A technological perspective on the lithic industry of the Bailiandong Cave (36–7 ka) in Guangxi: An effort to redefine the cobble-tool industry in South China.

Y. Zhou, Yuchao Jiang, G. Liang, Y. Li, H. Forestier, H. Li, P. Chen, T. Liang, C. He

Version of Record: https://www.sciencedirect.com/science/article/pii/S1631068319301551
Manuscript_71b99ddb113d9df4d5a8b2824376a500

A technological perspective on the lithic industry of Bailiandong Cave (36-7ka) in Guangxi: an effort to redefine the cobble-tool industry in South China

Une perspective technologique en l'industrie lithique de la grotte de Bailiandong (36-7ka) du Guangxi: un effort pour redéfinir l'industrie sur galet au Sud de la Chine

Yuduan Zhou [a, b], Yuanjin Jiang [c], Ge Liang [c], Yinghua Li [a, d, *], Hubert Forestier [b], Huan Li [a], Peng Chen [a], Liwei Wang [a], Tingting Liang [a], Chengpo He [a]

[a] *School of History, Wuhan University, Wuhan 430072, China*

[b] *UMR7194, Muséum national d'histoire naturelle, CNRS-UPVD, 1, rue René Panhard, 75013, Paris, France*

[c] *Museum of Bailiandong Cave Site, Liuzhou City 545000, Guangxi Zhuang Autonomous Region, China*

[d] *UMR 7041 CNRS ArSCAN, équipe AnTET, université Paris Ouest-Nanterre La Défense, 21, allée de l'Université, 92023 Nanterre cedex, France*

[*] Corresponding author.
E-mail address:lyhfrance2005@yahoo.fr (Y. Li).

Abstract

In South China and mainland Southeast Asia, lithic industry called "cobble-tool industry" dominated the entire Pleistocene and persisted until the Middle Holocene. Although this term has been used for a long time to summarize the characteristic of lithic industry and to compare between Paleolithic cultures on inter-regional level, however it is just a description about the raw material of lithic industry without indicating any essential technological information about lithic production. So it becomes ineffective when comparing the lithic industries of different sites in South China and mainland Southeast Asia because both regions are characterized by cobble/pebble raw material during their prehistory. In this paper, we studied the lithic collection of Bailiandong Cave, an important site in Guangxi, southern China dating to 36-7ka, from a new technological perspective and revealed the *chaîne opératoires* of production and the objectives of prehistoric knappers. After a concise comparison with the Hoabinhian techno-complex in mainland southeastern Asia, the long-lasting suspicion about the Hoabinhian elements at this site was dispelled. So, technological analysis did construct a solid foundation to redefine the cobble-tool industry in South China and to reveal the variability of lithic industries in a larger regional scale. The application of this approach on more sites is expected to help to decipher more clearly the technological and cultural scenario of prehistoric humans in South China and adjacent Southeast Asia.

Keywords: Lithic technology Bailiandong Cave South China Cobble-tool industry Hoabinhian Southeast Asia

Résumé

Dans la Chine du Sud et le Sud-est Asiatique continental, l'industrie lithique dénommée "cobble-tool industry" a dominé dans le Pléistocène entier et persisté jusqu'au Holocène Moyen. Bien que ce terme a été utilisé pour longtemps afin de synthétiser les caractères des industries lithiques et de comparer les cultures Paléolithiques à l'échelle régionale, il ne s'agit que d'une description de la matière première n'indiquant aucune information essentielle technologique sur la production lithique. En conséquence, il devient

inefficace quand on compare les sites différents de la Chine du Sud et le Sud-est Asiatique continental parce que les deux régions se caractérisent toutes par la “cobble-tool industry” pendant la plupart de leur préhistoire. Ici, nous présentons les résultats analytiques d’une perspective technologique sur la collection lithique datée de 36-7ka de la grotte de Bailiandong, l’un des sites importants en Guangxi, le Sud de la Chine. Notre étude technologique a permit de mettre en évidence les chaînes opératoires de production lithique et les objectifs des taillieurs préhistoriques. Après la comparaison concise avec le Techno-complex Hoabinhian du Sud-est Asiatique continental, le doute depuis longtemps sur l’existence d’élément Hoabinhian dans ce site a été éliminé. Donc l’analyse technologique a véritablement permit de construire une base solide pour redéfinir la “cobble-tool industry” au Sud de la Chine et révéler les variabilités des industries lithiques à l’ échelle régionale plus grande. Nous espérons que l’application de cette approche aux plus de sites contribuera à la mise en lumière plus clairement du scénario technologique et culturel des humains préhistoriques du Sud de la Chine et de la region adjacente, l’Asie de Sud-est.

Mots-clés: Technologie lithique Grotte de Bailiandong Sud de la China Industrie sur galet Hoabinhien Asia du Sud-Est

1. Introduction

For a long time, the nature of the lithic industry in South China during the Pleistocene was attributed to “cobble-tool industry” by many researchers, which dominated the lithic assemblages for the entire Paleolithic period although core-and-flake industry did emerge for some time during the late Late Pleistocene in this large and diverse geographical area (Bar-Yosef and Wang 2012; Gao 2013; Qu et al. 2013; Zhang 1999). Literally, the “cobble-tool industry” implies that the raw materials used to produce tools are river cobbles or pebbles, however the technological information regarding the organization, structure and method applied on this type of raw material in the lithic production process is almost totally lost when using this term. Due to that cobble tools are usually studied with a typological method which aims at classification of tools rather than understanding the process of realization of tools and the real objectives of prehistoric knappers, thus the comparative study became difficult if not impossible between this region and the adjacent mainland Southeast Asia which is also a world of “cobble-tool industry” during the Paleolithic period (Forestier 2010; Forestier et al. 2017a, b; Li et al. 2019; Pawlik 2009; Zeitoun et al. 2008). Especially when the widely dispersed Hoabinhian techno-complex in Indochina is concerned (Forestier et al. 2017a; Moser 2001; Zeitoun et al. 2008), suspicion about its existence/absence in southern China such as Guangxi Zhuang Autonomous Region and Guangdong Province was aroused (Bowdler 2006; Dai 1988; Deng 1992; Trinh 1992; Zhang and Qiu 1998) because these regions are very close to northern Vietnam where Hoabinhian sites are abundant during the same time period (Chung 2008; Colani 1926, 1927, 1939; Forestier et al. 2017a; Ha Van 1992; Moser 2001; Zeitoun et al. 2008). Recent excavation and research suggested that Hoabinhian techno-complex may originate from the upper reaches of Mekong River in Yunnan Province of Southwest China since about 40 ka, as the discovery of Xiaodong Rockshelter indicated (Ji et al. 2016), and it was also present at some localities in the western border area of Yunnan (Collective 2017), which seemed to make South China the potential technological cradle for mainland Southeast Asia late Paleolithic cultures (Forestier et al. 2017a). However, the question of whether Hoabinhian techno-complex also expanded to Guangxi and Guangdong regions of southern China remains to be clarified (Li et al. 2019).

In fact, many cave sites which belong to the late Late Pleistocene to the Early Holocene (~40-8ka) were excavated in Guangxi, Guangdong and Hainan Provinces of southern China in the past three decades, among

which several yielded good stratigraphic sequence, dating results and abundant lithic assemblages, such as Bailiandong Cave (Jiang 2009), Liyuzui Rockshelter (He et al. 1983), Zengpiyan Cave (Collective 2003), Yahuaidong Cave (Xie et al. 2018a) in Guangxi, and Qingtang Cave (Liu 2019), Huangyandong Cave (Song et al. 1992), Niulandong Cave (Jing et al. 1998; Zhang et al. 2013), Dushizai Cave (Qiu et al. 1980, 1982) in Guangdong and Luobidong Cave (i.e. Luobi Cave) in Hainan Island (Hao and Huang 1998) (Fig.1). Some authors claimed that Sumatralith-like tools--the *index fossil* of Hoabinhian culture in the nearby region of northern Vietnam, also existed among these sites of southern China (Deng 1992; Zhang and Qiu 1998), yet arguments which were based on simplified morpho-typological comparison and the similarity of raw material failed to define each lithic assemblage and to differentiate between the lithic industries from the two regions. As a result, obscurity and ambiguity persists about the particularity of the lithic industry in southern China and their relationship with the Hoabinhian techno-complex in the nearby region of mainland Southeast Asia during this transitional period due to methodological difficult and the lack of technological analysis on the production of tools. So as one of the first steps towards construction of a reliable comparative work of "cobble-tool industry" between the two regions, we have chosen one of the most typical and important cave site, i.e. Bailiandong Cave in Guangxi of southern China dated to the late Late Pleistocene-Early Holocene transitional period and studied its lithic industry from a new technological perspective in order to represent the operative sequences and its system of lithic production, and thus to redefine the "cobble-tool industry" in southern China. After that, we will make a brief comparison of the lithic industry of Bailiandong Cave with Hoabinhian industry of Southeast Asia to determine the nature of lithic industry of the former and try to examine the cultural diversity and homogeneity of "cobble-tool industry" in regional scale.

2. Bailiandong Cave: site introduction

2.1 Geographic and geological background

Bailiandong Cave (24°12'54" N, 109 °25'37" E) is 12 km southeast of Liuzhou City (12 km to the city center), Guangxi Zhuang Autonomous Region and is 123m above sea level at the entrance of the cave (Fig. 1). The site is about 5km from Liujiang River, which is the main river in Liuzhou and is one of the upper reaches of Zhujiang (Pearl) River. Liuzhou City has a reputation for its widespread typical karst landscape; the peak-forest plain characterizes this area which is in fact a small karst basin. 77% of the landform is karst and the rest is non-karst hilly area. Current geomorphology of Liuzhou was generally formed in the early Late Pleistocene, with the intensification of crustal movement since the Late Pleistocene when the development of karst landform in this region was also intensified and large scale ancient underground rivers and water-eroded groove were developed. Bailiandong Cave was just formed as the result of the uplift of ancient underground river. During the transitional period from the late Late Pleistocene to the Early Holocene the water level of Liujiang River decreased because of climate changes, so the erosion force from river water declined. At the same time the first terrace of Liujiang River mainly composed of sub-sandy soil was formed. After that, Liuzhou Basin was completely formed (Jiang 2009). The cave is located on the southern slope of the "Baimian Mountain" (White Face Mountain) formed by limestone and dolostone of Carboniferous Maping Formation, the base of which was connected with Huguangyan hills in the north, forming one part of the peak-forest plains. There is a big lotus-shaped white stalactite in front of the cave entrance from which its Chinese name "Bailiandong" (White Lotus Cave) origins. The cave is part of a large multi-genesis karst system that contains five connected and integrated stacked caves with a total length of 1 870 m and an area of about 7 000 m^2. The main chamber of the cave system which has a length of 973.6 m can be divided into three levels linked to each other by diagonal corridors and the site of Bailiandong Cave is located on the third level and has a recessed rockshelter-like entrance facing south (Jiang 2009).

Fig. 1. Location of Bailiandong Cave site and other important sites mentioned in this paper (A: Spatial distribution of sites; B: Baimian Mountain; C: Entrance of Bailiandong Cave; D: Inside the cave)

Fig. 1. Localisation de la grotte de Bailiandong et les autres sites importants mentionnés dans le texte (A: Distribution spatiale des sites; B: Montagne de Baimian; C: Entrée de la grotte de Bailiandong; D: Dans la grotte de Bailiandong)

2.2 History of excavation and research

The cave site was discovered in 1953. It was reported that the entrance of the cave faced south and about 20m above the ground and there were many mollusk shells and some deer teeth in the hard deposits of the cave. In 1956, leaded by Pei Wenzhong and Jia Lanpo, the Southern Archaeological Team of IVPP (Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences) conducted a field survey aiming at searching *Giantopithecus* and human fossils in Guangxi. The local farmers guided them to Bailiandong Cave and they found four pieces of stone tools, one bone awl and one bone needle (Jia and Qiu 1960; Jiang 2009).

Several times of small-scale excavations took place in 1973, 1979 and 1980-1981 organized by Liuzhou Museum and formal excavation project was conducted by a jointed archaeological team between Beijing Natural History Museum and Liuzhou Museum in 1981-1982 (Yi et al. 1987). Several human teeth, more than 3550 pieces of mammalian fossils, some bone and antler tools, dozens of pottery sherds and more than 500 stone artifacts were unearthed from the site according to a comprehensive report published by Jiang (2009). On the basis of research on lithic typology, plant remains, absolute dating/biostratigraphy, human and animal remains, human subsistence, paleo-environment etc., researchers proposed that the sequence of Bailiandong Cave represented a consecutive prehistoric cultural development from the Late Paleolithic to the Mesolithic then to the Early Neolithic and it could be taken as a typical site in transition from the Paleolithic to the Neolithic in southern China (He and Tan 1985; Jiang 2009; Xie and Zhang 1987; Zhou 1986).

2.3 Stratigraphy and chronology

2.3.1 Stratigraphy

The Bailiandong Cave site has an area of cultural sediments of more than 150 m^2, in which were deposited with human and mammalian fossils and a large number of archaeological remains. In the main chamber of the cave, an extremely thick calcareous plate (i.e. “big flowstone”) was developed which extended completely from west to east, separating two units of sediments which were obviously different. The deposits under the plate was comprised of russety and tawny sediments yielding fossils of *Homo sapiens* and of *Ailuropoda-Stegodon* faunal complex of the Late Pleistocene; the deposits above the plate were made up of grey-yellow and grey sediments yielding lots of extant mammalian fossils and mollusc remains. Due to the influence of multi-geological action and anthropic disturbance, the deposits in Bailiandong Cave varied evidently in composition and change greatly both horizontally and vertically. In general two sets of deposits were concentrated respectively at the eastern and western sides of the cave (Jiang 2009; Yuan et al. 1995; Zhou 1986).

The eastern deposit was at a relatively higher level containing 8 layers from top to bottom (Fig. 2):

Fig. 2. Stratigraphy of east deposits of Bailiandong Cave site according to Yuan et al. (1995)

Fig. 2. Stratigraphie du dépôt à l’est de la grotte de Bailiandong d’après Yuan et al. (1995)

East 1(E1): grayish brown calcareous plate and carbonated clay loam, with a maximum thickness of 28 cm, containing mollusc, breccia and many potsherds.

East 2(E2): milky white calcareous plate, spreading widely in the chamber and covering the cultural remains

East 3(E3): gray yellow clay loam, 30-37 cm thick, containing much freshwater mollusc remains, mammalian fossils and polished stones, perforated cobbles, knapped stones, burned bones and charcoal fragments.

East 4(E4): tawny clay loam, with carbonated cementation of hard texture, 38 cm thick on average, containing much mollusc remains, mammalian fossils, edge-ground stones, knapped stones and charcoal fragments.

East 5(E5): offwhite calcareous plate, 1-4 cm thick.

East 6(E6): chocolate brown clay loam, 48 cm thick, on the top is relatively consolidated and concentrated mollusc remains, containing knapped stones, perforated cobbles, few breccia, charcoal fragments and few small brick red blockks.

East 7(E7): light tawny calcareous plate, 44 cm thick. It is integrated into the extremely thick calcareous plate which extends from west to east and is divided into three sub-layers. The upper part is light tawny and of compact texture, containing fragments of breccia and few iron manganese concretion; the middle part is comprised of brick red clay loam, loose in texture; the lower part is chocolate brown clay loam, comprised of pure calcite crystal, with pinch-out at two ends.

East 8(E8): russety clay loam, about 100 cm thick containing numbers of breccia ranging from 2-3 to 10 cm in diameter and yielding mammalian fossils and black flint fragments.

The western deposit is at a relatively lower level containing 10 layers from top to bottom:

West 1: grayish brown clay and clay loam containing mammalian fossils, knapped stone, perforated cobbles, some breccia, blockk on flint, mollusc remains and burned bones, 20-56 cm thick.

West 2: cream yellow calcareous plate, mingled with few mollusc remains and mammalian bones, about 40 cm thick.

West 3: light tawny calcareous plate, 15-35 cm thick, connecting with East 7 and forming the extremely thick calcareous plate which extends from west to east. Three sub-layers are identified. The middle and lower part are comprised of russety, closely cemented clay loam, yielding much mollusc remains, some bone fragments, few breccia, burned bones and blocks on flint.

West 4: light tawny calcareous plate, 50 cm thick. It is integrated into the extremely thick calcareous plate which extends from west to east and is divided into three sub-layers. The middle part is comprised of red brown, closely cemented clay loam containing some breccia, fragments of calcareous plate, few iron manganese concretion, fragments of mammalian fossils and few mollusc remains. The lower part is comprised of tawny clay loam, containing many fragments of mammalian fossils, mollusc, breccia (the biggest one is more than 50 cm long), knapped stone (including many artifacts on black flint). Some charcoal fragments are present in the sediments.

West 5: russety clay loam, 30-55 cm thick, containing few breccia, fragments of calcareous plate, mammalian fossils, knapped stone including some black flints).

West 6: pale yellow calcareous plate, 10 cm thick.

West 7: tawny clay loam, loose in texture, 18 cm thick, containing breccia of different size, a very few iron manganese concretion, some mammalian fossils, knapped stone and human teeth.

West 8: gray yellow calcareous plate, 10 cm thick.

West 9: chocolate brown clay loam, 12 cm thick.

West 10: cream yellow calcareous plate, mingled with clay, yielding occasionally some fossil fragments. This layer has not reached the bedrock of the cave.

2.3.1 Chronology

Bio-stratigraphic analysis indicated that the deposits of the Bailiandong Cave could be divided into two complexes; the one deposited over the extremely thick calcareous plate could be attributed to the Early Holocene and the other buried under the plate to the Late Pleistocene (Jiang 2009; Zhou 1986).

Several times of dating work, including ^{14}C dating and U-series dating analysis had been conducted on the cave sediments. In early 1990s, the first conventional ^{14}C dating results were published by the ^{14}C dating laboratory of Beijing University, indicating that the deposits from the west side of the cave were dated at ca. 36 ka-20 ka, and the calcite from East 7 layer was dated to 11 670±150 years. (Yuan 1990a; Yuan et al. b, 1995).

However, researchers were very skeptical about the dating results because of some doubts on the nature of the sample from the East 7. So new fieldwork and laboratory work were conducted to determine the stratigraphy and chronology of the site. A series of AMS ^{14}C dating results were thus provided by Yuan et al. (1995). New research also showed that the age of the sediments from East 7 should be 19090±200 years and previous sample (dated 11 670±150 years) was in fact secondary deposits from a younger period (Yuan et al. 1995). So combined with previous U-series dating on 2 bone fossils and conventional ^{14}C dating results obtained in 1990, a new chronological framework of 36 000-7 000 years for the site was established (Jiang 2009) (Table 1).

Table 1

Dating results of Bailiandong Cave site

Tableau 1

Résultats de datation de la grotte de Bailiandong

To conclude, current dating data suggest a time range between 36 000 and 7 000 years ago (about the late Late Pleistocene to the Early Holocene) for the cultural deposits of the site, which corresponds well with the age of bio-stratigraphy and can be used as a time framework for human activities in this cave (Jiang 2009).

2.4 Cultural and animal remains and human fossils

Cultural remains contain 500 pieces of lithic artifacts, including hammer stones, choppers, flakes, scrapers, points, cores, debris, polished stone tools, donuts, grinding stones, perforated stones, 2 pieces of bone and antler tools, 12 pottery fragments, and 2 fireplaces. Raw materials of the stone assemblage include silex, quartzite, sandstone, silty metamorphic, diabase, quartz diorite and siliceous rock etc. (Jiang 2009).

The animal remains unearthed at the Bailiandong Cave were generally composed of mammals (23 species), mollusk (5 species), fish (2 species), amphibian (1 species), terrapin (1 species) and avifauna (undetermined). The mammalian remains were separated into two complexes by the thick calcareous plate; one deposited above the plate was attributed to "extant faunal complex" including 15 species, such as *Rhizomys sp.*, *Vespertilionidae gen.* et *sp. Indet., Macaca sp., Sus scrofa, Bubalus sp., Pseudaxis sp., Muntiacus sp., Cervus sp., Ovis sp., Paguma larvata, Rhinopithecus sp., Martes sp., Muridae indet., Vulpes cf. vulgaris and Lijiangocerus speciosus*, and the other deposited under the plate was attributed to "*Ailuropoda-Stegodon* faunal complex" of the Late Pleistocene, which included, in addition to 9 species identical to those deposited above the plate, *Hystrix subcristata, Ursus sp., Arctonyx collaris, Ailuropoda melanoleuca, Stegodon sp., Elephas sp., Rusa unicolor and Rhinoceros sinensis*.

Two well fossilized human teeth were unearthed in the layer of West 7; one was left lower third molar, and the other was right lower third molar. Except a very few archaic features, these teeth had no obvious difference from modern human teeth, so they were both attributed to *Homo sapiens sapiens* (i.e. Anatomically Modern Human) (Jiang 2009).

3. Accessibility of lithic material and its chrono-stratigraphic context

Since the lithic materials of Bailiandong Cave site have already been studied from a typological perspective by previous researchers (Jiang 2009; Yi et al. 1987), here we only focus on the chipped stones by using technological approach without consideration on those polished stones and non-cutting edge tools and just present their general characters in the lithic industry where necessary.

The lithic collection which was accessible to us are stored in the Bailiandong Cave Site Museum where we observed 403 pieces in total (not including those non-cutting edge tools and polished ones) because of the long time and limited conservation conditions in the local Museum, some of the stone artifacts were lost, while others are stored in other institutions and thus not accessible for study at the moment. During the observation, we found 2 broken flakes (in fact it was one flake broken into 2 pieces) coming from different layers (BLES③:172，BLES⑥:177) could be joined, which may suggest a possibility of stratigraphy mixing when excavation.

It's true that these lithic artifacts come from different layers of the site, however due to limited number of artifacts, the possibility of stratigraphic disturbance and some of the lithic collection in the local Museum we have observed had lost their original precise stratigraphic information, we were not able to study these stone artifacts layer by layer in a detailed way. Therefore we executed our analysis principally in a macro-scope perspective. In this sense the previous chronological framework was refined and the sequence was re-divided into 2 units according to their location with respect to the thick calcareous plate (i.e. big flow stone) in the main chamber of the cave: the upper unit which was above the calcareous plate and the lower unit below the plate. Correspondingly, the ages of the lithic artifacts we studied were specified by consulting previous dating results and the stratigraphic contexts that they belong to; the chipped stone artifacts from the lower unit have an age range from 36 000 to 20 000 years BP, while those of upper unit from 14 500 to 9 000 years BP.

4. Lithic technology

As for lithic assemblage of Bailiandong Cave, a systematic quantitative analysis was impossible because of the relatively small amount of specimens and the presence of a large proportion of broken blocks and debris which couldn't provide useful technological information. So we conducted here qualitative technological analysis on this lithic collection according to their stratigraphic units (i.e. the re-arranged lower unit and upper unit) so as to determine its operative sequences, i.e. *chaîne opératoires,* volumetric structures and the objectives of lithic production.

The total lithic assemblage of Bailiandong Cave site was classified into different categories. Generally, both *débitage* (flaking) and *façonnage* (shaping) products were present in the lower and upper units; quantitatively, *débitage* could have been the major technical strategy adopted by the prehistoric knappers in the lower unit, *façonnage* seemed to be less important; while in the upper unit, *façonnage* had a substantial role to play, but *débitage* still had an important place in the lithic assemblage (Table 2). As for the raw material exploited, they were river cobbles from the terrace of Liujiang River and silex nodules from outcrop which were 3-5km from the site; specifically, silex nodules dominated in the lower unit while in contrast it was very rare in the upper unit, however the majority of them were broken blocks and debris which made it difficult to evaluate their real importance when conducting quantitative analysis. Other common raw materials are quartz, sandstone, siliceous stone and metamorphic rock; raw materials used in the upper unit were much varied than those of

the lower unit (Fig. 3).

Table 2
Composition of lithic assemblage from the Bailiandong Cave Site Museum
Tableau 2
Composition de collection lithique du Musée de la grotte de Bailiandong

Fig. 3. Raw material composition of the lithic industry of Bailiandong Cave
Fig. 3. Composition de la matière première de l'industrie lithique de la grotte de Bailiandong

4.1 Cores: morphology, volumetric structure and method of débitage

In total, four types of cores which have different morphology and volumetric structures were selected and exploited (Fig. 4). All the cores were cobbles or silex nodules, to which no intentional initialization or preparation was applied to transform their original morphology and structure for flaking to obtain desired blanks, instead, the initialization consists of selecting natural technical characters on cobbles and blocks for further reduction such as suitable striking platform and flaking surface providing good lateral and distal convexity. So during such initialization, selecting raw material is very important and that's why the volumetric structure of the block chosen should be studied firstly. Generally, only a small volume of the core was exploited and the core *sensu stricto* (the exploited part of the cobble or block) of each type had similar volumetric structure, while the morphology of the unexploited part could be very diverse. Usually prehistoric knappers would search for the exploitable volume on the block until they couldn't extract useful flakes, then the rest of the block would be discarded or transformed into tools. The morphology of flakes obtained was thus very varied, which could be big or small, thin or thick. The technique applied for knapping was direct internal percussion with a hard hammerstone.

Fig. 4. Morphology and volumetric structure of the raw material selected as cores
(A, C. cobbles or silex nodules, B, D. cobbles)
Fig. 4. Morphologie et structure volumetrique de la matière première selectionnée comme nucléus
(A, C. galets ou nodules de silex, B, D. galets)

Type 1 (n=10): this type of core was the mostly exploited at the site. Although their morphology varies, structurally they present a general cube configuration (Fig. 4: A). The useful volume of the cube as a core is on its periphery wherever there is suitable flaking surface (surface of débitage), striking platform and angle. Usually, there were more than one platform and no preparation of striking platform and flaking surface, that is to say, prehistoric knappers kept changing the platform and flaking surface to find the useful volume on the periphery which was naturally present on the block; the methods of flaking could be mainly unidirectional (Fig. 5, 7, 8), or rarely bidirectional (Fig. 6). The morphology of flakes obtained was very unstable, including elongated, wide, triangular, quadrangular flakes and rare blades. Technologically, the majority of flakes have a butt with natural cortex and the direction of negatives on the dorsal face of flakes contain several patterns such as unipolar, bipolar, and the dorsal face usually has the residue of cortex while sometimes could be all negatives.

Fig. 5. Photo and diacritic diagram of core type 1 (Unidirectional method)
Fig. 5. Photo et schéma diacritique de nucléus type 1 (Méthode unidirectionnelle)

Fig. 6. Photo and diacritic diagram of core type 1 (Unidirectional and bidirectional method)
Fig. 6. Photo et schéma diacritique de nucléus type 1 (Méthode unidirectionnelle et bidirectionnelle)

Fig. 7. Photo and diacritic diagram of core type 1 (Unidirectional method)
Fig. 7. Photo et schéma diacritique de nucléus type 1 (Méthode unidirectionnelle)

Fig. 8. Photo and diacritic diagram of core type 1 (Unidirectional method)
Fig. 8. Photo et schéma diacritique de nucléus type 1 (Méthode unidirectionnelle)

Type 2 (n=1): although only one piece was discovered, it could represent a different morphology and structure type (Fig 4: B). The raw material was a big ovoid and spheric cobble (97×72×61mm, 419g, quartz), from which two series of reduction were produced by a method of algorithm (Forestier 1993). Within each series the method of flaking was recurrent unidirectional, each yielding 3 flakes (Fig. 9). The morphology of flakes thus obtained was relatively wide, and they contained full or partial cortex on dorsal face.

Fig. 9. Photo and diacritic diagram of core type 2 (Algorithm method)
Fig. 9. Photo et schéma diacritique de nucléus type 2 (Méthode de l'algorithme)

Type 3 (n=6): the speciality of this type lays in that the core (river cobble or silex nodule) presents a general plano-convex volumetric structure (Fig. 4: C). Usually, the plane surface was used as striking platform and the convex as flaking surface, but occasionally the two surfaces changed their roles. This special structure could provide knappers with excellent part(s) of useful volume on the periphery where the two surfaces intersect, without need for preparing the flaking surface, and the suitable angle for knapping was the main concerns for knappers during the reduction. Recurrent unidirectional flaking method dominated the process of débitage (Fig. 10, 11). From this type of core some flakes could be very distinguishing, for example the flake whose periphery on its dorsal face is circled with cortex could be produced with a unidirectional flaking method. Other flakes didn't present special morphology or characteristic; they were usually thin and had cortex on the dorsal face, and thick flakes could also be produced if the internal percussion technique drew back too far of the striking point from the periphery of block.

Fig. 10. Photo and diacritic diagram of core type 3 (Unidirectional method)
Fig. 10. Photo et schéma diacritique de nucléus type 3 (Méthode unidirectionnelle)

Fig. 11. Photo and diacritic diagram of core type 3 (Unidirectional method,)
Fig. 11. Photo et schéma diacritique de nucléus type 3 (Méthode unidrectionnelle)

Type 4 (n=2): this type of core has a special volumetric structure which is highly integrated (Fig. 4: D). The useful volume of core equals the totally natural cobble. The raw material selected was flattish ovoid cobble, and bipolar method was used to split it on an anvil into two half-cobble blanks, which could be used to make different tools as the knappers desired. The cutting edge of denticulate or rectilinear morphology could be obtained in this case (Fig. 12).

Fig. 12. Drawing of tools with the blank of split cobbles from core type 4 and the schematic representation of the bipolar method
Fig. 12. Dessins des outils sur les supports de semi-galets d'origine du nucléus type 4 et la répresentation schématique de la méthode bipolaire

To conclude, the organization and management of core reduction in Bailiandong Cave were mainly based on the idea of selecting of raw materials which naturally presented all the required technological criteria for successful flaking such as the distal and lateral convexity of the flaking surface. Generally there were 2-3 series of reduction on each piece of core and no preparation had been conducted for the artificial configuration of core, which produced predetermined and predetermining flakes at the same time. Most of the cores were retouched or transformed into tools (13 among 19 pieces) after débitage. Core type 1 and 3 were the most common ones, and they appeared in both lower and upper units of the site, and their quantity is relatively even in the two units. However, type 2 was rare and discovered only in the upper unit; type 4 contained 2 pieces and they were both from the lower unit. Overall, although there were minor changes in core types from the lower unit to the upper unit, stability in both core types and the idea of organization and management of core reduction in the sequence seemed to be apparent. The flakes obtained could have various morphology and usually had cortex on their dorsal face, which seems to indicate that no standardization of flake blanks existed during core reduction. As far as raw material is concerned, silex (nodule) was extensively used for débitage but never for façonnage, while cobbles were exploited for both débitage and façonnage as we can see below.

4.2 Shaped cobble tools

This type of tools refers to those end products made of cobbles and resulting from the concept of façonnage. In the occasion of Bailiandong Cave, shaping process was very short and concise aiming at creating a simple-bevel or rarely double-bevel structure on the end or side of a cobble, or sometimes at producing a special morpho-structure of the bevel (dihedral cross-section of the cutting-edge). According to the location of cutting-edge and the morpho-structure of the bevel, different types of choppers could be distinguished such as end chopper, double-chopper, side chopper, chopper of special volumetric structure etc. (see Table 1). Prehistoric knappers seem to have well foreseen the desired tool types when choosing the raw material, the structure of shaped tool was largely integrated into the original volume of cobble, that is to say, they preferred spending more effort on searching for the appropriate cobble which satisfied their intention and required less effort on shaping work. As a result, shaping was merely to create the bevel (dihedral cross-section) for further

cutting edge (see Fig. 13), and the prehensive part of the tool remained usually unmodified. As for the cutting edge, different technological requirements of knappers were manifested by different technical characters of cutting-edge such as its morphology, angle and position. Generally, retouch on the cutting edge was not so regular nor intensive.

Fig 13. Schematic representations on the different morpho-structures of choppers at Bailiandong Cave
(Red line: location of the cutting edge)
Fig. 13. Répresentations schématiques sur les différentes morpho-structures de choppers à la grotte de Bailiandong
(Ligne rouge: localisation du tranchant)

4.2.1 Typical end chopper (n=16)

This type of chopper has its transversal cutting edge on the distal end of cobble. The cutting edges themselves are varied as their morphology and angle change. The raw material selected were medium-sized river cobbles (132 mm long, 63mm wide, 39mm thick, >300g weight in average) of different lithology, whose original morphology was very diverse, such as triangle, oblong, oval and trapezoidal. The transversal section of the cobble presents mainly two different kinds of contour: quadrangular one (two parallel surfaces) and triangle one (plano-convex surfaces). In these two surfaces usually the plane one was used as striking platform for shaping (unidirectional knapping), resulting in a simple-bevel structure on which would form the further cutting edge. After the creation of bevel, sometimes the cutting edge came into being directly, sometimes retouch could happen, however it was usually simple. Among this type of choppers, different techno-types could be identified on the basis of the significant variability presented by the transformative unit of tool (i.e. the part directly contacted with the materials). The contour of cutting edge on front view could be rectilinear, convergent-point, concave, and the angle of cutting edge varies from 50 to100° to meet the needs of a variety of activities (Fig. 14).

Fig. 14. Typical end chopper from Bailiandong Cave
(Cutting edge: 1, 2: convergent-point; 3, 5-7, 9: rectilinear; 4, 8: concave)
Fig. 14. Chopper typique à tranchant transversal de la grotte de Bailiandong
(Tranchant: 1, 2: convergent-pointe; 3, 5-7, 9: rectilinéaire; 4, 8: concave)

4.2.2 End chopper with an abrupt front (n=4)

This type of chopper is different from the typical end chopper because they usually have a very abrupt front. Cutting edge is also on the end of cobble, but it is generally more than 90°. The raw material chosen was relatively big and thick cobble (average weight >500g), which often possesses triangle or irregular morphology on front view with a bi-convex but asymmetric transversal section. The knappers usually use the less convex surface as working platform, with successive unidirectional knapping towards the other surface, in which way an abrupt front (or simple-bevel) at one end of the cobble would be obtained. Retouch seems to be used to make the cutting-edge more obtuse (>90-100°). Choppers of this kind often exhibit many traces of percussion on the surface and periphery of its body (Fig. 15).

Fig. 15. End chopper with an abrupt front from Bailiandong Cave
Fig. 15. Chopper à front abrupt de la grotte de Bailiandong

4.2.3 Double-chopper (n=2)

Chopper of this type contains two cutting edges on the opposite ends of cobble separately (Fig. 16). Its difference with previous chopper is not obvious except the latter has only one cutting edge on the distal end of cobble. This type of chopper does present some interesting characteristics. The raw materials chosen are big and heavy river cobbles (74×64×49mm, 338g; 92×82×51mm, 606g) of quartzite and quartz sandstone, and its morphology is a little elongated and the two sides are generally parallel; the section is nearly oblong. One of the two specimens contains a double-bevel on the proximal end of cobble (Fig. 16:1), other cutting edges are on abrupt simple-bevel obtained by unidirectional knapping method. After the creation of the abrupt simple-bevel, only minimum retouch was carried out. The angle of cutting edge on two ends of cobble is 90° or more, so it's difficult to tell the intention of knappers for the abrupt bevels and the obtuse angle of "cutting edge".

Fig. 16. Double-chopper from Bailiandong Cave
Fig. 16. Chopper double de la grotte de Bailiandong

4.2.4 Side chopper (n=2)

There are only 2 pieces of this type, whose cutting edge is on the side rather than on the end of cobble. Cobble chosen were elongated with two parallel or plano-convex surfaces and the plane surface was used as striking platform. They also have a simple-bevel structure on which forms the cutting edge as those we have seen in end chopper. There is no essential difference between these two types of choppers except the position of cutting edge. The cutting edge is rectilinear on front view and the angle of cutting edge is about 60-80° (Fig. 17-1).

4.2.5 Special side chopper (n=4)

This type of chopper was made of ovoid cobble with two convex surfaces, in which one was more convex than the other. Shaping was usually conducted on one side of the cobble from the less convex surface (used as striking platform) to convex one. It has objective to create a simple-bevel *sensu lato* and a stage of retouch clearly existed to transform the angle, contour and dihedral cross-section of cutting-edge. Due to the presence of convex surface the cutting edge is more or less curved in transversal view which makes it different from previously mentioned side chopper. The cutting edge has concave, denticulate or convex contour in front view and its angle is generally about 60-70° (Fig. 17:2, 3).

4.2.6 Chopper of special volumetric structure (n=4)

This type of chopper has a quite different volumetric structure compared with previous types. The raw material is one kind of cobble of medium size (95×65×47mm in average) whose section is plano-convex. The shaping also took place on distal end of cobble. What makes it totally different is that, unlike end chopper makers who utilized the plane surface as working platform, these knappers used the convex surface as working platform and thus obtained a special volumetric structure with a triangle section in the distal and middle part instead of a typical simple-bevel (Fig. 13: D). Retouch was also conducted on this type of tool, but usually only a very short cutting edge with an angle of about 80° was obtained (Fig. 17:4, 5).

Fig. 17. Different types of choppers from Bailiandong Cave
（1: Side chopper; 2, 3: Special side chopper; 4, 5: Chopper of special volumetric structure)
Fig. 17. Different types de choppers de la grotte de Bailiandong
(1: Chopper à tranchant longitudinal; 2, 3: Chopper à tranchant longitudinal spécial; 4, 5: Chopper à structure volumétrique spéciale)

4.2.7 Chopper with a plane front (n=1)

The transformative part of this type of chopper was on one end of cobble with a plane front. The cobble chosen was elongated and had a square transversal section (quartz sandstone, 96×66×58mm, 557g). The shaping happened at one end of the cobble and the knapper kept changing striking platform and direction of knapping, aiming at producing a plane front. After that, no obvious retouch was conducted. It seems that the prehistoric knappers wanted a plane front rather than a sharp cutting edge, which made it a different tool type (Fig. 18).

Fig. 18. Chopper with a plane front from Bailiandong Cave
Fig. 18. Chopper à front plat de la grotte de Bailiandong

4.2.8 Shaped disc (n=1)

This is a special and fortuitous type, since only one specimen was discovered from the site. Its specialty lies in that the cobble was centripetally worked from its periphery resulting in a disc-like shaped product. The raw material exploited was a very big and thick oval cobble of plano-convex structure (>89×67×53mm, 420g, quartz sandstone). The plane surface was used as striking platform and the knapper kept working on the whole periphery of cobble to produce a special product of shaping, i.e. a thick “disc” with trapezoidal section and profile. The edge along its new periphery is very abrupt (mostly >90°) and only a small part has an angle of 75° (Fig. 19), which could serve as cutting edge. It’s difficult to explain the existence of this tool because its peripheral “cutting edge” was too obtuse for cutting. This tool was ever suspected to be a sumatralith-like tool of Hoabinhian culture in southeastern Asia (Jiang 2009). Morphologically, they are similar in some aspects but technologically their structures are so markedly different that they should not be taken as an identical tool from the operational sequences (see below for detailed discussion).

Fig.19. Shaped disc from Bailiandong Cave
Fig. 19. Disque façonné de la grotte de Bailiandong

4.3 Flakes and flake tools

There are 200 pieces of flakes and flake tools in total, among which 51 pieces from the upper unit and 149 from the lower unit. However, more than half of the flakes didn’t provide clear technological information for us

to judge the techno-types of flakes. Based on the relative intact flakes we distinguished 4 main techno-types of flakes (45 pieces from upper unit, and 46 from lower unit) according to our technological reading on the direction, extent and order of negatives on the dorsal face of flakes (Fig. 20):

Techno-type 1: flake having no negative on their dorsal face, so it is the "first" flake detached from the cobble or block.

Techno-type 2: flake having one or more negatives on the dorsal face with the same direction as that of the flake itself. The butt is often cortical. The cortex can also be seen on dorsal face, which can be on the peripheral or distal part of the flake, sometimes on the whole periphery or most part of the periphery (Fig.20-2a). This sub-type of flake was called "*Bailiandong flake*" by Chinese researchers because it was thought to be a special character of flakes in this cave compared with other cave sites in southern China (Jiang 2009), while it could be obtained during both débitage of cores and façonnage of cobble tools (example: shaped cobble tool with a special volumetric structure could have produced this techno-type of flakes during shaping).

Techno-type 3: flake having no cortex on their dorsal face, which is full of unipolar negatives compared with the direction of the flake itself.

Techno-type 4: flake having negatives on their dorsal face with different direction from that of the flake itself (i.e. convergent or oblique).

Fig. 20. Techno-types of the flakes at Bailiandong Cave site
(Note : negative(s) on the dorsal face was (were) removed earlier than the flake itself)
Fig. 20. Techno-types des éclats de la grotte de Bailiandong
(Note: négatvie(s) sur la face supérieure d'éclat était(étaient) débité(s) plus tôt que l'éclat lui-même)

Quantitative analysis shows that the trend of distribution of different techno-types of flakes is similar from lower unit to upper unit, except techno-type 3 which is much more numerous in the lower unit because the raw material of this type i.e. silex dominated in this unit but was rarely present in the upper one. So generally, the pattern of flaking in both units is similar. Technologically, these flakes could come from both façonnage and débitage processes which were attributed to two different chaîne opératoires.

As for flake tools, 68 pieces show traces of utilization or retouch, among which 39 pieces from lower unit and 29 from upper unit. Structurally, these flake tools could be divided into two categories: the first category was made on big and thick flakes, and most importantly they have a simple-bevel structure like end choppers; the second category has no simple-bevel structure, in which several techno-types can be easily differentiated according to the existence or no of back on the flake and their general morphology. In total, 12 techno-types of flake tools were identified according to their morpho-structural characteristics (Fig. 21). A variety of cutting edges were realized on different blanks, including denticulate, point, rectilinear, convergent, beak, convex, concave, rostrum etc. (Fig. 22). The retouch was conducted on some of the flakes to get the desired tools, and sometimes more than two cutting edges were made on one blank. The angle of cutting edge ranges from 20 to 80°, while the majority are about 50-60°. The idea behind the selection of flakes as tool blanks was mainly to choose those flakes with a relatively thick back which became the further prehensive part of the tool. The backed flakes generally possessing cortex dominated the tool types in both lower and upper units and they were usually directly obtained during production with a certain degree of predetermination. Both débitage and façonnage could result in this kind of flake (including the so-called *Bailiandong flake,* see the techno-type 2a of flakes), which indicated that the knapper may apply a free and flexible strategy for selecting flakes as tool blank to meet their needs.

Fig. 21. Morpho-structural types of flake tools at Bailiandong Cave
(Red line indicates the location of cutting edge)
Fig. 21. Types morpho-structurels des outils sur éclats de la grotte de Bailiandong
(Ligne rouge indique la localisation du tranchant)

Fig. 22. Flake tools at Bailiandong Cave
(Note: grey color indicates the ventral face of flake)
Fig. 22. Outils sur éclats de la grotte de Bailiandong
(Note: couleur grise indique la face inférieure d'éclat)

4.4 Others

Many broken blocks and debris of silex were found from the lower unit, which could indicate that knapping activities ever happened at the cave. There are also several pieces from which we couldn't extract technological information because their negatives were heavily wrapped by carbonates. Except the chipped stone artefacts, there are also a few polished stones tools, donuts, grinding stone (with ochre remains on it), perforated stones, antler point and antler spade tools (Fig. 23). The partial polished cobble tool (on cutting edge, BLWS④:57) first appeared in the lower unit at around 20ka, and fully polished cutters were found in the upper unit. This possibly indicates that Bailiandong Cave witnessed the development of polished stone tool industry in a time period when knapped stone tools coexisted with it and dominated the whole lithic assemblage. Bone and antler tools with sharp ends might have been an important composition of the whole tool kit of the inhabitants of Bailiandong Cave. Donut tools and perforated stones should manifest other types of activities, while grinding stone with ochre stigma might bear some social and religious information which means that human behavior tended to be more complex in the later period of occupation.

Fig. 23. Other tools at Bailiandong Cave
(1,7: donut stone; 2: partial polished tool; 3: fully polished tool; 4: antler point; 5: antler spade; 6: special perforated stone; 7: grinding stone with ochre traces on it)
Fig. 23. Autres outils de la grotte de Bailiandong
(1,7: pierre perforée; 2: outil partialement poli; 3: outil entièrement poli; 4: pointe en bois de cerf; 5: spatule en bois de cerf; 6: pierre perforée spéciale; 7: galet à broyage avec des traces d'ocre)

4.5 Synthesis of lithic industry of Bailiandong Cave

After our technological analysis on cores, shaped tools and flakes, the characteristics of the lithic industry of Bailiangdong Cave could be summarized as follows:

First of all, although there are four types of volumetric structure of cores, the idea behind the organization of reduction is very similar. The strategy of exploitation of cores is to fully take advantage of the natural useful volume for flaking without preparation and the stage of initialization is to select raw material of river cobbles or blocks (mainly silex nodules from outcrop) which have suitable striking platform and surface of débitage. Once the useful part is exploited, the rest of core will be abandoned or transformed into tools. Several methods of flaking were applied such as unidirectional, bidirectional and algorithm. Sometimes prehistoric knappers frequently changed striking platform to get favorable volume on the core and thus several (usually 2-3) series of reduction could be identified and each series was relatively independent. The flakes resulting from débitage are not standardized in morphology and often contain cortex on dorsal face and butt which could serve as the

back of further tool. As we can see in the flake tools, backed flake tools have an important role in the stone tool composition, which seems to indicate that the existence or no of a back on flake could be one important technical character that the knapper searched for.

Secondly, the concept of façonnage (shaping) is very stable considering that "simple-bevel" choppers dominated the shaped cobble tools in both upper and lower units of the site. However the appearance of several special shaped tool types, i.e. chopper of special volumetric structure, chopper with a plane front and shaped disc, could represent new technological needs in the later period of prehistoric human's occupation at the site. Generally, all the different types of shaped tools suffered a very short and concise knapping process which aimed at creating the transformative part of tools rather than structuralizing of the total body of cobble and the prehensive part of the shaped tool usually remains unmodified. Put another way, the final volumetric structure of tools was partially integrated into the original morphology and structure of raw material.

Thirdly, the management of raw material seems to have existed to some extent because prehistoric knappers managed to make different types of shaped tools according to different cobble morphology and structure. This could be seen clearly in different types of choppers and in the exploitation of silex which was not used in façonnage but exclusively in débitage in the lower unit. So, the organization of chaîne operatoire on the basis of raw material did exist at the site if not strictly followed by prehistoric knappers.

Fourthly, the concepts for producing uniface or biface *sensu stricto* do not exist at this site. The unifacial shaping was applied only to get simple-bevel tools. Retouch is not a compulsory stage to realize the cutting edge because sometimes the shaping of simple-bevel brings at the same time a suitable dihedral cross-section of utilizable cutting edge. However, the angle of cutting edge of shaped cobble tools is often larger than 60°.

Fifthly, although they are only in very small quantity, the tools made on bone and antler might be an important composition of the whole tool kit considering that the flake tools with sharp ends and heavy shaped cobble tools with point are quite rare. Other lithic tools such as donut stones are only found in the upper unit which means that new technical activities might have appeared from then on. The early presence of partial polished tool in the lower unit and the intensification of polishing on the whole body of tool in the upper unit should be an evidence of the gradual establishment of a new type of lithic technological system which coexisted with chipped stone tools for more than 10 000 years at the site.

At last, there are both similarities and differences of lithic technology in the lower and upper units. On the one hand, débitage and façonnage coexisted in the two units, which could be complementary technical solutions for a variety of subsistence activities; on the other hand, some differences did exist between the two units; the concept of débitage seems to be more important in the lower unit, although façonnage was also present; while in the upper unit cobble tools resulting from the concept of façonnage have a higher proportion but flakes tools and cores are numerous as well; there are more techno-types of shaped cobble tool in the upper unit than in the lower unit. Overall, technologically the tradition of lithic industry in the lower unit continued to exist in the upper unit to some extent, while the whole technological system in the upper unit seems much more complex, developed and diverse due to presence of different shaped tools, bone and antler tools, donuts and fully polished tools.

5. Discussion and conclusion

Although the relative small number of artefacts and the macro-stratigraphic division of two units of the site make a quantitative analysis less meaningful, technological analysis from a qualitative point of view did yield new insights about the lithic technology of Bailiandong Cave from the late Late Pleistocene to the Early Holocene. Unlike previous researches which defined the lithic industry of Bailiandong Cave as small flake-tool industry in the lower unit and large cobble-tool industry in the upper unit and the conclusion that a significant change in

lithic production took place from lower to upper units (Jiang 2009; Wang 2005, 2016; Zhou and He 2016), our technological analysis has revealed that the nature and characteristics of lithic industries could be much more complex than previously perceived and we prefer not to take the flake-tool industry as an isolated technological phenomenon but one coexisting with shaped cobble tools during this period at Bailiandong Cave site. The coexistence of two concepts (i.e. débitage and façonnage) and associated products is possibly a regional fact in southern China as some authors recently claimed (Xie et al. 2018b). It's true that river cobble was an important source of raw material for prehistoric knappers in southern China, but diverse chaîne opératoires could be applied on them including débitage and façonnage, and more specific operative sequences, as shown by 4 types of cores and several different structures of shaped cobble tools, have also been employed in tools production. So this analysis provides us with a much more complex image about the technical behavior of prehistoric human exploiting the cobble materials. In this sense we need to further question the real meaning of "cobble-tool industry" if not abandon it, since it doesn't and can't give us clear information about lithic production but only a descriptive term of raw material. It also renders comparative study difficult on a regional scale especially within southern China and the neighboring mainland Southeast Asia where river cobble was also frequently used during the late Late Pleistocene to the Early Holocene (Forestier 2010; Forestier et al. 2017a, b; Li et al. 2019; Pawlik 2009; White 2011; Zeitoun et al. 2008). A technological perspective appears to be an efficient and concise way to clarify the ambiguity surrounding the so-called "cobble-tool industry" as indicated by detailed technological analysis on Hoabinhian techno-complex in Southeast Asia during the past 20 years (Forestier 2000, 2010; Forestier et al. 2015, 2017a; Forestier and Zeitoun 2005; Zeitoun et al. 2008). Therefore, our analysis not only represents the first steps towards the comparative study in southern China where technological analysis has just taken initial step (Li et al. 2019; Zhou et al. in review) but also contributes to the comparison of lithic industries between southern China and Southeast Asia.

In light of our technological analysis on the lithic industry of Bailiandong Cave, the possibility of the existence of Hoabinhian techno-complex at the site could be excluded, so the previous suspicion about the sumatralith-like tools in this assemblage based on some morphological similarities with real sumatralith in mainland Southeast Asia could be clarified. As previously summarized, the lithic industry of Bailiandong contains products of both débitage and façonange; although unifacial shaping was practiced on all types of choppers, yet there is no real uniface (sumatralith in this context) in the lithic assemblage and the split cobble tools are also very rare (tools made on half-cobble blanks which are obtained by a bipolar method to split the cobble into two half-cobbles on an anvil or not); in contrast, Hoabinhian industry is characterized by the presence of three main chaîne opératoires (operational sequences): uniface (sumatralith) usually coexists with numerous split cobble tools and choppers as we have seen at the typical Hoabinhian site of Lang Spean Cave in Cambodia (Forestier et al. 2015, 2017a; Forestier and Zeitoun 2005; Zeitoun et al. 2008). However, the potential existence or not of Hoabinhian in Southern China can be verified only by extensive analysis and comparison on the basis of the same technological criteria. To answer this question, the main authors of this paper (Yinghua Li and Yuduan Zhou) have conducted a quick examination on the lithic collections of some important cave sites from southern China which yielded relatively solid stratigraphy and reliable age (from the late Late Pleistocene to the Early Holocene), including Liyuzui Rockshelter (He et al. 1983), Zengpiyan Cave (Collective 2003), Yahuaidong Cave (Xie et al. 2018a) in Guangxi, Huangyandong Cave (Song et al. 1983, 1992), Huangmenyan Cave 2 (Qingtang site) (Deng et al. 2019; Liu 2019), Dushizai (Qiu et al. 1982) and Niulandong Cave (Jing et al. 1998; Zhang et al. 2013) in Guangdong, and Luobi Cave in Hainan Island (Hao and Huang 1998; Li et al. 2019) (Fig. 1). It was indicated that they all lack critical facies of Hoabinhian techno-complex and some of them seem to be more close to that of Bailaindong lithic industry, while other sites look like close to the so-called "Son Vi culture" (Nguyen 1994) in Northern Vietnam which is characterized by the presence of abrupt side-chopper with obtuse

angle and coexisted with shell tools. However, for the time being our quick examination of concerned lithic assemblages in southern China just represents a macroscopic impression and whether Hoabinhian dispersed or not into southern China (i.e. Guangxi and Guangdong regions) and how it evolved during the late Late Pleistocene to the Early Holocene remains to be an open question to explore in the future considering the extreme close distance (ca. 100 km) between northern Vietnam (yielding about 300 Hoabinhian sites, pers, commun. with Dr. Pham Thanh Son) and the border area of Guangxi, and more over only a very small quantity of cave sites have been excavated and analyzed in the latter. We expect that further field work in the border area of Guangxi will clarify this question since Hoabinhian hunter-gatherers inhabited in northern Vietnam for more than 10 000 years (about 20-8ka BP) (Chung 2008; Nguyen 2008; Yi et al. 2008; Zeitoun et al. 2008), and it seems odd if they didn't move a little north now that neither geographic nor political barrier existed during that time.

The monotonous persistence of cobble-tool industry in southern China from the Early Pleistocene to the Early Holocene does not mean that the technical behavior of human was also changeless and simple. Particularly during the period of site occupation of Bailiandong Cave, the hunter-gathers, who were totally anatomically modern humans, may have experienced a great change in technical system as indicated by the development of polished stone tools and donuts which might echo the appearance of totally new rules in lithic production and their social life and by the emergence and invention of pottery in some caves of southern China (not including several discoveries from the nearby northern Provinces of Jiangxi and Hunan) (Boaretto et al. 2009; Cohen et al. 2017; Hung et al. 2017; Sato and Natsuki 2017; Wu et al. 2012a, b). The other tools made of new raw material of freshwater mollusc shell (Collective 2014; Jing et al. 1998; Liu 2019; Xie et al. 2018a), and bone, antler and possibly other organic material suggested in a combined way that the technological system was becoming more and more complex. The development towards more complex behaviour was not an insular phenomenon at Bailiandong Cave, but a fact and a trend in many cave sites in southern China from the terminal Pleistocene to the Early Holocene (Chi and Hung 2012; Dikshit and Hazarika 2012; Wang 2016; Zhang and Hung 2008). Although the concept and knowledge about chipped stone tool production at Bailiandong Cave were relatively stable from lower to upper unit, yet some major transformation manifested by other technological parameters in the whole subsistence system did happen during this period. So lithic industries i.e. mineral tools should only be taken as one part of the whole technological system used by these hunter-gatherers if we need to judge their technological ability. Also it may be more appropriate to interpret human behaviors and cultures in a comprehensive perspective rather than in an isolated way.

Recently, the subtropical South China attracts more and more international concerns because many new sites were excavated and analyzed, providing reliable or controversial data on several important topics such as the Acheulean-like industry in Bose basin of Guangxi (Hou et al. 2000), the so-called Levallois technology in Guizhou (Hu et al. 2019; Otte et al. 2017), the Hoabinhian techno-complex in Yunnan (Ji et al. 2016), and the early presence of modern humans in several cave sites (Bae et al. 2014; Cai et al. 2017; Liu et al. 2010, 2015; Shen et al. 2002; Zhao et al. 2016) etc. However, as many authors claimed, the Paleo-history in this area could be very different with from that of the west side of the old continent based on archaeological and human fossil records, so the uniqueness of the technological development and human evolution in east world could be better understood from a local perspective rather than citing old-fashioned paradigms and prejudging with preoccupations (Boëda et al. 2013; Boëda and Hou 2011; Gao 2013; Li 2011; Liu et al. 2016; Wei et al. 2017). As one part of that endeavor, technological analysis on the lithic industry in southern China would be one of the most productive approaches which could shed new insights about the history and prehistory of humans since abundant data were, are and will be discovered in this area.

To conclude, as one of the initial practices of applying technological method to lithic industry in southern

China, this research revealed the chaîne opératoires of the lithic collection of an important site in southern China dating to the late Late Pleistocene to the Early Holocene, and provided us a general structural information about lithic production and tools on cobbles and other raw materials. This is an important step towards further systematic comparative study on a larger inter-regional scale to clarify their relationship with the nearby Hoabinhian hunter-gatherers. Considering that many sites in this area are still lacking of accurate stratigraphic and dating data, more fieldwork and laboratory research needs to be conducted in the near future to construct more reliable time frame and to redefine the complexity of "cobble-tool industry" in both synchronic and diachronic way. Other work such as ancient DNA analysis needs also to be carried out to help us better understand the difference/affinity between prehistoric humans of southern China and Southeast Asia if human fossils of good quality are available at the sites.

Acknowledgements

The authors would like to thank Dr. Yuan Junjie, from Guangxi Normal University for his warm help when studying the lithic collection at Bailiandong Cave Site Museum in Liu Zhou, Guangxi. We also thank Prof. Ji Xueping, from Provincial Institute of Cultural Relics and Archaeology in Kunming, Yunnan Province, for his suggestions to improve this manuscript. Thanks will also be given to Tian Jun and Xu Ke from Bailiandong Cave Site Museum for helping us during the observation of the specimens. This work was supported by National Social Science Project of China (18BKG003), the Chinese Scholarship Council (CSC 2018-2021) and National Museum of Natural History of France (MNHN, ED227).

References

Bae C. J., Wang W., Zhao J. X., Huang S. M., Tian F., Shen G. J., 2014. Modern human teeth from Late Pleistocene Luna Cave (Guangxi, China). Quaternary International 354, 169-183.

Bar-Yosef O., Wang Y., 2012. Paleolithic Archaeology in China. Annual Review of Anthropology 41, 319-335.

Boaretto E., Wu X., Yuan J., Bar-Yosef O., Chu V., Pan Y., 2009. Radiocarbon dating of charcoal and bone collagen associated with early pottery at Yuchanyan Cave, Hunan Province, China. Proceedings of the National Academy of Sciences 106 (24), 9595-9600.

Boëda E., Hou Y. M., Forestier H., Sarel J., Wang H. M., 2013. Levallois and non-Levallois blade production at Shuidonggou in Ningxia, North China. Quaternary International 295, 191-203.

Boëda E., Hou Y., 2011. Étude du site de Longgupo – Synthèse. L'Anthropologie 115 (1), 176-196.

Bowdler S., 2006. The Hoabinhian: Early Evidence for SE Asian Trade Networks? Paper presented at 10th International Conference of the European Association of Southeast Asian Archaeologists. The British Museum London.

Cai Y., Qiang X., Wang X., Jin C., Wang Y., Zhang Y., 2017. The age of human remains and associated fauna from Zhiren Cave in Guangxi, southern China. Quaternary International 434, 84-91.

Chi Z., Hung H., 2012. Later hunter-gatherers in southern China, 18 000-3000 BC. Antiquity 86 (331), 11-29.

Chung T. N., 2008. Research on Hoa Binh Culture in Viet Nam, Laos and Cambodia. Vietnam Archaeology 3, 19-32.

Cohen D. J., Bar-Yosef O., Wu X., Patania I., Goldberg P., 2017. The emergence of pottery in China: Recent dating of two early pottery cave sites in South China. Quaternary International 441, 36-48.

Colani M., 1926. Découverte d'industries paléolithiques dans la province de Hoa-Binh, Tonkin. L'Anthropologie 36, 609-611.

Colani M., 1927. L'âge de la pierre dans la province de Hoa Binh (Tonkin). Mémoires du Service Géologique de l'Indochine 14 (1), 1-86.

Colani M., 1939. La civilization hoabinhienne extrême-orientale. Bulletin de la Société préhistorique française 36, 170-174.

Collective (Ed.), 2003. Report on the Zengpiyan Cave site in Guiling City. Beijing: Cultural Relics Press.

Collective (Ed.), 2014. Xianrendong Cave and Diaotonghuan Cave. Beijing: Cultural Relics Press.

Collective (Ed.), 2017. Report on the field survey in the western border area of Yunnan Province. Shanghai: Shanghai Ancient Books Publishing House.

Dai G., 1988. On the relationship between "Hoabinhian cultures" of Southeast Asia and Cultures of South China. Southeast Asia 1, 52-60.

Deng C., 1992. Main points for archaeological reconstruction of aboriginal cultural circles in South China., Archaeological Research on Southeast China (Volume 2). Xiamen: Xiamen University Press, pp. 83-94.

Deng W., Liu S., Wu Y., Liu T., Li W., Wang Y., 2019. A preliminary report on excavation at the Huangmenyan Cave 2 of Qingtang site, South China in 2016. Acta Anthropologica Sinica 38, 1-9.

Dikshit K. N., Hazarika M., 2012. The Earliest Pottery in East Asia: A Review. Puratattva 42, 227-237.

Forestier H., 1993. Le Clactonien : mise en application d'une nouvelle méthode de débitage s'inscrivant dans la variabilité des systèmes de production lithique du Paléolithique ancien. Paléo 5, 53-82.

Forestier H., 2000. De quelques chaines opératoires lithiques en Asie du Sud-Est au pléistocène supérieur final et au début de l'holocène. L'Anthropologie 104 (4), 531-548.

Forestier H., 2010. La pierre et son ombre : réflexion sur le phénomène hoabinhien d'Asie du Sud-est. Habilitation à diriger des recherches, Université Paris Ouest Nanterre La Défense.

Forestier H., Sophady H., Celiberti V., 2017a. The Hoabinhian technocomplex in Mainland Southeast Asia: The history of a pebble which hides the forest. Journal of Lithic Studies 4 (2), 3-45.

Forestier H., Grenet M., Borel A., Celiberti V., 2017b. Les productions lithiques de l'Archipel indonésien. Journal of Lithic Studies 4 (2), 231-303.

Forestier H., Sophady H., Puaud S., Celiberti V., Frère S., Zeitoun V., 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., 2005. Prospections paléolithiques et perspectives technologiques pour redéfinir le hoabinhien du Nord de la Thaïlande (campagnes 2002-2005). Aséanie 15, 33-60.

Gao X., 2013. Paleolithic Cultures in China: Uniqueness and Divergence. Current Anthropology 54 (S8), S358-S370.

Ha Van T., 1992. Van hoa Hoa Binh: nhung van de sau 60 nam (The Hoabinhian: problems after 60 years). Khao Co Hoc (Archaeology) 2 1-4.

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

He N., Huang Y., Liu W., 1983. The Neolithic shell midden site of Liyuzui Rockshelter in Liuzhou, Guangxi. Archaeology 9, 769-774.

He N., Tan S., 1985. On the mesolithic in southern China. Acta Anthropologica Sinica 4 (4), 308-313.

Hou Y. M., Potts R., Yuan B. Y., Guo Z. T., Deino A., Wang W., 2000. Mid-Pleistocene Acheulean-like stone technology of the Bose basin, South China. Science 287 (5458), 1622-1626.

Hu Y., Marwick B., Zhang J., Rui X., Hou Y., Yue J., 2019. Late Middle Pleistocene Levallois stone-tool technology in southwest China. Nature 565 (7737), 82-85.

Hung H., Chi Z., Matsumura H., Zhen L., 2017. Neolithic Transition in Guangxi: Long Development of Hunting-Gathering Society in Southern China. In: H. Matsumura, H. Hung, L. Zhen &K. Shinoda (Eds.), Bio-Anthropological studies of early Holocene hunter-gatherers sites at Huiyaotian and Liyupo in Guangxi, China. National Museum of Nature and Science Monograph No.47, pp. 205-228.

Ji X., Kuman K., Clarke R. J., Forestier H., Li Y., Ma J., 2016. The oldest Hoabinhian technocomplex in Asia (43.5ka) at Xiaodong rockshelter, Yunnan Province, southwest China. Quaternary International 400, 166-174.

Jia L., Qiu Z., 1960. The age of the knapped stone in the cave sites of Guangxi. Paleovertebrata et Paleoanthropologia 2 (1), 64-68.

Jiang Y. (Ed.), 2009. Report on the excavation of Bailiandong Cave site. Beijing: Science Press.

Jing Z., Zhang Z., Qu J., Yu X., Kuang M., Yi Z., 1998. Brief report on the test excavation of Niulandong Cave site, Yunling County, Yingde City, Guangdong Province. Jianghan Archaeology 1, 14-20.

Li Y., 2011. Étude technologique de l'industire lithique du site de Guanyingdong dans la province du Guizhou, sud-ouest de la Chine. France: @rchéo-éditions.com.

Li Y., Hao S., Huang W., Forestier H., Zhou Y., Li H., 2019. A new variability of cobble-tool industry associated with a bone tool technology from the Luobi Cave, South China (ca.11-10 ka): a comparative perspective from Southeast Asia. Journal of World Prehistory. (in press).

Liu S., 2019. The prehistoric site of Qingtang, Yingde City, Guangdong Province. http://www.ccrnews.com.cn/index.php/Pingxuantuijie/content/id/68610.html. Last visited: 16, March 2019.

Liu W., Jin C. Z., Zhang Y. Q., Cai Y. J., Xing S., Wu X. J., 2010. Human remains from Zhirendong, South China, and modern human emergence in East Asia. Proceedings of the National Academy of Sciences 107 (45), 19201-19206.

Liu W., Martinón-Torres M., Cai Y., Xing S., Tong H., Pei S., 2015. The earliest unequivocally modern humans in southern China. Nature 526 (7575), 696-699.

Liu W., Wu X., Xing S., 2016. Emergence and dispersal of modern humans: the fossil evidence from China. Acta Anthropologica Sinica 35 (2), 161-171.

Moser J., 2001. Hoabinhian: Geographie und Chronologie eines steinzeitlichen Technokomplexes in Südostasien. Linden Soft.

Nguyen K. S., 1994. The Sonvian and the problem of the proto-Hoabinhian in Vietnam. Vietnam Social Sciences 5 (43), 22-30.

Nguyen V., 2008. Hoabinhian macrobotanical remains from archaeological sites in Vietnam: indicators of climate changes from the late Pleistocene to the early Holocene. Bulletin of the Indo-Pacific Prehistory Association 28, 80-83.

Otte M., Weiwen H., Hu Y., Hou Y., 2017. Panxian Dadong et le Levallois chinois. L'Anthropologie 121 (3), 255-269.

Pawlik A. F., 2009. Is the functional approach helpful to overcome the typology dilemma of lithic archaeology in Southeast Asia?. Bulletin of the Indo-Pacific Prehistory Association 29, 6-14.

Qiu L., Song F., Wang L., 1980. Brief report on the excavation of Dushizai Cave site in Yangchun, Guangdong Province. Paleovertebrata and Paleoanthropologia 3, 260.

Qiu L., Song F., Wang L., 1982. Excavation at the Neolithic site of Dushizai Cave, Yangchun, Guangdong Province. Archaeology 5, 456-459.

Qu T., Bar-Yosef O., Wang Y., Wu X., 2013. The Chinese Upper Paleolithic: Geography, Chronology, and Techno-typology. Journal of Archaeological Research 21 (1), 1-73.

Sato H., Natsuki D., 2017. Human behavioral responses to environmental condition and the emergence of the world's oldest pottery in East and Northeast Asia: An overview. Quaternary International 441, 12-28.

Shen G. J., Wang W., Wang Q., Zhao J. X., Collerson K., Zhou C. L., 2002. U-Series dating of Liujiang hominid site in Guangxi, Southern China. Journal of Human Evolution 43 (6), 817-829.

Song F., Qiu L., Wang L., 1983. The Huangyandong Cave site in Fengkai County, Guangdong Province. Archaeology 1, 1-3.

Song F., Zhang Z., Deng Z., Zeng X., Chen Q., 1992. Brief report on the excavation at the Huangyandong Cave site in 1989 and 1990, Fengkai County, Guangdong Province. Southeast Culture 1, 148-156.

Trinh N. C., 1992. Đặc Trưng văn hóa Hòa Bình trong sơ kỳđá mới nam Trung Quốc (The Hoa Binhian features in early neolithic of South China). Khao Co Hoc (Archaeology) 2, 81-89.

Wang Y., 2005. The origin and development of ancient Chinese human and culture. Beijing: Science Press.

Wang Y., 2016. Behavioral modernity and variability of late Late Pleistocene humans in South China: a case study of Diaotonghuan in Wannian, Jiangxi Province. Acta Anthropologica Sinica 35 (3), 1-10.

Wei G., Huang W., Boëda E., Forestier H., He C., Chen S., 2017. Recent discovery of a unique Paleolithic industry from the Yumidong Cave site in the Three Gorges region of Yangtze River, southwest China. Quaternary International 434, Part A, 107-120.

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. Pacific Linguistics, pp. 9-46.

Wu X., Zhang C., Goldberg P., Cohen D., Pan Y., Arpin T. (2012a). Early pottery at 20,000 years ago in Xianrendong Cave, China. Science 336 (6089), 1696-1700.

Wu X., Boaretto E., Yuan J., Bar-Yosef O., Pan Y., Qu T., 2012b. Early pottery from the Yuchanyan Cave site in Daoxian County, Hunan Province and the ^{14}C dating on the stratigraphy. Cultural Relics in Southern China 3, 7-15.

Xie C., Zhang X., 1987. On the cultural remains of Bailiangdong Cave site: a discussion on the related questions. Southern Ethnology and Archaeology, pp.161-168.

Xie G., Yu M., Lu J., 2018a. Important discoveries at the Yahuaidong Cave site, Longan County, Guangxi. Weekly of Chinese Cultural Relics, 2018-01-19.

Xie G., Lin Q., Wu Y., Hu Z., 2018b. The late paleolithic industries of southern China (Lingnan Region). Quaternary International. doi:https://doi.org/10.1016/j.quaint.2018.09.043.

Yi G., Yang Q., Huang Y., Liu W., Guo R., Chen G., 1987. Report on the excavation at the Stone Age site of Bailiangdong Cave, Liuzhou City, Guangxi. Southern Ethnology and Archaeology 1, 143-160.

Yi S., Lee J., Kim S., Yoo Y., Kim D., 2008. New data on the hoabinhian: investigations at Hang Cho Cave, Northern Vietnam. Bulletin of the Indo-Pacific Prehistory Association 28, 73-79.

Yuan S., 1990a. ^{14}C dating on the cave sediments, ^{14}C dating research in China. Beijing: Science Press.

Yuan S., Chen T., Gao S., Ma L., 1990b. Dating the cave sites of Dushizhai and Bailiandong: preliminary study on the timing of the transition from late Paleolithic to early Neolithic. In: Collective (Ed.), Symposium to commemorate the establishment of Archaeology major in Peking University（1952-1982). Beijing: Cultural Relics Press, pp. 40-47.

Yuan S., Gao S., 1994. Re-dating on the age of Bailiandong Cave site. In: G. Zhou (Ed.), Symposium of the Internationl Conference on the Prehistoric Cultural Relationship Between China and Japan. Beijing: China International Broadcasting Press.

Yuan S., Li K., Yuan J., Zhang Z., Wang J., Liu K., 1997. Applications of AMS radiocarbon dating in Chinese archaeological studies. AIP Publishing, pp. 803-806.

Yuan S., Zhou G., Guo Z., Zhang Z., Gao S., Li K., 1995. ^{14}C AMS dating the transition from the Paleolithic to the Neolithic in South China. Radiocarbon 37 (2), 245-249.

Zeitoun V., Forestier H., Nakbunlung S., Coupey A., 2008. Préhistoires au sud du Triangle d'or. France: IRD Éditions.

Zhang C., Hung H., 2008. The Neolithic of Southern China-Origin, Development, and Dispersal. Asian Perspectives 47 (2), 299-329.

Zhang S., 1999. On the important advancement of the Paleolithic archaeology in China since 1949. Acta Anthropologica Sinica 18 (3), 193-214.

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

Zhang Z., Qiu L., Tan H., Zheng Z., Yu S., Ma T. (Eds.), 2013. Niulandong Cave site in Yingde City: a comprehensive study the rice cultivation and environment. Beijing: Science Press.

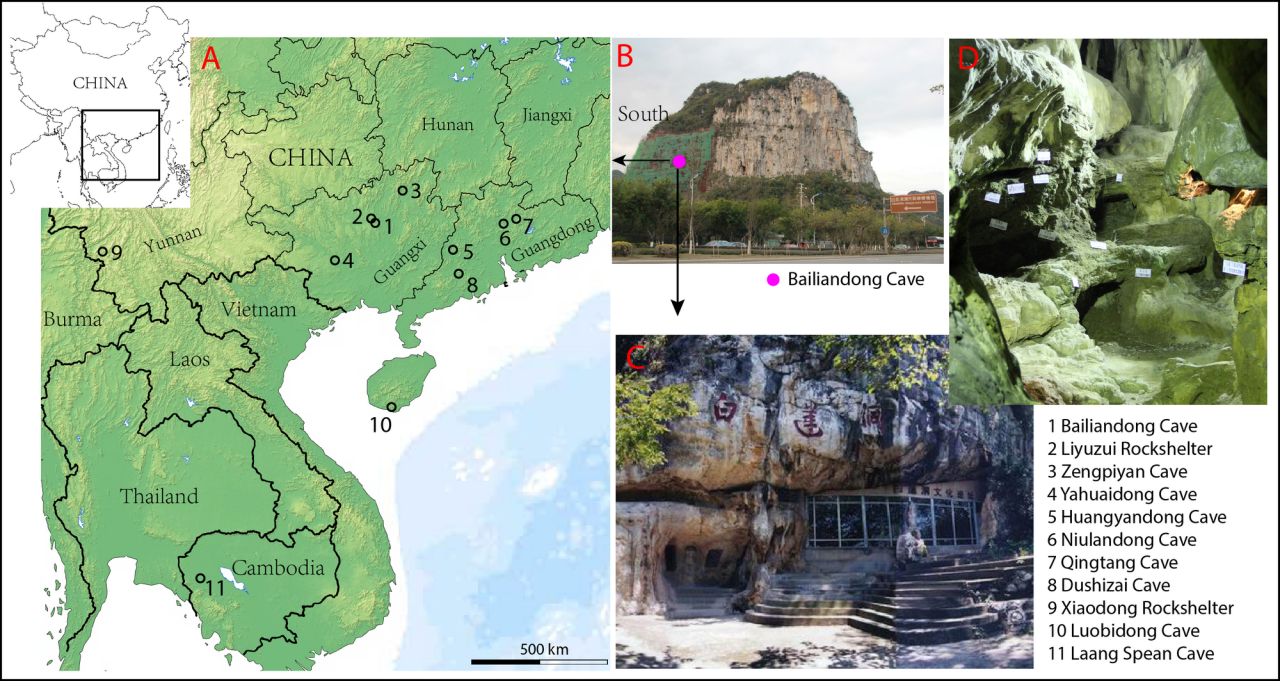
Zhao L., Zhang L., Du B., Nian X., Zheng Y., Zhang Z., 2016. New discovery of human fossils and associated mammal fauna

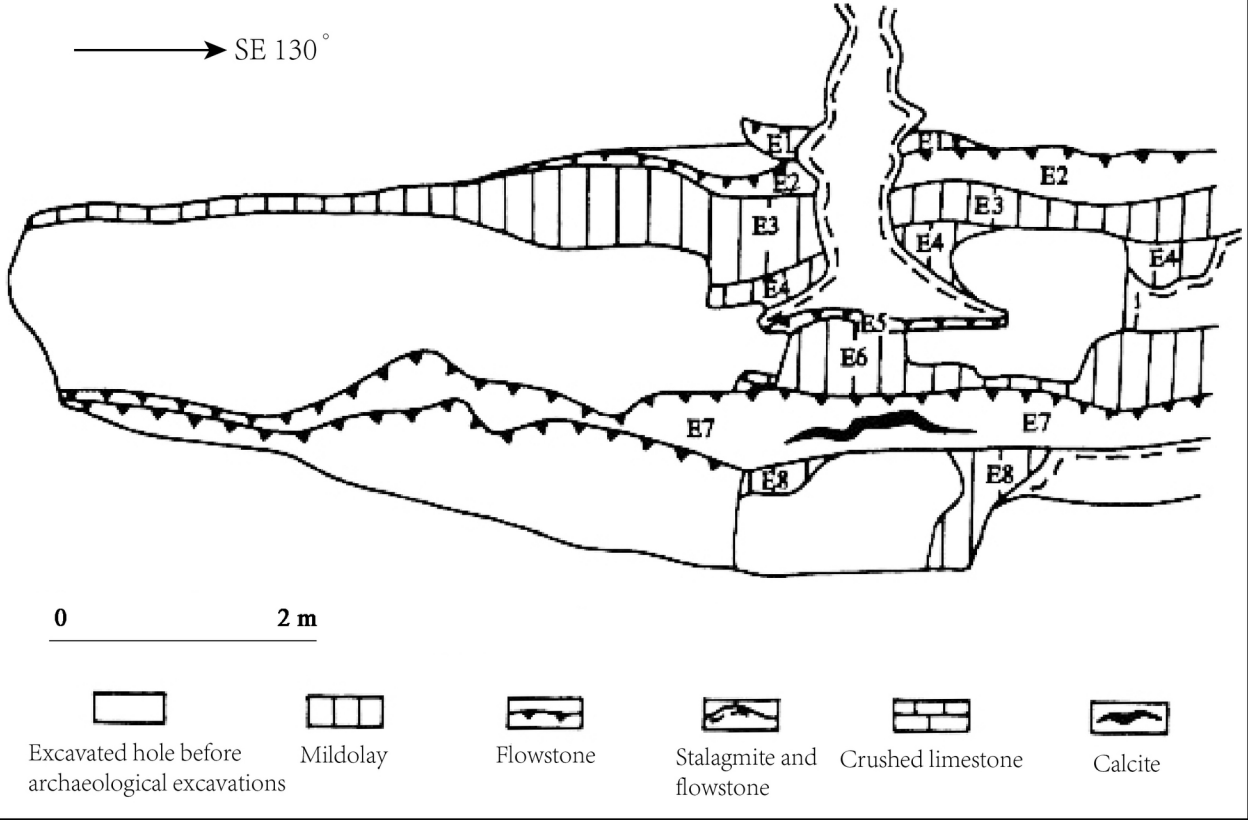
from Mawokou Cave in Bijie, Guizhou Province of southern China. Acta Anthropologica Sinica 35 (1), 24-35.

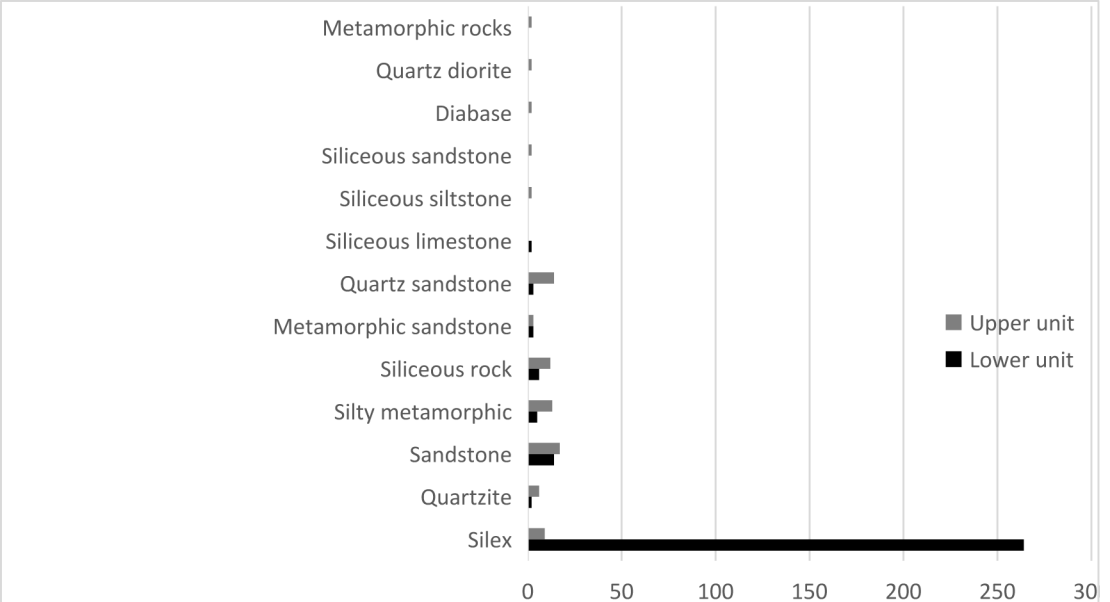
Zhou G., 1986. The stone age site of Bailiandong Cave in Liuzhou City, Guangxi of South China: an exploration on the transition from late Paleolithic to early Neolithic in southern China. Southeastern Cultures 2, 8-13.

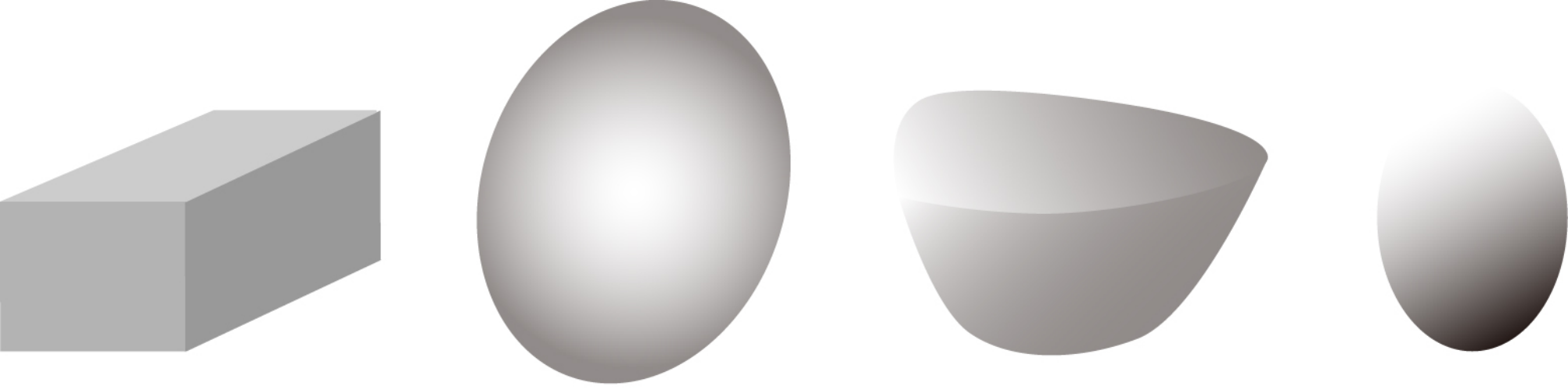
Zhou G., He Q., 2016. On the origin of pottery in human culture: another hypothesis about the origin of pottery. Southern Cultural Relics 1, 51-58.

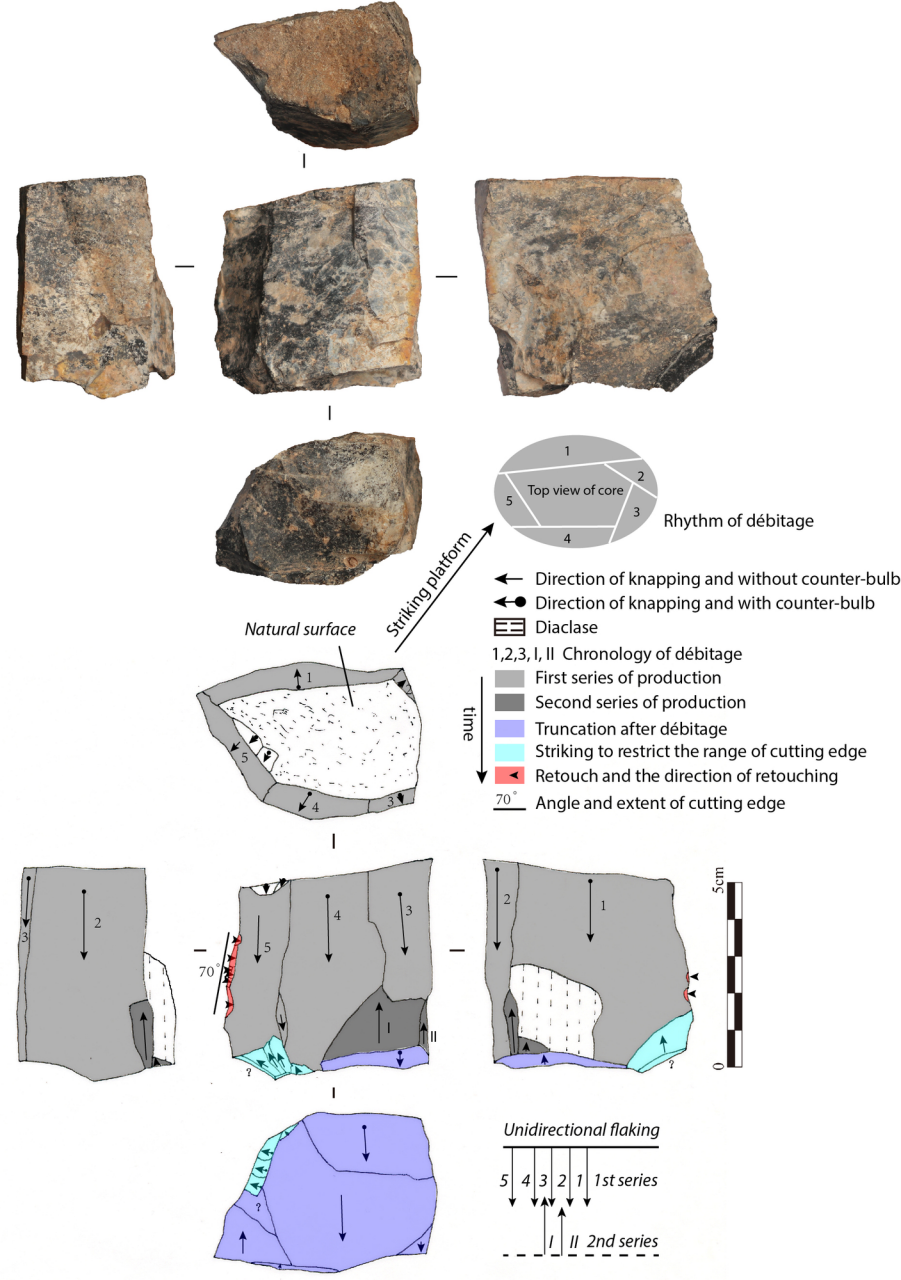
Zhou Y., Ji X., Li Y., Forestier H., Jablongski N. G., Ding S., 2019. Tangzigou open-air site: an original lithic assemblage during the Early Holocene in Yunnan Province, Southwest China. Quaternary International.(in review)

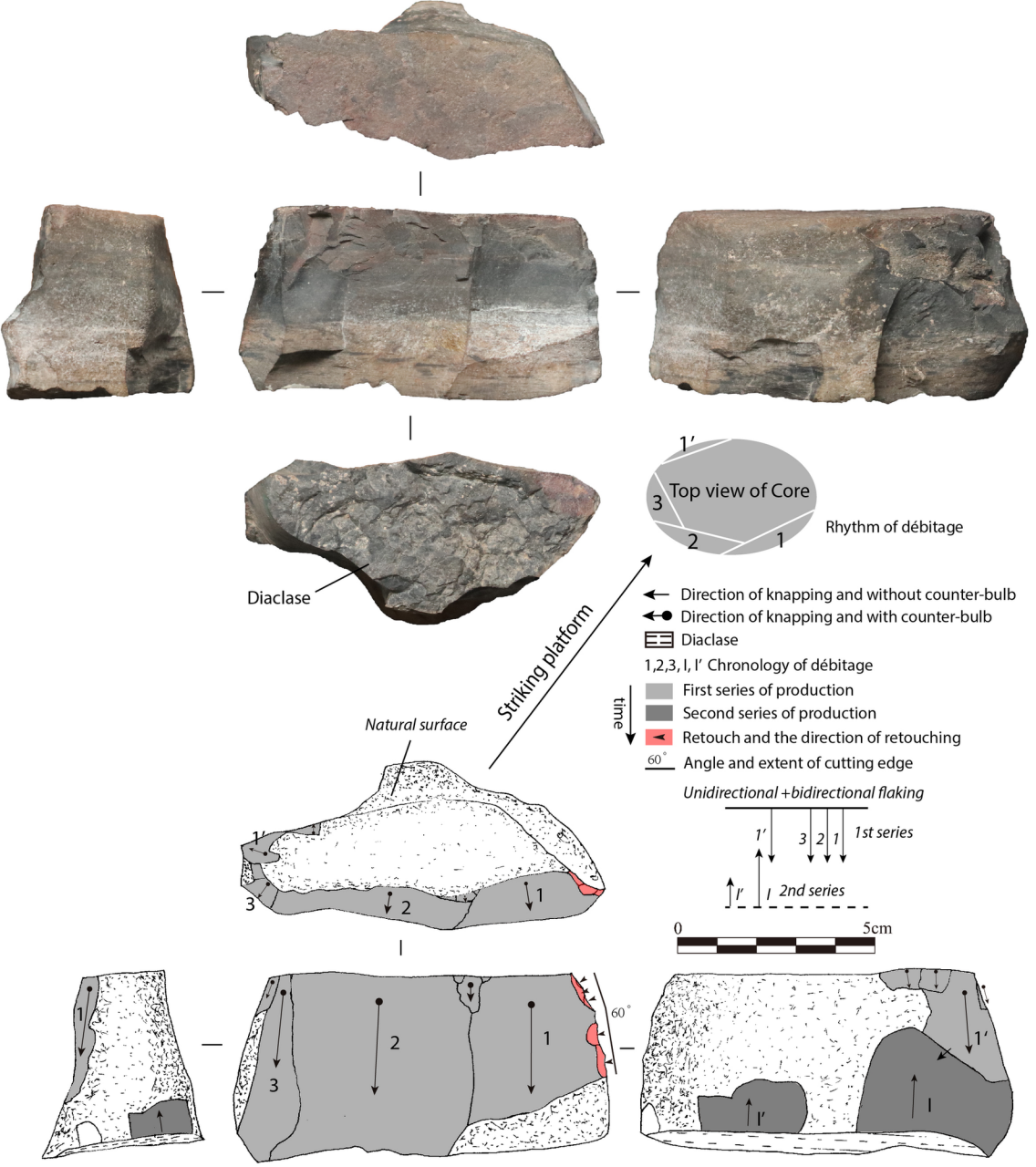

CHINA
A
CHINA
Hunan
Jiangxi
Yunnan
Guangxi
Guangdong
Burma
Vietnam
Laos
Thailand
Cambodia
1
2
3
4
5
6
7
8
9
10
11
500 km
B
South
Bailiandong Cave
C
D
1 Bailiandong Cave
2 Liyuzui Rockshelter
3 Zengpiyan Cave
4 Yahuaidong Cave
5 Huangyandong Cave
6 Niulandong Cave
7 Qingtang Cave
8 Dushizai Cave
9 Xiaodong Rockshelter
10 Luobidong Cave
11 Laang Spean Cave

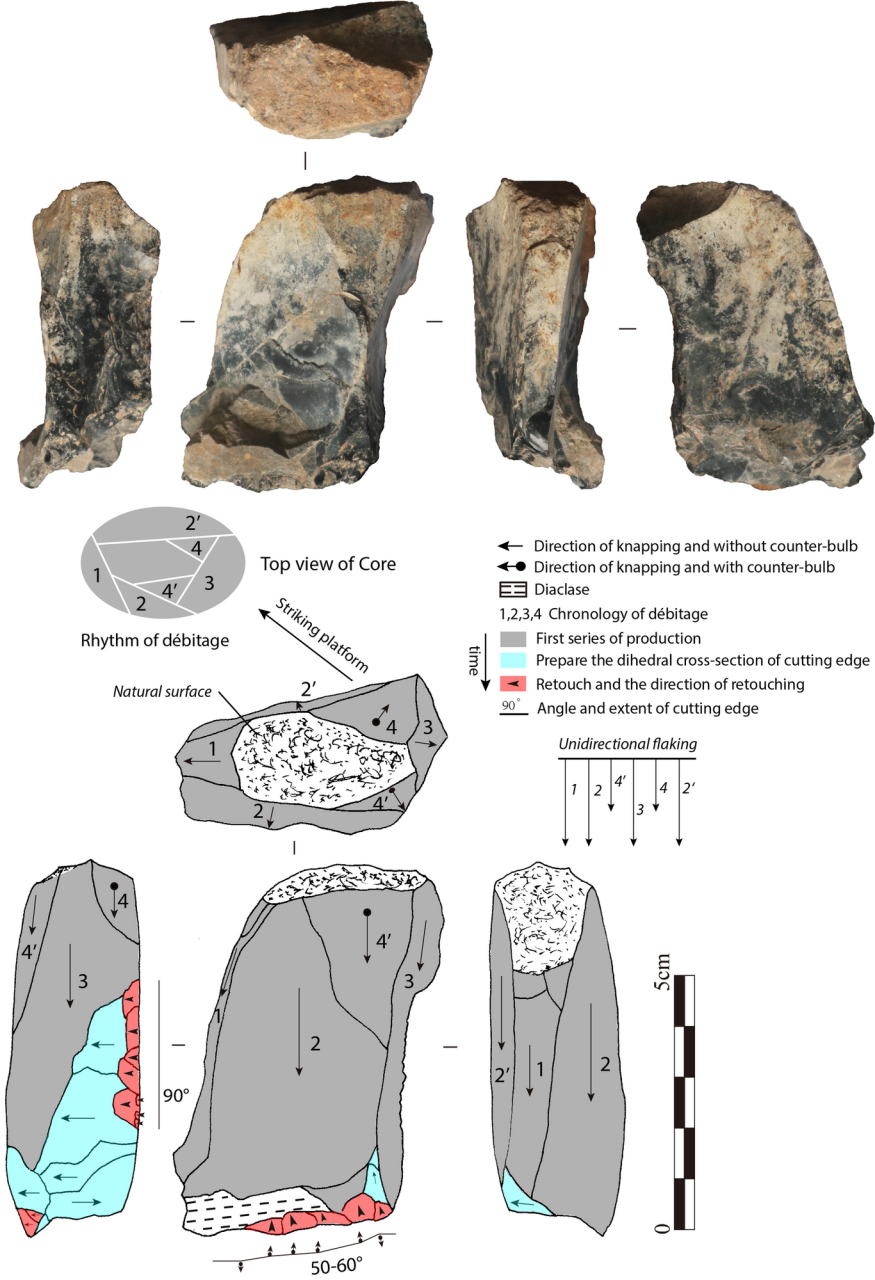

SE 130°
E1
E2
E3
E4
E5
E6
E7
E8
0
2 m
Excavated hole before archaeological excavations
Mildolay
Flowstone
Stalagmite and flowstone
Crushed limestone
Calcite

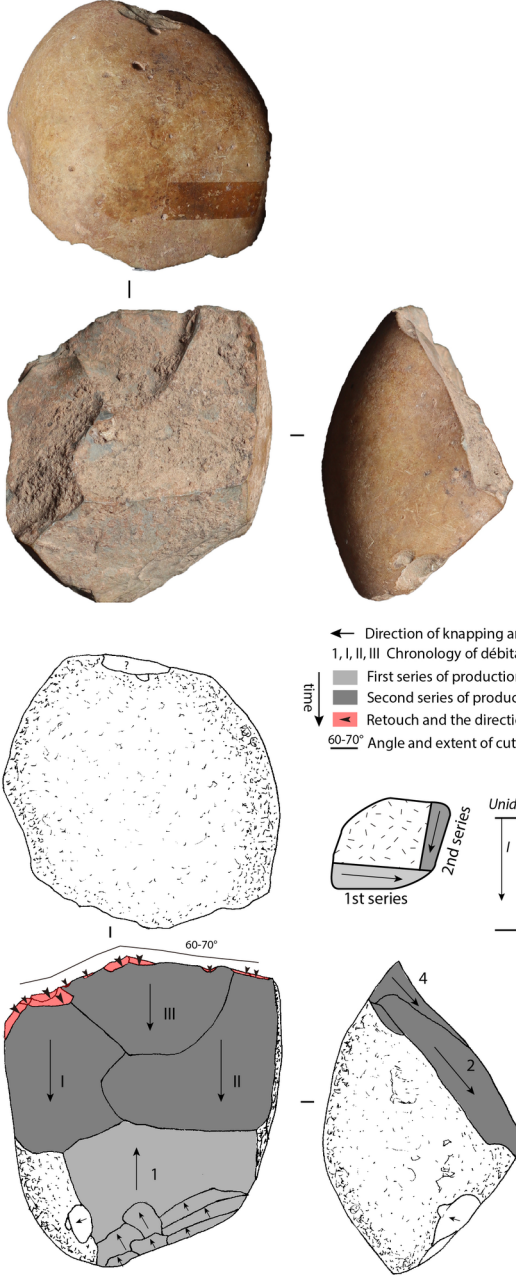

Metamorphic rocks
Quartz diorite
Diabase
Siliceous sandstone
Siliceous siltstone
Siliceous limestone
Quartz sandstone
Metamorphic sandstone
Siliceous rock
Silty metamorphic
Sandstone
Quartzite
Silex
Upper unit
Lower unit
0
50
100
150
200
250
30

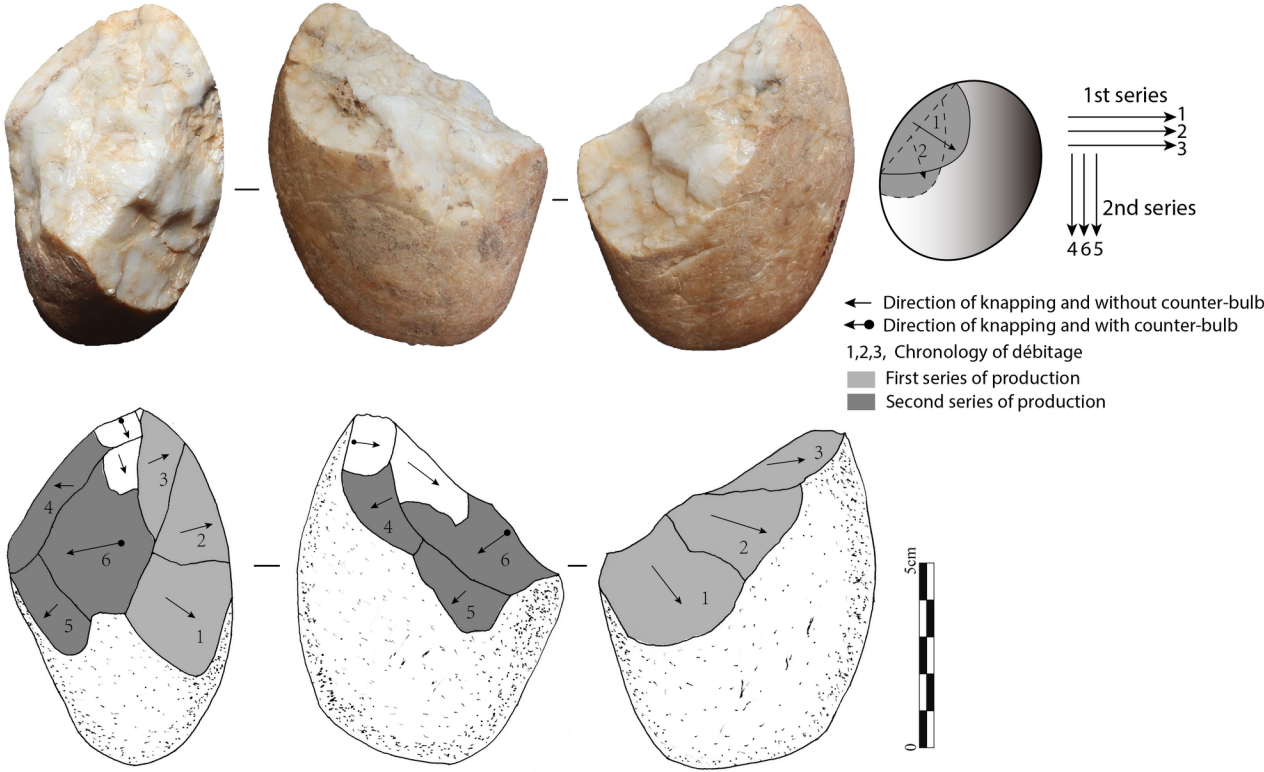

A
B
C
D

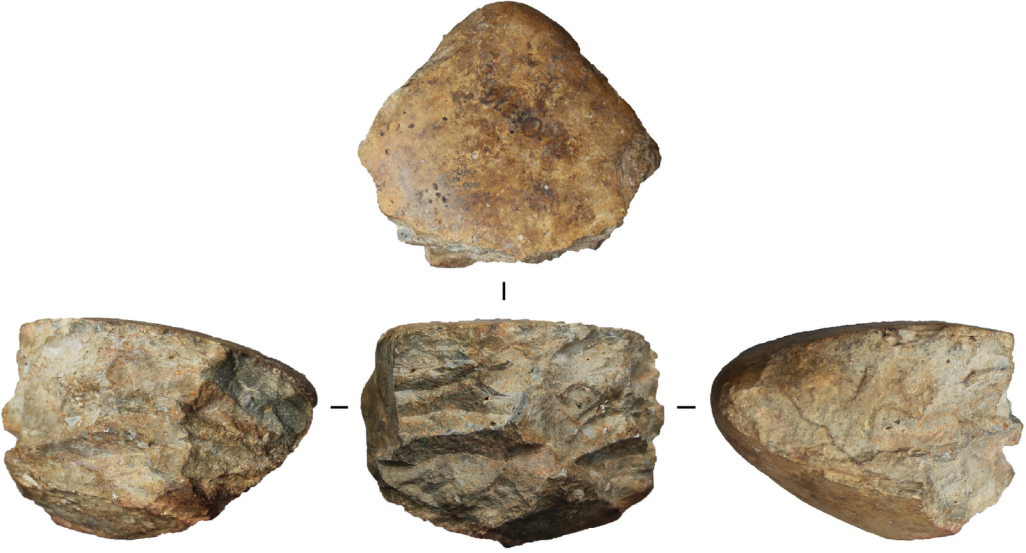

Top view of core
Rhythm of débitage
Striking platform
Natural surface
Direction of knapping and without counter-bulb
Direction of knapping and with counter-bulb
Diaclase
1,2,3, I, II Chronology of débitage
First series of production
Second series of production
Truncation after débitage
Striking to restrict the range of cutting edge
Retouch and the direction of retouching
70°
Angle and extent of cutting edge
time
5cm
0
Unidirectional flaking
1st series
2nd series

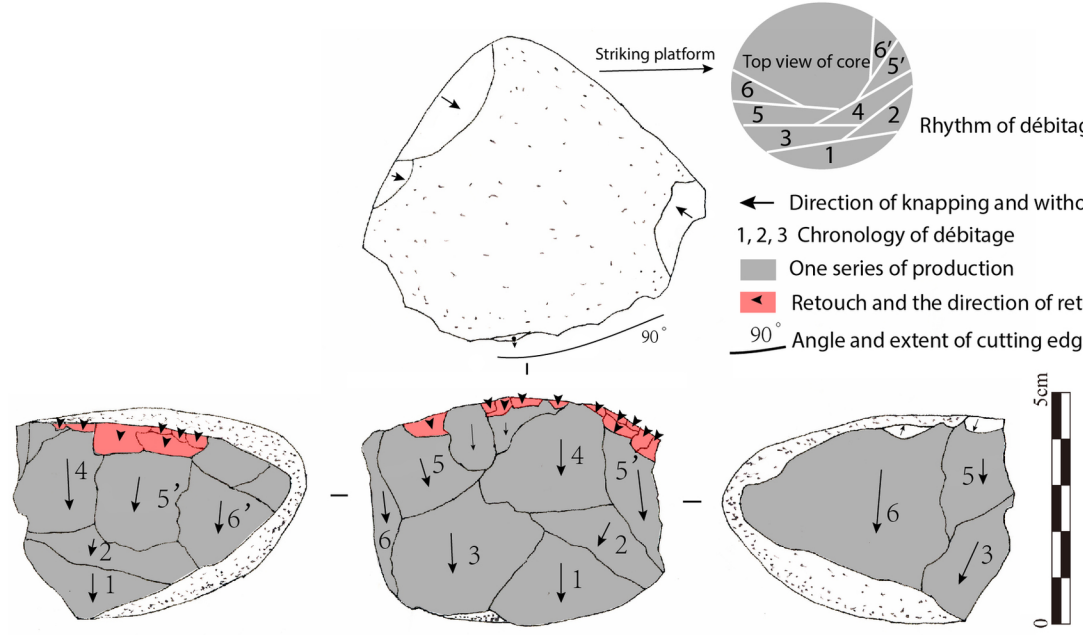

Diaclase
1′
Top view of Core
3
2
1
Rhythm of débitage
Direction of knapping and without counter-bulb
Direction of knapping and with counter-bulb
Diaclase
1,2,3, I, I′ Chronology of débitage
First series of production
Second series of production
Retouch and the direction of retouching
60°
Angle and extent of cutting edge
Striking platform
time
Natural surface
Unidirectional +bidirectional flaking
1′
3
2
1
1st series
I′
I
2nd series
0
5cm
60°

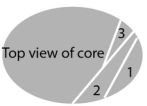

Top view of Core
Rhythm of débitage
Striking platform
Natural surface
Direction of knapping and without counter-bulb
Direction of knapping and with counter-bulb
Diaclase
1,2,3,4 Chronology of débitage
First series of production
Prepare the dihedral cross-section of cutting edge
Retouch and the direction of retouching
Angle and extent of cutting edge
time
Unidirectional flaking
90°
50-60°
5cm
0


Direction of knapping and without counter-bulb
1, I, II, III Chronology of débitage
time
First series of production
Second series of production
Retouch and the direction of retouching
60-70° Angle and extent of cutting edge
2nd series
1st series
Unidirectional flaking
2nd series
1st series
60-70°
I
II
III
1
2
4
5cm
0


1st series
1
2
3
2nd series
4 6 5
Direction of knapping and without counter-bulb
Direction of knapping and with counter-bulb
1,2,3, Chronology of débitage
First series of production
Second series of production
5cm
0




Striking platform
Top view of core
6′
5′
6
5
4
2
3
1
Rhythm of débitage
Direction of knapping and without counter-bulb
1, 2, 3 Chronology of débitage
One series of production
Retouch and the direction of retouching
90°
Angle and extent of cutting edge
90°
4
5′
6′
2
1
5
4
5′
6
3
2
1
6
5
3
5cm
0



Rhythm of débitage

Direction of knapping and without counter-bulb

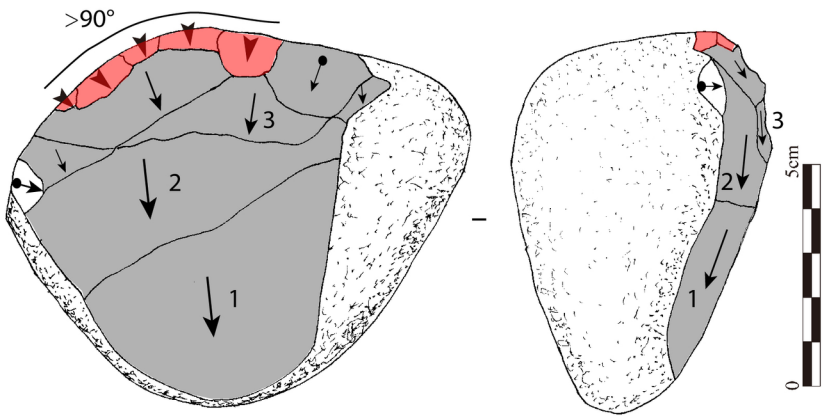
Direction of knapping and with counter-bulb

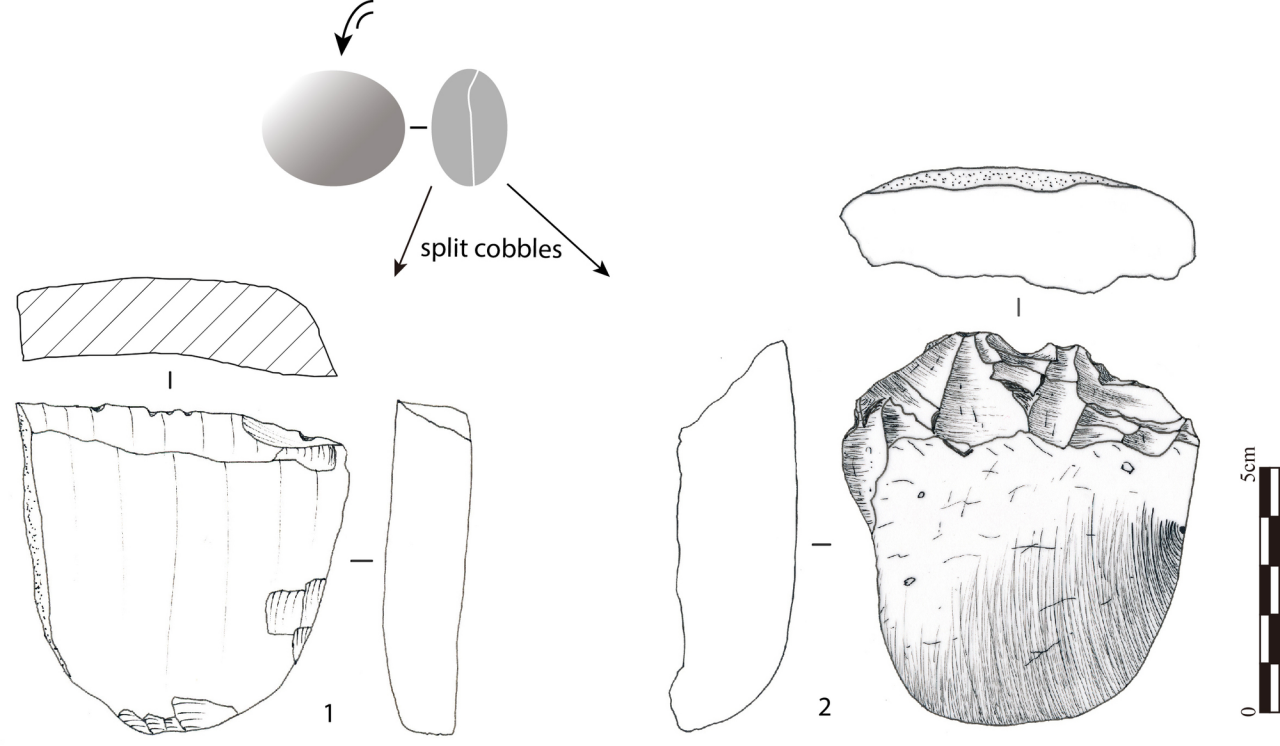
1,2,3, Chronology of débitage

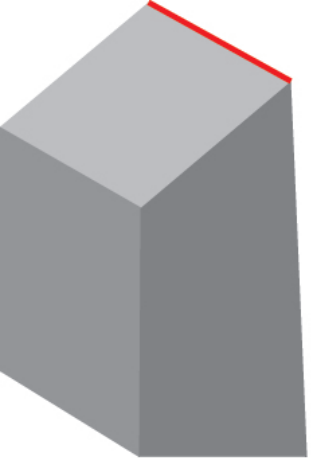
One series of production

Retouch and the direction of retouching

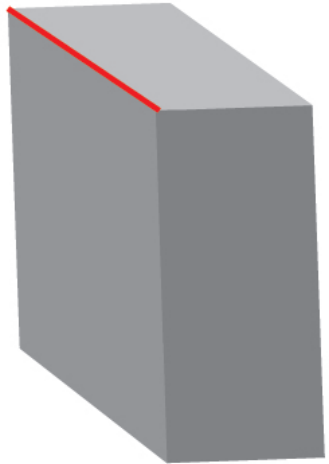
90° Angle and extent of cutting edge



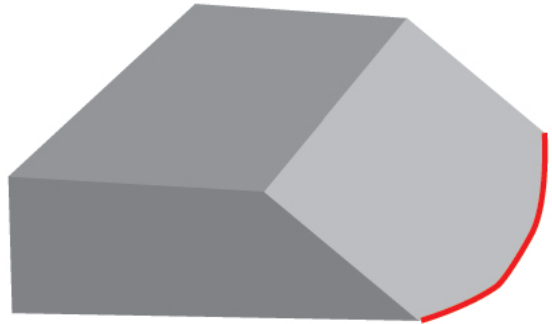

split cobbles
1
2
5cm
0



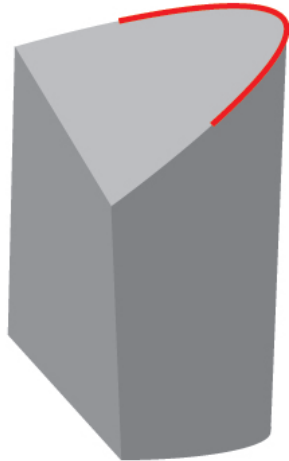
A



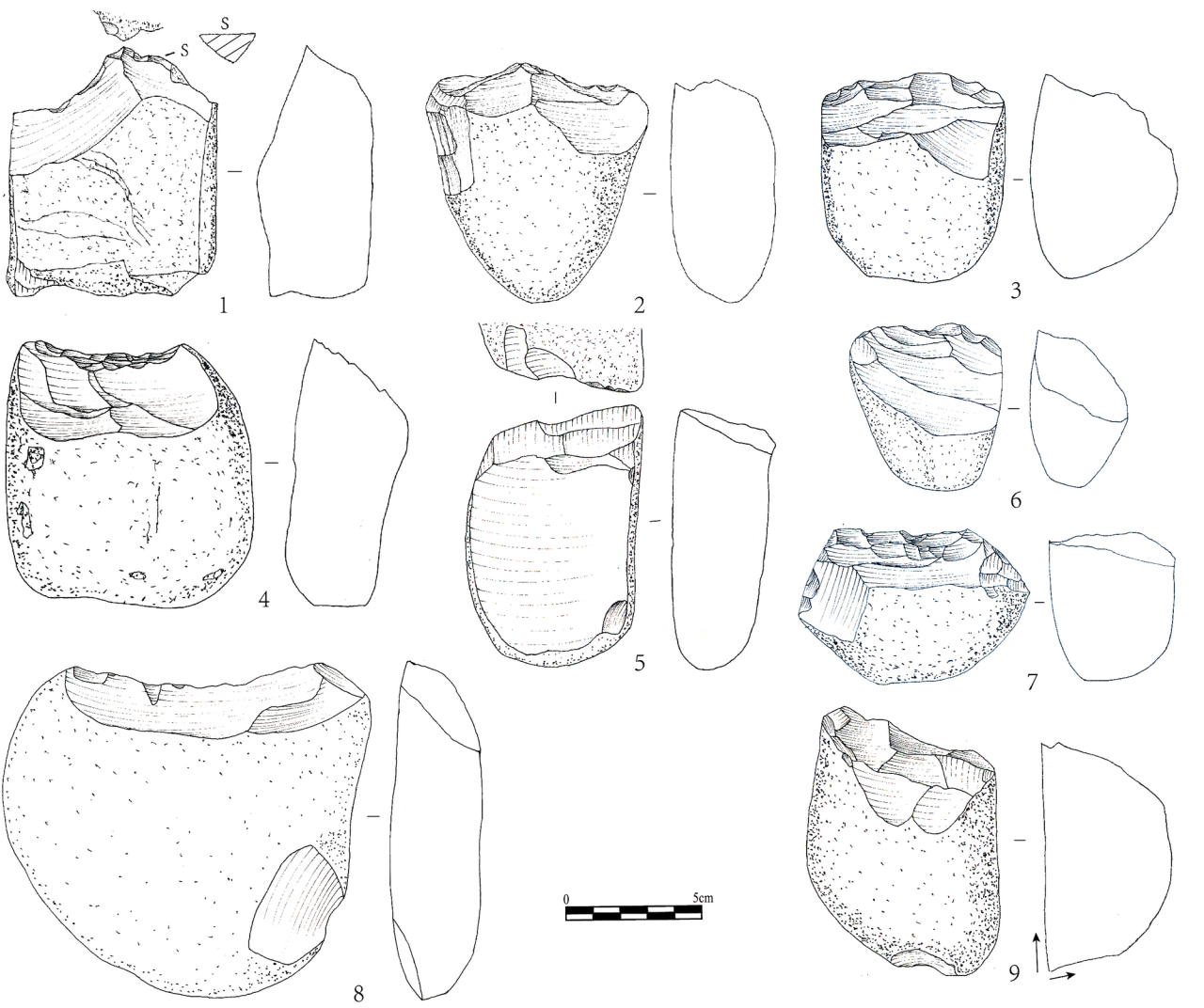
B

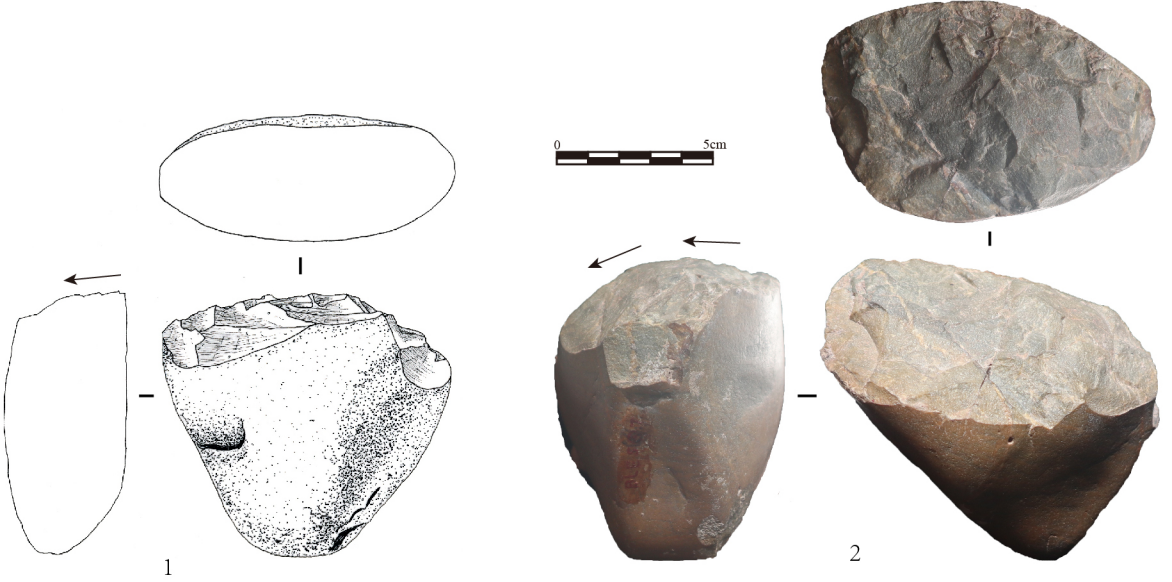


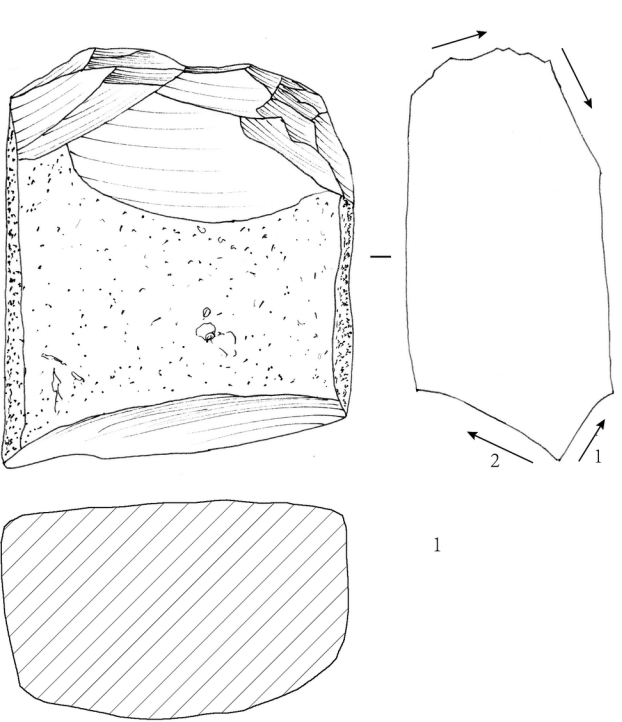
C



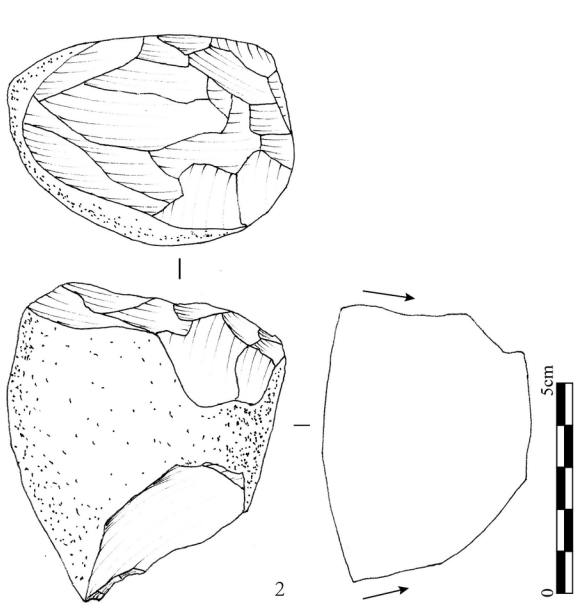
D


S
S
1
2
3
4
5
6
7
8
9
0
5cm

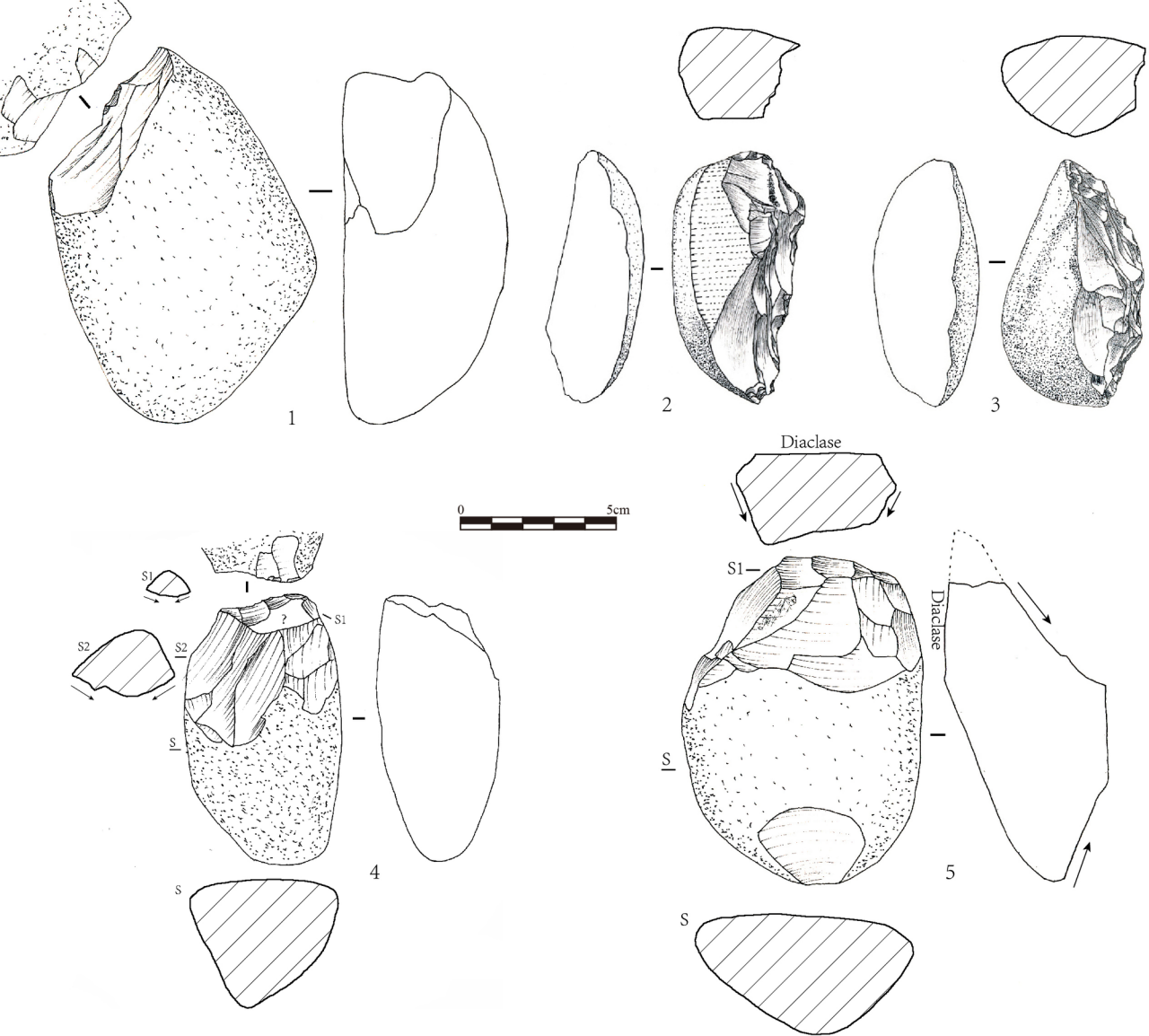

0
5cm
1
2

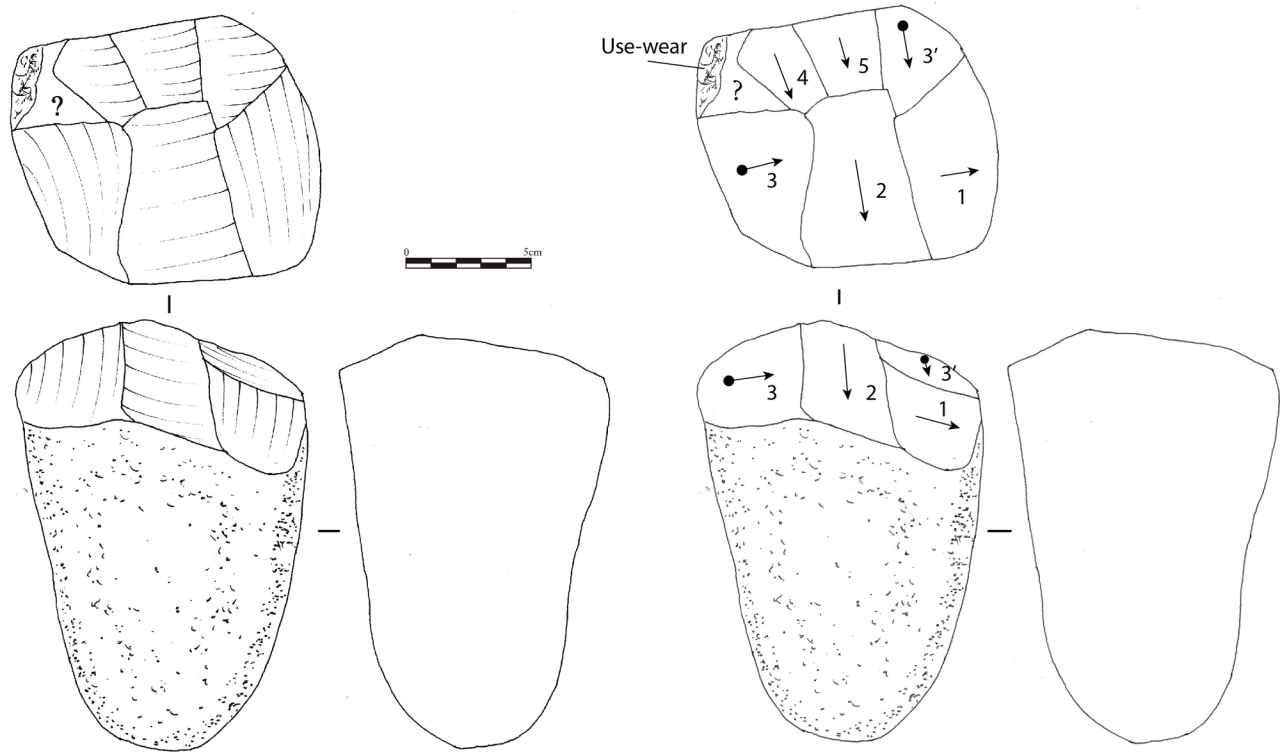


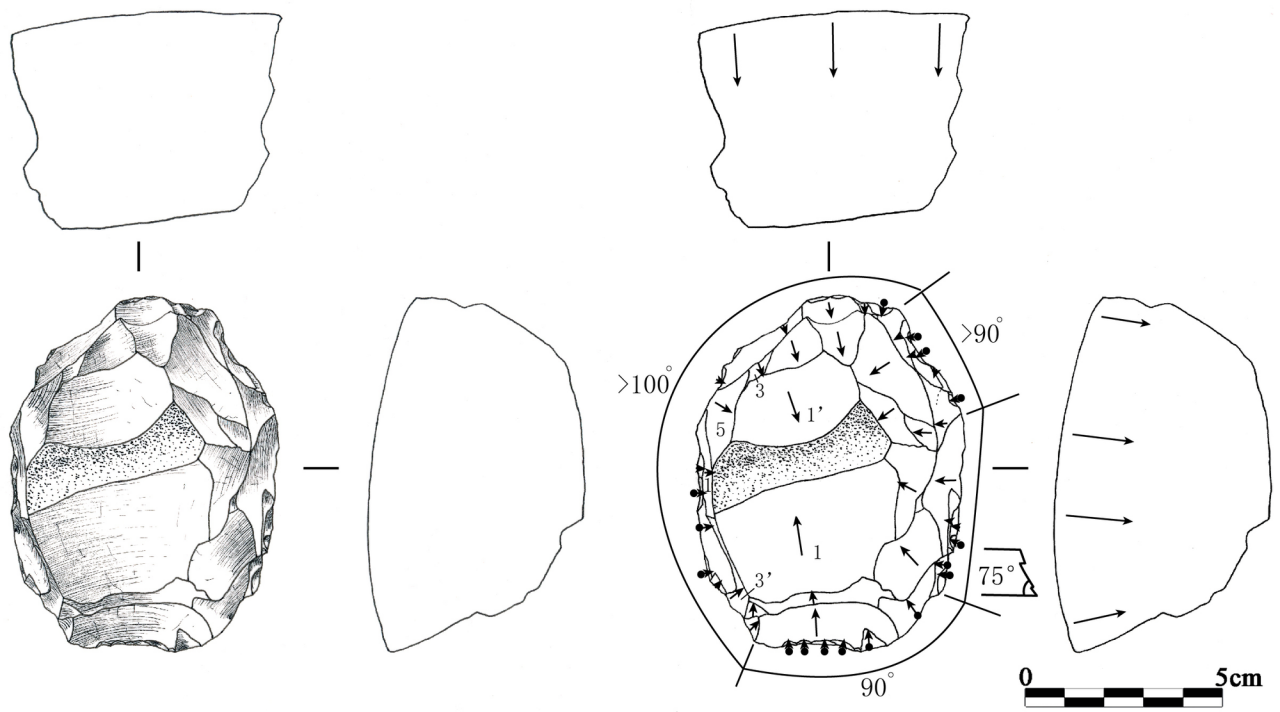
1



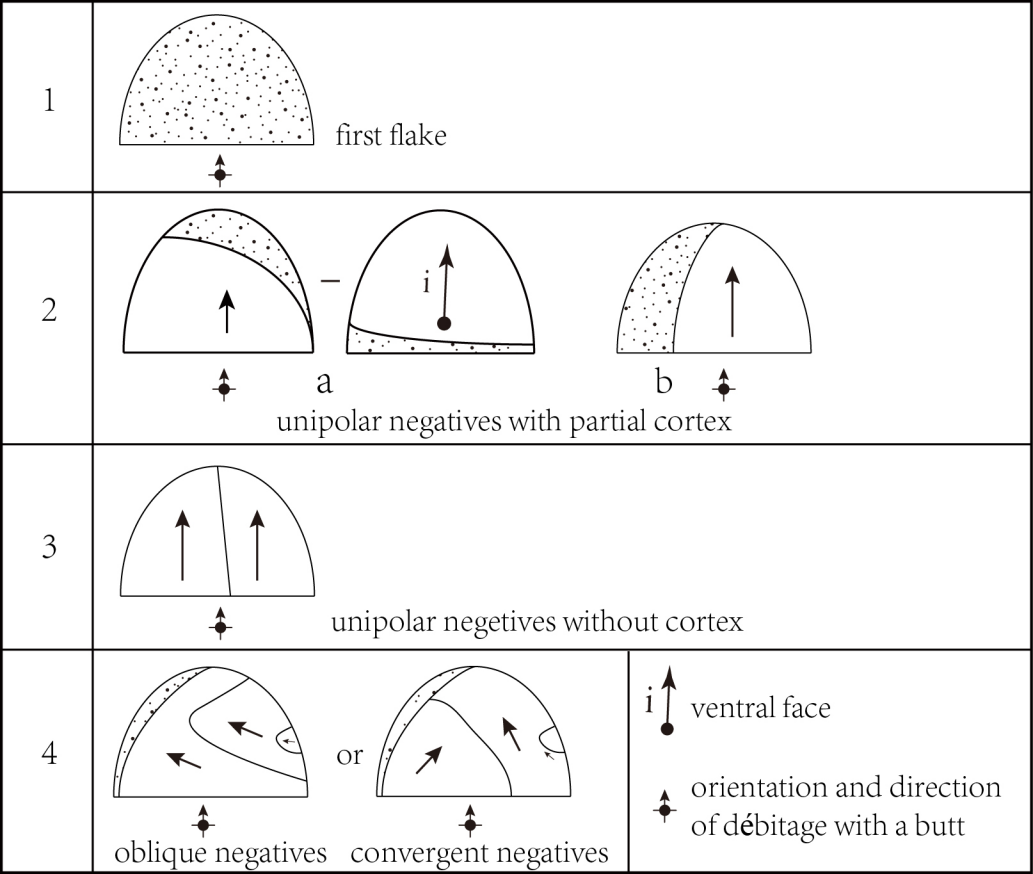
2


1
2
3
0
5cm
S1
S2
S2
S1
?
S
S
4
Diaclase
S1
Diaclase
S
5
S

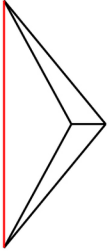

Use-wear
?
4
5
3′
3
2
1
0
5cm
?
I
I
3
2
3′
1
Direction of knapping and without counter-bulb
Direction of knapping and with counter-bulb



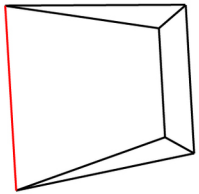
← 1 early period of shaping work 75° potential cutting edge and angle


1
first flake
2
i
a
b
unipolar negatives with partial cortex
3
unipolar negetives without cortex
4
or
oblique negatives
convergent negatives
i
ventral face
orientation and direction
of débitage with a butt

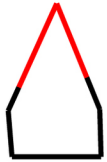
1



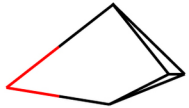
2



3



4

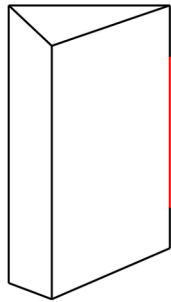


5

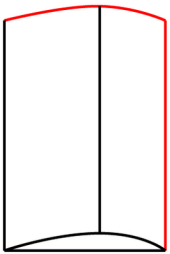
6

7

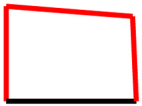
8



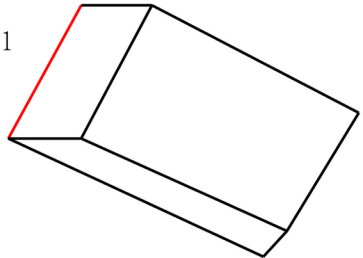
9



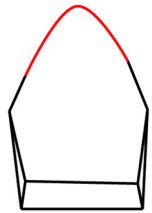
10

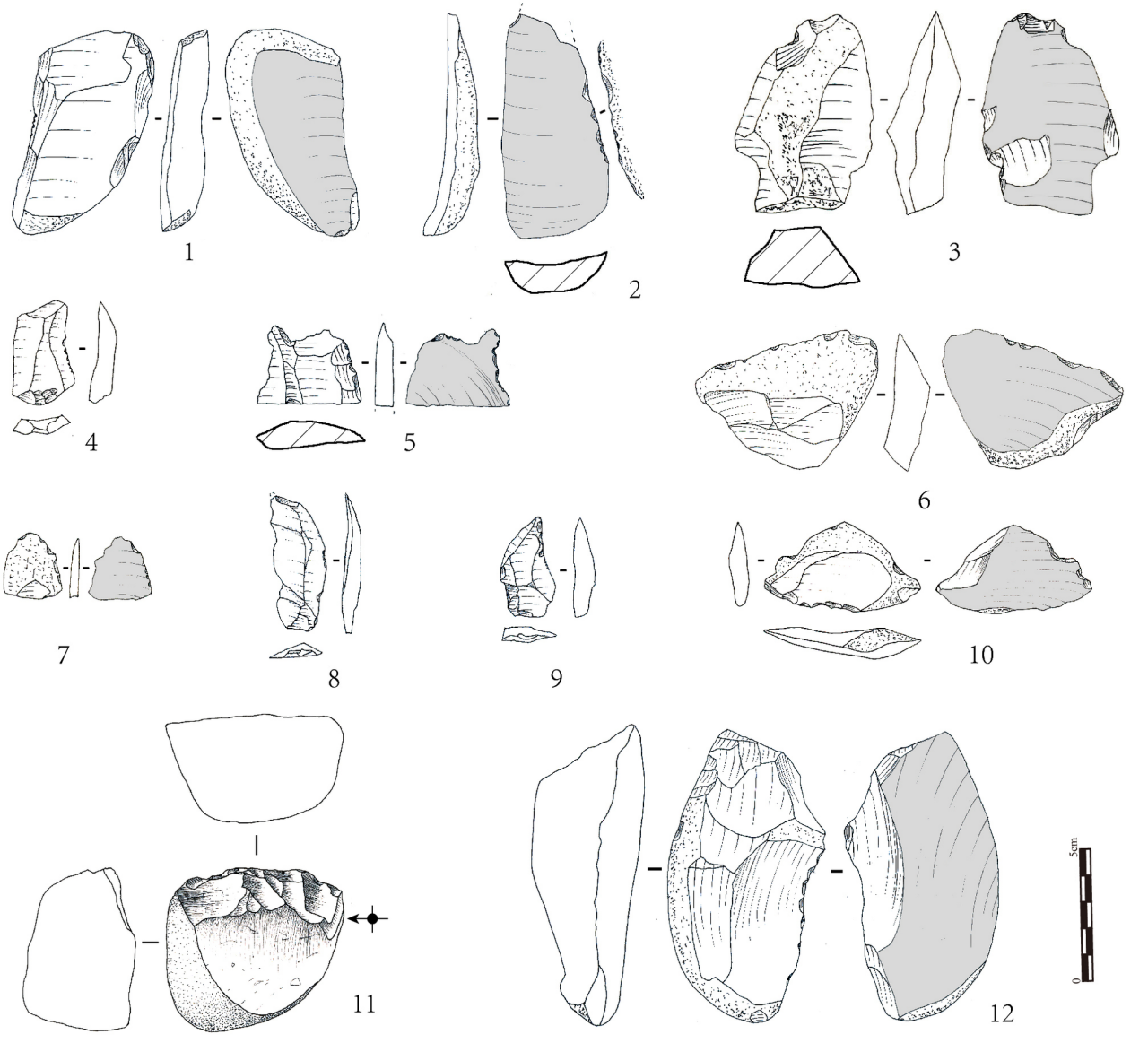


11



12




1
2
3
4
5
6
7
8
9
10
11
12
5cm
0


1
2
3
4
5
6
0
5cm
7
8

Stratigraphy of the east part	Conventional and AMS ^{14}C dating (yr BP)	Stratigraphy of the west part	Conventional and AMS ^{14}C dating (yr BP)	U-series (on fossils)
East 1	6 880±125			
East 2	9 250±90			
East 3	10 840±580	Upper part of West 1	10 020±290	
East 4	13 170±590			
East 5	13 905±250	Lower part of West 1	17 680±300	
East 6	14 240±230	West 2	12 420±180 19 145±180	
		West 3	17 930±410	
East 7	11 670±150 19 090±200	West 4	Top: 20 960±150 Bottom:25 920±625	
East 8	20 240±660	West 5		
		West 6		28 000±2 000
		West 7		
		West 8		
		West 9		
		West 10	36 000±2 000	
References	(Yuan 1990a; Yuan et al. 1995, 1997; Yuan and Gao 1994)		(Yuan 1990a; Yuan et al. b, 1995, 1997)	(Yuan et al. 1990b)

Note: the grey color indicates the thick calcareous plate (big flow stone) across the main chamber of the cave site

Category		Lower unit	Upper unit	Total
Cores (*débitage*)		8	11	19
Bipolar-split products (*débitage*)		2		2
Shaped cobble tools (*façonnage*)	Typical end chopper	2	14	16
	Chopper with an abrupt front		5	5
	Chopper with a plane front		1	1
	Double-chopper	1	1	2
	Side chopper	1	1	2
	Special side chopper	1	3	4
	Chopper of special volumetric structure		4	4
	Shaped disc		1	1
Flakes (from *débitage* or *façonnage*)	Flake tools	39	29	68
	Unmodified or unused	110	22	132
Others	Broken blocks	61	5	66
	Debris	73	1	74
	Unidentified pieces	6	1	7
	Partial and fully polished cutters	1	2	3
	Donut stones		5	5
	Perferated stones		2	2
	Grinding stone		1	1
Total		305	109	414