra: Australian National University.
Tan, H. V. (1976). The Hoabinhian in the context of Vietnam. *Vietnamese Studies, 46,* 127–197.

Tartar, E. (2012). The recognition of a new type of bone tools in Early Aurignacian assemblages: Implications for understanding the appearance of osseous technology in Europe. *Journal of Archaeological Science, 39*(7), 2348–2360.

Thaw, U. A. (1971). The 'Neolithic' culture of the Padah-lin Caves. *Asian Perspectives, 14,* 123–133.

Thiel, B. (1990). Excavations at Musang Cave, Northeast Luzon, Philippines. *Asian Perspectives, 28*(1), 61–81.

Thong, P. H. (1980). Con Moong Cave: A noteworthy archaeological discovery in Vietnam. *Asian Perspectives, 23*(1), 17–21.

Tomasic, J. J. (2012). Donut stones as thigh-supported spindle whorls: Evidence of ancient Maya household yarn and cordage production. *Latin American Antiquity, 23*(2), 215–228.

Van Noten, F. (1977). Excavations at Matupi cave. *Antiquity, 51*(201), 35–40.

Wang, H. (1990). The discoveries of and researches on Neolithic in Hainan Island. *Journal of Hainan Normal University, 1,* 81–89 **(in Chinese)**.

Wang, Y. (1998). Human adaptations and Pleistocene environment in South China. *L'Anthropologie, 36*(1–2), 165–175.

Watson, V., & Cole, D. (1977). *Anthropological studies in the eastern Highlands of New Guinea, Vol III: Prehistory of eastern Highlands of New Guinea*. Seattle & London: University of Washington Press.

White, J. C. (2011). Emergence of cultural diversity in mainland Southeast Asia: A view from prehistory. In N. J. Enfield (Ed.), *Dynamics of human diversity: The case of mainland Southeast Asia* (pp. 9–46). Canberra: Pacific Linguistics.

White, J., & Gorman, C. (2004). Patterns in 'amorphous' industries: The Hoabinhian viewed through a lithic reduction sequence. In V. Paz (Ed.), *Southeast Asian archaeology: Wilhem G. Solheim Festschrift* (pp. 411–441). Quezon City: University of the Philippines Press.

Wu, H., & Yang, J. (1976). Trail excavation at the site of Zengpiyan Cave in Guilin, Guangxi. *Archaeology, 3,* 175–179 **(in Chinese)**.

Xhauflair, H., Pawlik, A., Gaillard, C., Forestier, H., Vitales, T. J., Callado, J. R., et al. (2016). Characterisation of the use-wear resulting from bamboo working and its importance to address the hypothesis of the existence of a bamboo industry in prehistoric Southeast Asia. *Quaternary International, 416,* 95–125.

Yao, Y., Harff, J., Meyer, M., & Zhan, W. (2009). Reconstruction of paleocoastlines for the northwestern South China Sea since the Last Glacial Maximum. *Science in China, Series D: Earth Sciences, 52*(8), 1127–1136.

Yellen, J., Brooks, A. S., Cornelissen, E., Mehlman, M. J., & Stewart, K. (1995). A Middle Stone Age worked bone industry from Katanda, Upper Semliki Valley, Zaire. *Science, 268*(5210), 553–556.

Yi, M., Barton, L., Morgan, C., Liu, D., Chen, F., Zhang, Y., et al. (2013). Microblade technology and the rise of serial specialists in north-central China. *Journal of Anthropological Archaeology, 32*(2), 212–223.

Yi, S., Lee, J. J., Kim, S., Yoo, Y., & Kim, D. (2008). New data on the Hoabinhian: Investigations at Hang Cho cave, Northern Vietnam. *Bulletin of Indo-Pacific Prehistory Association, 28,* 73–79.

Zeitoun, V., Auetrakulvit, P., Forestier, H., Zazzo, A., Davtian, G., Nakbunlung, S., et al. (2013). Discovery of a Mesolithic burial near the painted rock-shelter of Ban Tha Si (Lampang province, Northern Thailand): Implications for regional mortuary practices. *Comptes Rendus Palevol, 12*(2), 127–136.

Zeitoun, V., Auetrakulvit, P., Zazzo, A., Pierret, A., Frère, S., & Forestier, H. (2019 in press) Discovery of an outstanding Hoabinhian site from the Late Pleistocene at Doi Pha Kan (Lampang province, northern Thailand). *Archaeological Research in Asia*. https://doi.org/10.1016/j.ara.2019.01.002.

Zeitoun, V., Bourdon, E., Latsachack, K. O., Pierret, A., Singthong, S., Baills, H., & Forestier, H. (2019). Discovery of a new open-air Hoabinhian site in Luang Prabang province (Lao PDR). Dating and technological study of the lithic assemblage. *Comptes Rendus Palevol, 18*(1): p. 142–157.

Zeitoun, V., Forestier, H., & Nakbunlung, S. (2008). *Préhistoires au sud du Triangle d'Or*. Paris: Éditions IRD.

Zeitoun, V., Forestier, H., Pierret, A., Chiemsisouraj, C., Lorvankham, M., Latthagnot, A., et al. (2012). Multi-millennial occupation in northwestern Laos: Preliminary results of excavations at the Ngeubhinh Mouxeu rock-shelter. *Comptes Rendus Palevol, 11,* 305–313.

Zhang, S. (1995). A brief study on Chuandong prehistoric site (excavated in 1981). *Acta Anthropologica Sinica, 14*(2), 132–146 **(in Chinese)**.

Zhang, S. (2002). Advances in Chinese Paleolithic archeology in the past 20 years and some comments. *Quaternary Sciences, 22,* 11–19 **(in Chinese)**.

Zhang, S., D'Errico, F., Backwell, L. R., Zhang, Y., Chen, F., & Gao, X. (2016). Ma'anshan cave and the origin of bone tool technology in China. *Journal of Archaeological Science, 65,* 57–69.

Zhang, Z., Fu, R., Chen, B., Liu, J., Zhu, M., Wu, H., et al. (1985). A preliminary report on the excavation of Paleolithic site at Xiaogushan of Haicheng, Liaoning Province. *Acta Anthropologica Sinica, 4*(2), 78–92 **(in Chinese)**.

Zhang, J., Huang, W., Yuan, B., Fu, R., & Zhou, L. (2010). Optically stimulated luminescence dating of cave deposits at the Xiaogushan prehistoric site, northeastern China. *Journal of Human Evolution, 59*(5), 514–524.

Zhang, C., & Hung, H. (2012). Later hunter-gatherers in southern China, 18 000–3000 BC. *Antiquity, 86*(331), 11.

Zhang, Z., & Qiu, L. (1998). Relevations from archaeological discoveries of Dongzhongyan, Luoshayan, Huangyan Caves. *Journal of Xijiang University, 38*(2), 15–21 **(in Chinese)**.

Zhao, C., Wu, X., Wang, T., & Yuan, X. (2004). *Early polished stone tools in South China evidence of the transition from Palaeolithic to Neolithic* (pp. 131–137). XXXI: Documenta Praehistorica.

Zhou, G. (2007). The 'all-purpose tool' in the Stone Age: Perforated pebble or bored stone (weight stone). *Agricultural Archaeology, 1,* 127–147 **(in Chinese)**.

Zou, X., Li, L., & Wu, Y. (1999). Preliminary report on the prehistoric site of Dongwanzibei, on Mawan Island, Hongkong. *Archaeology, 6,* 1–17 **(in Chinese)**.

Affiliations

Yinghua Li[1,2] · Side Hao[3] · Wanbo Huang[4,5] · Hubert Forestier[6] · Yuduan Zhou[1,6] · Huan Li[1]

✉ Yinghua Li
lyhfrance2005@yahoo.fr

1 School of History, Wuhan University, Luojiashan, Wuchang, Wuhan 430072, Hubei Province, China

2 CNRS UMR 7041 ArScAn–AnTET, Université Paris X, Maison de l'Archéologie et de l'Ethnologie, 21 allée de l'Université, Nanterre 92023, France

3 The Provincial Museum of Hainan Island, Guoxing Boulevard 68, Haikou 570203, Hainan Island, China

4 Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China

5 Chongqing Museum of Natural History, 398 Xinhua Road, Beibei, Chongqing 200062, China

6 Muséum National d'Histoire Naturelle, UMR 7194 CNRS-MNHN-UPVD, Institut de Paléontologie Humaine, 1 rue René-Panhard, 75013 Paris, France