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The first lithic industry of mainland Southeast Asia: Evidence of the earliest hominin in a tropical context

Les premières industries lithiques d'Asie du Sud-Est continentale : évidence des premiers hominines en contexte tropical

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ABSTRACT:

Recent discoveries of ancient sites in mainland Southeast Asia confirm the presence of old lithic industries as early as 0.8 Ma, i.e., at the transition between the Early to Middle Pleistocene. Although these open-air sites still require geochronological and biostratigraphic precisions, they allow us to understand the oldest vestiges of human presence in the tropics and the technical orientations chosen by these hominins. This article aims to present an objective and critical synthesis of the material discovered at the main sites. Some sites in Cambodia and Thailand have been the subject of archaeological field missions by the Ministère de l'Europe et des Affaires Étrangères (MEAE).

The diversity of lithic tool types and manufacture methods encountered from the Middle Pleistocene in peninsular Asia shows a technical variability that stands out as a counterexample to diffusionist hypotheses of a cultural fabrication inherited from the West. The diversity of production methods, tools, and raw material matrices remains incomparable to those encountered in the West, Africa, or South Asia. To date, only evidence from China has allowed us to put forward the hypothesis of a common technical basis that would have spread from its southern territories; however, this hypothesis is currently under debate. Researchers have proposed the idea of continuous technical progress and the shift from heavy industry to a lighter and polished stone in Southeast Asia. However, the omnipresence of the pebble prevents a clear conclusion because these technical objects from Southeast Asia are quite simply incommensurable; a chopper in these regions may not be comparable with another chopper from the terraces of the Garonne or the Roussillon in France, for example. In other words, these tools are above all 'tropical' tools, and they belong to a distant cognitive world(s) with specific use(s), gesture(s), and meaning(s), making it impossible for them to be compared or evaluated by our faculty of Western judgment.

Keywords: Mainland Southeast Asia, Middle Pleistocene, Pebble tool, Handaxe, Lithic assemblage

RÉSUMÉ:

Les récentes découvertes de sites anciens en Asie du Sud-Est continentale confirment de la présence de vieilles industries dès 0.8 Ma, c'est-à-dire à la transition entre le Pléistocène ancien et moyen. Même si ces sites de plein air nécessitent encore des précisions géochronologiques et biostratigraphiques, ils permettent d'appréhender les plus anciens vestiges de la présence humaine sous les tropiques et les orientations techniques choisies par les hominines. D'un point de vue typotechnique, un ensemble de critères confirme l'hypothèse anthropique de ces objets qui affichent une variabilité étonnante pour une période aussi reculée du Quaternaire dans une Asie tropicale encore à découvrir. Cet article a pour objectif de présenter une synthèse objective et critique du matériel découvert sur les principaux sites dont certains au Cambodge et en Thaïlande ont fait l'objet de missions de terrain archéologiques du MEAE. La diversité des différents types d'outils lithiques et des modes de fabrication rencontrés dès le Pléistocène moyen en Asie péninsulaire, montrent très tôt une

variabilité technique qui s'impose à la fois comme un commencement et comme un contre-exemple à toute explication diffusionniste d'une nappe culturelle héritée de l'Ouest. La diversité des modes de production et des outillages mais aussi des matrices des matières premières, restent incomparables à celles rencontrées en Occident, Afrique ou en Asie du Sud. Seule la Chine permet à ce jour d'avancer l'hypothèse d'un fond technique commun qui se serait répandu depuis ses territoires méridionaux et encore, rien n'est absolument certain. Est-il possible, au fond, de parler de progrès techniques continus et de passage d'industrie lourde à plus légère puis à la pierre polie en Asie du Sud-Est? L'omniprésence du galet nous empêche de répondre en nous rappelant que ces objets techniques rencontrés en Asie du Sud-Est sont tout simplement incommensurables, autant que peut l'être un chopper dans ces régions avec un autre trouvé des terrasses de la Garonne ou du Roussillon en France. Autrement dit, ces outils sont des outils avant tout « tropicaux » et ils appartiennent à des mondes cognitif(s), d'usage(s), de geste(s), de sens trop éloignés pour qu'ils puissent être comparés ou évalués par notre faculté de juger occidentale.

Mots clés: Asie du Sud-Est continentale, Pléistocène moyen, Outil sur galet, Biface, Assemblage lithique

« La compréhension des problèmes européens nécessitant les données de l'Asie, nous commencerons par celles-ci. »
F. Bordes 1968, *Le Paléolithique dans le Monde*, p. 83.

1. Introduction to the prehistory of mainland Southeast Asia

Before introducing the Early Paleolithic lithic evidence from mainland Southeast Asia, we would like to return to the wording of our title and to the term 'first tools', which is used here in its broadest sense, in terms of a beginning or start. The term 'first' was preferred to 'archaic' which, for us, is too restrictive if not pejorative from a cultural and cognitive point of view. In our opinion, the term 'archaic' is also abused in prehistory to subjectively qualify, on the one hand, a state of a civilization and, on the other hand, would imply a value judgment on what must *de facto* be a 'before' with the capacity to justify an 'after'. Consequently, there would be an implicit evolutionary tendency against a deterministic background of linear causality, which is nothing more than an imagined and imaginative intellectual construction that is too often found in the history of techniques over the long period of prehistory. In other words, to make people believe in a linear causality that in fact does not exist in the progressive sequence of tool types during the Paleolithic, particularly in Southeast Asia.

1.1. What is mainland Southeast Asia?

First and foremost, it is a land of transition and a crossroads of migrations. This southeastern part of Asia differs from East Asia (China) from a geo-climatic point of view, since it has a hot and humid tropical climate with high annual rainfall. The whole of Southeast Asia is more maritime than continental, covering 4.5 million km² of land and 9.3 million km² of sea. This Indochinese Peninsula of approximately 2 million km² includes six countries, all unified by the monsoon and with no desert divide, which has favoured incredible plant biodiversity and extensive rainforests in Myanmar (Burma), Thailand, Cambodia, Laos, Vietnam, and Malaysia. Located at the end of the Asian continent, from which it is separated by mountain ranges originating from the Himalayan foothills, it constitutes the tropical end of the continent.

Mainland Southeast Asia, situated between the Indian subcontinent and South China and working as an open door to the south (the Indonesian archipelago), is an outward-looking crossroads

whose biodiversity is so high that it sometimes challenges the idea that it is a region. The term 'Southeast Asia' is itself an exogenous crucible, a hub for gene and cultural flows.

These territories form the terrestrial and mountainous face of what is known *sensu largo* as Southeast Asia, to which must also be added nearly 20,000 islands and islets spread over two archipelagos (the Philippines and Indonesia) and a large isthmus (Kra-Malaysia), signalling the transition between the Indochinese Peninsula and the islands in the intertropical zone.

The geographical area of interest in this article is the Indochinese Peninsula of Southeast Asia located within the Himalayan and Tibetan foothills, which are characterised by an abundance of natural hydrographic channels such as the Mekong, the Chao Phraya, the Irrawaddy, the Salween, and the Red River. This Asia of large rivers and deltas appears as a cultural crossroads very early in the history of the first human migrations, particularly those that interest us in the Early-Middle Pleistocene. It should also be noted that the island domain has been relatively frequently connected to the present continent due to eustatic variations related to glacial and inter-glacial phenomena. The islands and the present continent constitute the Sunda shelf.

1.2. How to introduce the prehistory of mainland Southeast Asia?

Without creating a duality with Indonesian Java and its rich fossil sites, we would state that there is an exception in the mainland that is not only environmental but also cultural. An exception that is rooted in an international scientific controversy with the 'Movius Line' (Movius, 1948), which posed the problem of the spatio-temporal limits of the diffusion of the Acheulean bifaces from Africa to India and their disappearance in Southeast Asia with the arrival of pebbles: "Perhaps the most salient feature characterizing the Lower Paleolithic culture complex of Southeastern Asia, Northern India and China as a whole is the absence of certain characteristic types of Lower Paleolithic implements (hand-axes and Levallois flakes), as much as it is the presence of others (choppers and chopping-tools)" (Movius, 1969, p.72).

In other words, the prehistory of mainland Southeast Asia would not exist without this famous line which, as Marcel Otte has reminded us, designates 'un voile plutôt qu'une ligne (a veil rather than a line)' (Otte, 2010a, 2019). In our opinion, the famous Movius line and what has been said about it by different authors has, over the years, become a smokescreen because these earlier Paleolithic implements could not be defined by their form or group type within a geographical space. This is also the reason why we name these tools in a similar way, albeit having some technological differences and contradictions: chronocultural objects of a Prehistory without a homeland. The difficulty lies in finding the pieces of a large puzzle that has neither a periphery nor center.

To conclude, the Movius line should not be considered as the 'Great Wall', because humans have crossed it to travel to tropical regions. The line should be unveiled, informed, or re-questioned through the particularities of human productions such as they appear from the Middle Pleistocene. We aim to assess the first cutting stone tools discovered in the six countries of mainland Southeast Asia. In addition, we consider data from the major sites in southern China, which now suggest the hypothesis of a pre-tropical 'homeland' in the border foothills of Yunnan and Guangxi (Fig. 1).

Fig. 1. Map of the ancient Paleolithic sites mentioned in the text. 1. Bose, 2. Modaozhan, 3. Yuanmou, 4. Gantangjing, 5. Irrawaddy sites, 6. Lampang, 7. Sao Din, 8. An Khê, 9. Mekong terrace localities, 10. Lenggong.

Carte des principaux sites paléolithiques anciens mentionnés dans le texte.

H.-L. Movius, in his own way, arbitrarily delimited two worlds, one with handaxes in Africa, the Near East and India, and another with unifaces (chopper-chopping tools) in China and the Far East. He openly asked the question of the similarities and differences between the artefacts from the West and East: the presence or not of a cultural frontier in the Early Paleolithic between South Asia and East/Southeast Asia.

The presence of numerous biface sites in East Asia, such as in China around 1.0 Ma and in mainland Southeast Asia, demonstrate the falsity of the Movius model. However, Movius was correct about one element: the preferential choice of pebbles as raw material for knapping. River quartz, quartzite, or hornfels pebbles, which are very well represented for tool-making in the subtropical and tropical Far East, were preferred to flint blocks. Thus, Movius' famous line can be assumed to be half true, i.e., 50% true, 50% incorrect, but it has become a 'model' to its detriment. The line is true because there is obviously a preference for pebbles as raw material for different *chaîne opératoires* (shaping and debitage). It is also incorrect from a technological perspective, as there is a great diversity of shaping (bifacial, unifacial, etc.) and debitage operations, which cannot be fitted into a linear evolutionary framework. A pebble as a cultural, temporal, and spatial boundary is perhaps not the most relevant cultural-technical marker, especially when we know that most lithic tools in mainland Southeast Asia were preferentially made on pebbles in the diachrony from the Early Paleolithic to the Neolithic (Forestier, 2020). We observe that this diversity is already very present from the Early Paleolithic and that it is difficult to precisely define a particular technical culture for this period in Southeast Asia. For this reason, we use the historical names of the different technocomplexes created for this region in this article.

2. South China: a pre-peninsular cultural homeland

2.1. Bose sites, Guangxi Zhuang Autonomous Region

2.1.1. Geographical and chronological context

The Basin of Bose is situated about 200 km northeast of Nanning City, Guangxi Zhuang Autonomous Region. It is long and narrow, being 100-80 km long and 15-10 km wide. The Youjiang River, a branch of the Xijiang River, passes through the basin. The basin formed at the beginning of the Tertiary and has seven terraces (T1-T7). It adjoins the Yunnan-Guizhou Plateau in the western extremity and borders on northern Vietnam (de Lumley et al., 2020; Yuan et al., 1999).

The basin yields a complex comprising more than 120 Paleolithic sites on the terrace T4 of the Youjiang River (de Lumley et al., 2020; Xu et al., 2012). Since the 1970s, handaxes have been fortuitously discovered, but often on the surface (Huang et al., 1990; Huang and Zhang, 2010). More recently over the last two decades, several sites (e.g., Fengshudao, Damei Nanbanshan, Baigu, Gaolingpo) containing *in situ* handaxes have also been excavated (Hou et al., 2000; Wang et al., 2006, 2014; Xie et al., 2018; Xie and Bodin, 2007). According to the $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the tektites coexisting with the handaxes, the age of the bifacial assemblages from the T4 is generally attributed to around 0.8 Ma (de Lumley et al., 2020; Hou et al., 2000). However, whether the age of the tektites could represent that of the stone tools remains debated (Langbroek, 2014; Wang and Bae, 2015).

2.1.2. Raw materials of the lithic assemblages

The raw materials are essentially composed of cobbles of sandstone, quartzite and quartz, while silicified limestone, limestone, conglomerate, basalt and chert are very rare (de Lumley et al., 2020; Guangmao et al., 2003; Hou et al., 2000). These cobble materials are available from the basal conglomerates of T5 through to T7 during the phases of artefact manufacture and deposition (Hou et al., 2000); however, more recent ge archaeological research suggests that the T4 gravel bed may also have provided cobbles for the knappers (Wang et al., 2014). The size of the selected river cobbles ranges from several centimeters to more than 20 cm, and the shaped tools are generally larger than 10 cm (Hou et al., 2000; Wang et al., 2014).

2.1.3. The lithic categories and technological characteristics of the handaxes

Based on data from four well-excavated sites yielding *in situ* bifacial tools, i.e., Fengshudao, Namei Nanbanshan, Baigu, and Gaolingpo, we could reliably evaluate the quantitative importance of the different tools and production systems (Table 1).

First, the cores are generally rare, although they are more frequent at Fengshudao and Damei Nanbanshan. Three core production methods were identified: bipolar, orthogonal, and discoidal (de Lumley et al., 2020; Wang et al., 2014).

Second, the shaped tools are mainly produced with unifacial knapping and bifacial working is not common. The choppers dominate the toolkit (except at Fengshudao); they often have transversal cutting edges. The convergent choppers are numerous and often have one or two lateral cutting edges associated with a distal working edge. Handaxes are far less encountered (<5% of the assemblage at each site), and they are rarely made on flakes except for several pieces identified at Fengshudao and Yangwu (Bodin, 2011; de Lumley et al., 2020). Unifaces or discs are present but rare; chopping tools are almost absent (Bodin, 2011; de Lumley et al., 2020). Picks are relatively common at the different sites. Cleavers are very rare (<1%); they were excavated in Damei Nanbanshan and Baigu, and surface finds were identified at Fengshudao.

Third, a small quantity of flake tools is present (<10% of the toolkit); the support is a shaping flake or from core debitage (Bodin, 2011; de Lumley et al., 2020).

The handaxes are the main subject of debate; however, they generally present individualised metrical and morpho-techno-functional characteristics at Bose. The knapping work is usually not intensive, and the majority of the handaxes contain a natural cortex, which covers 10%-80% of the surface (usually presenting a cortical and thick butt). Knapping mainly aims to create the needed working edges rather than a general volume (Bodin, 2011; de Lumley et al., 2020; Gao, 2012). The blanks are rarely flakes; they are dominated by river cobbles ranging in size from 13 cm to 29 cm. Blanks are rarely elongated and are of variable thickness; the width/thickness ratio is less than 1.5 for half of the blanks (Bodin, 2011). As recognised by many researchers (e.g., Bodin, 2011; de Lumley et al., 2020; Gao, 2012; Lin, 1996; Wang et al., 2012; Xie and Bodin, 2007), Bose handaxes, like other Chinese handaxes, seldom have lateral and bifacial symmetry, making them unlike typical Acheulian handaxes. In contrast, some scholars conclude that Bose and other Chinese handaxes are similar to the Acheulian facies (Lei et al. 2021, Li et al. 2014, Li and Li 2017, Kuman et al. 2014). The morphology of Bose handaxes is variable and irregular (Bodin, 2011; de Lumley et al., 2020; Gao, 2012; Moncel et al., 2018a). These tools often have a distal convex cutting edge associated with one or two longitudinal edges (Bodin, 2011). This edge is a notable character of Bose handaxes (and picks), and it is named 'tongue-like edge' by some researchers (e.g., de Lumley et al., 2020; Li et al., 2021; Wang, 2021) (Fig. 2).

Table 1

Categories of lithic tools found *in situ* at the Bose sites.

Catégories d'outils lithiques découverts in situ sur les sites de Bose.

Fig. 2. Examples of handaxes from Bose, China. 1-3. Fengshudao (de Lumley et al., 2020); 4. Gaolingpo (Bodin, 2011); 5. Damei Nanbanshan (Bodin, 2011); 6,7. Baigu (de Lumley et al., 2020)
Exemples de handaxes de Bose, Chine.

2.1.4. Summary of the Bose industry

The tools from Bose are mainly made on river cobbles, and the flake blanks only account for 10% of the tools. The concept of shaping dominates the production, while debitage is rare (Bodin, 2011). The toolkits at different sites are predominated by choppers on massif cobbles with concise knapping work to obtain the needed cutting edge. The chopping tool is absent, and other types of tools are also rare or few in number, such as handaxes, picks, unifaces, and flake tools (de Lumley et al., 2020). Handaxes are present, but their morphology, technology, and small quantity in the toolkit are generally different from their western counterparts, making the hypothesis of local development or convergence feasible (Bodin, 2011; Derevianko et al., 2016; de Lumley et al., 2020; Gao, 2012; Moncel et al., 2018b; Otte, 2010a, 2010b).

The biface is a well-represented object, but another emblematic tool of the 'Chinese Acheulean' is probably the cleaver. The cleaver is not well represented in China (e.g., Bose sites) or in the majority of sites during this period in Southeast Asia, but it could be a special tool in the tropical regions as noted by Chavaillon (1979, p. 77): "Le hachereau se révèle essentiellement un outil des régions chaudes. On le trouve en Chine, aux Indes et en Syrie. Mais l'Afrique est, de loin, le continent le plus riche. Cet outil est d'aussi lointaine origine que le biface, avec un tranchant plus aigu acquis progressivement. (...) Il devient alors un des outils les plus représentatifs de l'Acheuléen tropical. On le trouve plus tard au Maghreb, en Espagne et même en France. Dans de telles régions, il reste toutefois exceptionnel". The question of the presence of the cleaver is still a current scientific problem, especially since its association with other tools types is not yet resolved. Data from East and Southeast Asia are expected to provide new information on the presence of this particular tool in subtropical and tropical forest environments.

2.2. Modaoshan site, Guangdong Province

2.2.1. Site location and history of excavation

The Modaoshan open-air site is situated in the Hedu Village, Yunan County, Guangdong Province (22°50'40"N, 111°41'44"E). It is located in the northeastern part of the Nanjiang Basin and on the terrace T4 of the Nanjiang River; the site's elevation is 103 m, and it is 75 m above the river. The site was discovered in 2013 by the Guangdong Provincial Institute of Cultural Relics and Archaeology (GPICRA) and excavated at Locality 1 from April to August in 2014 by a joint archaeological team consisting of the GPICRA, Peking University, and local museums. The area of excavation was 200 m² and reached the gravel layer. A total number of about 400 pieces of lithic artefacts were excavated, neither fauna nor tektites were found (Liu, 2017).

2.2.2. Stratigraphic and chronological context

Eight natural layers were distinguished, and the lithic assemblages mainly come from layer 6B. A small number of samples lost their original stratigraphy, but they have the same raw material composition and technological characteristics as those of *in situ* artefacts. The stone artefacts are mostly impregnated with white or yellow netting marks, and the overall degree of weathering is high. Some have a certain degree of rounding, but most of them have clear cutting edges and are well preserved. The direction, inclination, and inclination angle of the lithic artefacts are variable. This suggests that they were buried *in situ* and partially affected by weak hydraulic forces (Liu, 2017). According to geological research in this area, the age of terrace T4 is Q1-2 or Q1, and the absolute age is around 0.8-0.6 Ma. Based on the geomorphic location, stratigraphic horizons, and cultural features, the overall age of the lithic assemblages at Modaoshan Locality 1 may reach the early stage of the Middle Pleistocene. The age of the assemblages should be the same as the formation of the terrace T4 (Liu, 2017).

2.2.3. Lithic artefacts

The published lithic artefacts include several surface collections, which are often of ‘beautiful’ pieces. The raw materials are mainly river cobbles of quartz, sandstone, and quartzite, with a small amount of fine sandstone and metamorphic sandstone, which is equivalent to the gravel found in the gravel layer near the site. The lithic categories include core, flake, tool, manuport, fragment, and debris (Fig. 3). A small number of tools are present (Liu, 2017).

The cores are mainly of single-platform with only one removal, multi-platform is rare and there is no core preparation, both the striking platform and flaking surface are natural. The blanks obtained are of different sizes and shapes. The tools are mainly on cobbles and fragments; flake blanks are rare. The shaping method is dominated by unifacial knapping (choppers); bifacial working was observed among the handaxes and picks. The shaping work is often concise with the aim to create the cutting edge, and the basal part of the blank is usually unmodified. The picks and bifaces seem to have a more or less pointed edge at the distal end (Fig. 3 nn 1-3, n 5), unlike those of Bose, which often have a tongue-like edge at the extremity. The shaped tools are of large-medium size. Quantitatively, products belonging to the shaping concept are more numerous than those of the debitage. The knapping technique is direct percussion with a hard hammer (Liu, 2017).

Fig. 3. Lithic tools from the Modaoshan site, Guangdong Province, China. 1. Biface; 2. Pick (surface collection); 3. Biface (surface collection); 4. Chopper; 5. Pick; 6. Scraper on flake; 7. Single-platform core, single removal; 8. Single-platform core, recurrent removals (after Liu, 2017).

Outils lithiques du site de Modaoshan site, Guangdong Province, Chine. 1. Biface; 2. Pic (collection de surface); 3. Biface (collection de surface); 4. Chopper; 5. Pic; 6. Racloir sur éclat; 7. Nucleus à une surface de plan de frappe; 8. Nucleus à une surface de plan de frappe (d’après Liu, 2017).

2.2.4. Summary of Modaoshan industry

Both shaping and debitage coexist at the site, but the former dominates. Unifacial tools such as choppers are more often encountered than bifacially shaped tools, although the precise proportion of the different tools is not currently available.

2.3. Yuanmou site, Yunnan Province

2.3.1. Site location and history of excavation

The Yuanmou site is situated in the Shangnaba Village in the Yuanmou Basin, Yunnan Province, southwest China. The site is famous for the discovery of two hominin incisors assigned to *Homo erectus* by the geologist Qian Fang in 1965. However, these fossils were collected from the surface of the bottom of a small hill which is composed of brown clay. In 1973 and 1975, the site was excavated by an archaeological team from IVPP (Institute of Vertebrate Paleontology and Paleoanthropology) and local museums. Human fossils were not discovered during these excavations, but seven stone artefacts were excavated from the brown clay layers (which were said to have yielded the human fossils), and ten other pieces were collected from the site’s surface (Zhang and Zhou, 1978).

2.3.2. Chronology

The age of the human fossils has been much debated over the past decades. Based on research on the geo-stratigraphy, fauna, and absolute dating, different ages for the fossils have been proposed: Early Pleistocene (1.7 Ma) (Li et al., 1976; Liang et al., 1988; Pu and Qian, 1977; Qian, 1985; Zhu et

al., 2008), 1.6-1.1 Ma (Huang and Grun, 1998; Wu and Qian, 1991), and Middle Pleistocene (0.7-0.5 Ma) (Hyodo et al., 2002; Liu and Ding, 1983). The general consensus seems to be the Early Pleistocene (1.7 Ma), and this age has been recently confirmed by the isochron $^{26}\text{Al}/^{10}\text{Be}$ burial dating method (Luo et al., 2020).

2.3.3. *Lithic artefacts*

The Yuanmou lithic assemblage is composed of seven *in situ* artefacts and ten surface finds, some of which have no clear technological characteristics. Among the *in situ* samples, four pieces were identified as scrapers, and the raw material was small quartz pebbles. As for the surface collections, three pieces were identifiable: one pointed tool, one bifacial core containing cortex, and one flake. The artefacts are smaller than 60 mm (Zhang and Zhou, 1978; Zhu et al., 2008) (Fig. 4). The knapping technique would have been direct percussion with a hard hammer (Wen, 1978; Yuan et al., 1984).

Fig. 4. Lithic artefacts made on quartz from the Yuanmou site, Yunnan, China. 1. Scraper on flake; 2. Small core (quartz) (after Zhu et al., 2008).

Matériel lithique sur quartz du site de Yuanmou, Yunnan, Chine. 1. Racloir sur éclat; 2. Nucléus (quartz) (d'après Zhu et al., 2008).

2.3.4. *Summary of the Yuanmou industry*

Based on the limited information on the lithic artefacts, we conclude that the Yuanmou site is characterised by debitage on small quartzite pebbles. The knapping method may be orthogonal (evidenced by the bifacial core) with application of a hard hammer. The shaping concept is absent among the assemblage. Zhu et al. (2008) consider that the lithic industry at Yuanmou appears to be quite similar to African Oldowan artefacts made of quartz or quartzite and related to a forest-grassland environment indicated by the pollen and faunal remains (Zhang and Zhou, 1978).

2.4. *Gantangjing site, Yunnan Province*

2.4.1. *Site location and history of excavation*

The Gantangjing open-air site is situated in the Shanglongtan Village, Jiangchuan County, Yunnan Province. It was discovered in 1984 and excavated in 1989 by the Yunnan Provincial Institute of Cultural Relics and Archaeology. A large number of stone artefacts, bones, and abundant mammal fossils were unearthed. In order to gain an in-depth understanding of the site's stratigraphy, chronology, and cultural characteristics, the site was re-opened for excavation from 2014 to 2015 (Liu, 2016; Zhang et al., 1998).

2.4.2. *Stratigraphic and chronological context*

The site is located in the depression between the ancient Fuxian Lake, and the stratum is lakeside marsh deposits. During the 1980s excavation, six natural layers within a depth of about 2.2 m were revealed; cultural remains and animal fossils are mainly from the sixth layer. Based on the faunal remains (similar to the Yuanmou fauna) and geo-stratigraphy, the site was estimated to be from the Early Pleistocene (Zhang et al., 1998).

The stratigraphy was refined in recent excavations. According to the published preliminary report on the excavation (Liu, 2016), a total of 20 natural layers were distinguished within a depth of about 6

m. More than 25,153 stone artefacts, 28 pieces of bones and antlers (tools?), and tens of wood sticks (tools?) were discovered; moreover, abundant fauna and plant fossils were also associated with the artefacts. A preliminary study (i.e., Liu, 2016) indicates that the artefacts were deposited and buried in a stable and primary context without obvious transport. The age of the site was again estimated to the Early Pleistocene on the basis of faunal remains and the geological context. A comprehensive study of this important site, and its absolute aging, is in progress (Liu, 2016).

2.4.3. Lithic artefacts

During the 1980s excavation, two *in situ* stone artefacts were collected from layer 6 and both were classified as cores. The raw materials were silex and quartzite pebbles of medium-small size (Zhang et al., 1998). Recent excavations confirm the presence of a small flake-tool industry at the site. According to Liu (2016), the lithic artefacts are dominated by small pieces, including tools, cores, flakes, fragments, and debris (Fig. 5). The production method is mainly bipolar debitage of pebble on an anvil. The types of tool include scrapers, notches, and pointed tools, while the scraper dominates. In general, the Gantangjing lithic assemblage is different from the large cobble tool industry in southern China but similar to the Early Paleolithic industries in the Nihewan Basin of northern China (Liu, 2016).

Fig. 5. Examples of small scrapers from the Gantangjing site, Yunnan, China. 1. Multiple-edge tool; 2-6. Scrapers with lateral edge (after Liu, 2016).

Exemples de petits racloirs sur éclat du site de Gantangjing site, Yunnan, Chine. 1. Outil à tranchant multiple; 2-6. Racloirs à tranchant lateral (d'après Liu, 2016).

2.4.4. Summary of the Gantangjing industry

Although detailed data of the site are yet to be published, we appear to have a distinct lithic tradition at Gantangjing since the debitage system and small flake tools are very abundant. According to the excavators, the bipolar method on cobbles was intensively applied. Bones and wood sticks seem to be used as tool supports, but all these observations need further systematic study to be confirmed. The importance of the site has been recognized by the excavators; the age and cultural remains make Gantangjing a promising site for many important issues, such as the 'bamboo hypothesis' (Liu, 2016).

3. Myanmar

The Burmese territory is still a no man's land for prehistoric research, especially for the ancient Paleolithic period. The pioneering work of Movius (1948) in the pre-war years on the Irrawaddy terraces provided the first data on heavy tools dating back to the Middle Pleistocene period called the Anyathian. This lithic technocomplex, which is still poorly dated, comprises massive tools shaped on river pebbles, tuff, and silicified wood, including many choppers, chopping tools, a few unifaces with rare bifacial pieces, and flake tools. This was the first data on Paleolithic human activity in Myanmar, identified and collected by Movius on the terrace surface in the Irrawaddy Valley (Chauk, Magwe, Yenangyaung, Nyaung-U, Yesagyö). These finds were also mentioned by F. Bordes, who published silicified wooden choppers and a 'pointed uniface' made on silicified tuff (Bordes, 1968).

The so-called Arakan Yoma area in the north of the country close to the Sino-Burmese border has long been an interesting area to understand the migration of the first hominins from the Yunnan Province (Shutler and Braches, 1988). In the 1980s, research in central Burma in the Chindwin Basin (Nwe Gwe village) reported dental remains attributed to *Homo erectus* (Maw, 1993). Despite the early record of Paleolithic sites in the Ayeyarwady River valley in the 1870s (Brown, 1931), the Paleolithic

of Myanmar remains relatively unknown because of political instability and interests in historical archaeology (Aung et al., 2015). Recently, researchers have conducted the first luminescence dating in Myanmar on the Badahlin and Gu Myaung caves, both Paleolithic sites (Schaarschmidt et al., 2019). The earliest hominin traces in Myanmar include both fossilised mandible fragments of *Homo erectus*, attributed subjectively to around 0.2 Ma (Ba Maw, 1995) and the early Anyathian lithic industries (Middle Pleistocene?) previously discovered in central Myanmar by Movius and his team in the 1930s (Movius, 1943). We focus on the Anyathian lithic industries in this research.

3.1. Anyathian lithic industries: history of research and site location

Current knowledge on the Anyathian lithic industries is still largely based on the American Southeast Asiatic Expedition investigations during the 1937-1938 field season. In 2008-2009, members of the Department of Archaeology, Ministry of Culture, Myanmar, investigated the sites surveyed by the American expedition, and they found 800 Paleolithic stone implements (Aung et al., 2015), but no further information was published on these discoveries. According to Movius (1943), the principal Anyathian sites are situated on the left bank of the Irrawaddy between Magwe in the south and Nyaungu, a small village near Pagan, in the north. A few implements were also found at Minbu and Pakokku, on the right bank of the river.

3.2. Stratigraphic and chronological context

According to research on the terrace stratigraphy by Helmut de Terra and Teilhard de Chardin in the Irrawaddy Valley, five terraces could represent six stages of the river. The Middle and Upper Pleistocene and post-Pleistocene ages were given to the terraces based on the regional geological sequence. The Anyathian lithic artefacts from different terraces were divided into two periods: Early Anyathian and Late Anyathian. The former was sub-divided into three phases (Early Anyathian 1, 2, 3) and the latter two phases (Late Anyathian 1, 2). The Early Anyathian 1 and 2 were defined as belonging to the Middle Pleistocene, while the rest were defined as the Upper Pleistocene (Movius, 1943). The Anyathian lithic artefacts were collected from the surface and gravel deposits. Movius (1943) believed they were associated with the formation of the river terraces, and this point could be seen in his description of the context of the artefacts: “Early Anyathian 1.- This is always very heavily rolled and is found *in situ* in the Lateritic Gravel. Early Anyathian 2.- Early 100 implements found either in or associated with the basal ferruginous crust (ironstone hardpan) exposed under T3 at Nyaungu represent the second phase of the Early Anyathian.” (Movius, 1943, p. 346). However, their geological association with the Pleistocene river terraces has been highly criticised and doubted; considering the complexity of the geology of central Burma, the terrace’s geological sequence for central Burma is most likely invalid (Aung et al., 2015; Dennell, 2014; Hutterer, 1977).

3.3. Anyathian lithic artefacts

More than 650 objects were collected by Movius (1943, 1948), including two major types of raw material: silicified tuff and fossil woods. A small number of vein quartz and fine-grained quartzite were also exploited. The former often has a fine and homogeneous texture and is abundant between Magwe and Chauk, the Pleistocene terrace gravels of the Irrawaddy. The fossil wood is also very rich in the Late Tertiary-Early Pleistocene Irrawaddy beds (de Terra, 1943). Although three sub-phases of the Early Anyathian were defined, there is no discernible difference in the typo-technological aspects of the implements between sub-phases. Artefacts from the Early Anyathian are often heavily rolled, while those of the Late Anyathian are only slightly rolled; the Late Anyathian contains essentially the same implements, with the exception of chopping tools with alternately flaked edges (Movius, 1943).

Large implements are typical in the Early Anyathian and almost all of the specimens are over 10 cm. Most specimens are made on natural fragments of rock either in roughly tabular or in pebble form, and they usually display a large area of the cortex (Movius, 1943).

The 481 specimens were classified into 11 categories (Table 2, Fig. 6). As highlighted by Movius, the Anyathian lithic assemblages are characterised by primitive chopper-chopping tools, which are the most numerous tool type; in contrast, the bifacially shaped handaxes are absent. Flakes and cores are present in small numbers. The Early Anyathian cores all display roughly prepared striking platforms formed by the removal of a large flake from one face of a natural pebble of silicified tuff. Recurrent unidirectional removals and bifacial flaking seem to be often adopted (Movius, 1943, 1948). Most of the lithic artefacts clearly present the work of knapping. Some artefacts are heavily rolled and weathered, which makes some researchers skeptical about their nature as artefacts (e.g., Dennell, 2014; Hutterer 1977).

Table 2. Lithic categories of the Anyathian lithic assemblages, after Movius (1943, 1948).
Catégories lithiques des assemblages lithiques d'Anyathien synthétisés après Movius (1943, 1948).

Fig. 6. Tools from the terraces of Irrawaddy, Myanmar, attributed to the Anyathian. 1-2. Choppers on cobbles; 3. Single-platform core with recurrent and orthogonal removals (silicified tuff); 4-8. Choppers (hand-adzes) shaped on fossil woods (after Movius, 1943).
Outils taillés provenant des terrasses de l'Irrawaddi, Myanmar attribué à de l'Anyathien. 1-2. Choppers sur galets; 3. Nucléus à plan de frappe unique avec des enlèvements récurrents et orthogonaux (tuf silicifié); 4-8. Choppers (herminettes) façonnés sur bois fossilisé (d'après Movius, 1943).

4. Vietnam

As in the case of Burma, the very ancient Vietnamese sites, or those estimated to be, are still relatively unknown and lack stratigraphic context and precise dating. Most of the so-called 'ancient Paleolithic' sites in Vietnam, such as the controversial surface 'Acheulean' open-air workshops of Mount Do (e.g., Nui Do, Quân Yên), have not yielded convincing evidence to discuss *Homo erectus* and their tools (Boriskovsky, 1967; Pham, 1976; Van Tan, 1980). In the 1970s, the French prehistorian E. Saurin had also reported the presence of some handaxes, polyhedral pieces, choppers, and axes at the open-air site of Xuan Lôc located in the south of the country near the Mekong delta not far from the city of Ho Chi Minh (Saurin, 1971; Saurin and Carbonnel, 1974). The most recent and serious work is that of a Russian-Vietnamese team working at the An Khê sites (Derevianko et al., 2016, 2018).

4.1. The An Khê prehistoric sites

The An Khê sites are situated near the town of An Khê, Gia Lai Province, north of southern Vietnam. The sites are located on the river terraces of the upper Ba River, in a transitional zone between the Pleiku Plateau and the coastal plain of the Binh Dinh Province (Derevianko et al., 2016). The sites containing handaxes were discovered during a Russian-Vietnamese archaeological expedition in 2014 (Su and Doi, 2015). Until 2018, a total number of 23 Paleolithic localities with handaxes had been discovered during fieldwork in the An Khê area. Systematic excavations were conducted at Roc Tung and Go Da in 2015-2018 by the team, and these localities represent the earliest evidence of hominin presence in Vietnam (Derevianko et al., 2016, 2018).

4.1.1. Stratigraphic and chronological context

Different localities at Roc Tung, located on the left bank of the Ba River, generally have a similar stratigraphic context. The sites are situated on an elevated hilly plateau, and the bedrock is composed of basalt, acidic tuffs, and granite, while the overlying sediments are mainly riverine and lacustrine, including alluvial fans. Soft sediments were accumulated primarily during the final Early and Middle Pleistocene. The upper layer was heavily disturbed by human activities and natural factors to a depth of 20-30 cm and even 100 cm. Pilot excavations demonstrated that cultural layers belong to a single stratigraphic horizon; the cultural layer was deposited in a red-coloured lateritic unit of mosaic pattern (Derevianko et al., 2016, 2018).

The Go Da site, located on the right bank of the Ba River, appears to have a different stratigraphy. Unlike the Roc Tung sites, the cultural horizon at Go Da was found directly in the weathering crust and slope wash sediments, and no distinct red laterite layers (which would attest to hot and humid conditions) were found. The sedimentation processes on the right bank of the Ba appear to have differed significantly from those on the left bank. Based on stratigraphic positioning, the Lower Paleolithic sites on the right bank are somewhat older than those on the left bank. About 200 *in situ* tektites associated with bifacial artefacts were recovered, and two samples from Go Da and Roc Tung 1 were dated. A date of 806 ± 22 ka BP was obtained for the cultural layer at Go Da, while the Roc Tung 1 cultural layer was dated to 782 ± 20 ka BP (Derevianko et al., 2018).

4.1.2. Lithic artefacts

Four years of investigations found approximately 1200 lithic artefacts, including 872 pieces recovered from cultural horizons and more than 300 pieces collected from the surface. The tools were mainly produced out of pebbles and, in rare cases, out of rocks. Quartz, quartzite, and sometimes chert were used as raw materials. Course-grained vein quartz was the main raw material in the Ba River basin, and quartzite was seldom used. Inhabitants of the sites appear to have collected the raw material in the river valley. The excavators hypothesise that the stone tools found *in situ* in a cultural layer or on a surface form a single homogenous techno-typological complex at all localities, i.e., all localities revealed similar typo-technological lithics (Derevianko et al., 2016, 2018). The tools were classified into eight main categories (Table 3). Only 11 handaxes were identified. The dominant large tool types include chopper-chopping tools, picks (mostly unifacial working), and spurred tools (unifacially worked tool with a convergent pointed edge) (Derevianko et al., 2018). Cores and tools were mostly made on pebbles and boulders varying in size and shape. Tools were rarely made on flakes, but unretouched flakes were occasionally used (Derevianko et al., 2016, 2018).

The handaxes were made on large, elongate, triangular pebbles with a lenticular profile and cross-section. Handaxes on flakes were not identified. The convergent edge of such tools exhibits bifacial removals, while the rest of the tool is cortical. Some artefacts also show evidence of additional working near the 'butt' of the biface. The picks were made mostly on large pebbles and boulders and are generally large and heavy. Only the pointed working edge was subjected to knapping, while the rest of the mass remains unmodified (Derevianko et al., 2018) (Fig. 7).

A small number of cores were identified. They are often made on pebbles with only one or two removals. The striking platform and flaking surface are rarely intentionally configured; sometimes, the striking platform was prepared by one or several removals. Some cores demonstrate several flaking surfaces. Amorphous flakes of varying size were detached from such cores. Radial cores are occasionally encountered, with a round shape and lenticular profile and cross-section. Most of them exhibit a prepared striking platform and large flakes were produced via centripetal removals (Derevianko et al., 2018).

Table 3. Lithic tool types at An Khê localities (after Derevianko et al., 2016, 2018).

Types d'outils lithiques trouvés dans les localités d'An Khê (d'après Derevianko et al., 2016, 2018).

Fig. 7. Examples of shaped tools from An Khê (Roc Tung 1 locality). 1, 2. Handaxes; 3. Pick (after Derevianko et al., 2016, 2018).

Exemples d'outils façonnés du site An Khê (localité Roc Tung 1). 1, 2. Handaxes; 3. Pic (d'après Derevianko et al., 2016, 2018).

5. Thailand

In the 1950s, Teilhard de Chardin wrote an article in *L'Anthropologie* on the 'Paleolithic of Siam' which presents some information about surface discoveries from Van Heekeren's (1948): "(...) essentiellement composé de galets quartzitiques plus ou moins aplatis, éclatés marginalement, uniquement sur leur face convexe, en forme de disques, ou bien (plus souvent) de «choppers» triangulaires ou arrondis" (Teilhard, 1950, p. 547). At that time, Thailand appeared to be a virgin space for Early Paleolithic industries and traces of early human settlement in Southeast Asia. However, previously, Sarasin (1933) had collected some artefacts in the Chiang Mai and Chiang Rai areas of northern Thailand and in the central Lopburi area. All the objects described are undoubtedly not knapped, but this author had already asked the fundamental question on the relevance of using prehistoric terms such as 'Paleolithic' inherited from Western construction and incorrectly applied to local Asian lithic material. Copying the European model of cultural evolution in Southeast Asia was then again criticised by Hutterer (1976).

Van Heekeren (1948) uncovered stone artefacts on a terrace near Ban Kao in Kanchanaburi Province in west-central Thailand. These artefacts, particularly the choppers, served as the basis for inventing the Fingnoian industry by extending the regional work established by Movius (1944). The term Fingnoian, which is no longer used today, refers to the Fing Noi River, better known as the Kwai River. Another term also appeared in the 1960s-70s to designate the tufa, pebble and silicified wood industries of the Early Pleistocene of Thailand, i.e., the 'Lannatian', which is no longer used as frequently. In eight localities in the Kanchanaburi Province, Heider (1957, 1958) subsequently unearthed about 100 lithic artefacts which he attributed as Paleolithic pebble implements but which also corresponded to classical Hoabinhian cobble tools (Forestier et al., 2005) dated back to the late Pleistocene around 43 ka (Ji et al., 2016) in China and to 3.7 ka in Thailand (Forestier et al., 2013). However, such isolated objects do not have the value of 'guiding fossils' or markers of time and space, as Soriano (2003) has noted: archaic does not mean ancient. The issue of defining and dating Thai industries has been raised repeatedly (Sarasin, 1933; Hutterer, 1977; Reynolds, 1993).

For decades, the lithic material considered to be the oldest in Thailand has been found at various localities in the volcanic Lampang region of northern Thailand (Sorensen, 1976, 2001; Pope et al., 1986; Zeitoun et al., 2008). These are mostly cobble tools, but the stratigraphic position of the deposits on which this material was found is imprecise, and the samples used to date them are not directly related to the areas from which the material originates (Zeitoun et al., 2013).

5.1. Lampang

In the Lampang area (Fig. 8) at the Ban Mae Tha site, the material is described as embedded in the top of a strongly lateritic pebble conglomerate overlain by fluvial sands (Sorensen, 1976, p. 243). The so-called 'MTI/I' site is located on the highest river terrace, although its exact location is not indicated or mapped. Furthermore, this site was destroyed during a road construction (Sorensen, 2001), and Sorensen (1976, p. 249) mentioned: "(...) at site MT. I/II in Lampang, chopping-tools only account for 2% of the total number of finds" and that "the number of tools from site MT.I/II amounts to over 250". Unfortunately, this material has since disappeared and has not been illustrated or documented. The same is true for the six pieces originally found by Suchit Pritagool at the Kao Pah Nam locality.

For the south Mae Tha locality, six artefacts (L-1, L-2, L-3) and (MTS 86-1, MTS 86-2, MTS 86-3) were found in a matrix of red laterites and fluvial gravels that were thought to be from the same matrix (Pope et al., 1986). However, the stratigraphic position of the material from these localities was based on geological observations made at a distance from the localities described by Sorensen with the precisions stated above (Pope, 1985; Pope et al., 1981, 1986). A single artefact (BDM' 86-1) was recovered *in situ* from the Ban Don Mun locality to which two flakes could be associated, according to Pope et al. (1981). A basalt flow was described as directly overlying the gravel deposits containing this material (Pope et al., 1986), but it was revealed that the artefact called BDM'-86-1 (Fig. 9 n 6) was donated by Mr. Champa Pananan, who found it about 66 cm below the ground surface during the construction of a house situated below the basaltic outcrop (Champa Pananan, comm. pers.). Therefore, it is very likely that this object came from the surface of this basalt.

Twenty-five objects (choppers, chopping-tools, converging pieces, splinters, and a trihedral spike) were found between a depth of 10 cm and 22 cm (Fig. 8 and 9), in the vicinity of this site. They were found during field trips of students from the Silpakorn University within the framework of the Franco-Thai Paleolithic Mission between 2005 and 2012. A technological analysis has been carried out on these pieces, which are the result of a rather complex and precise procedure for making the cutting edge (Forestier et al., 2008) (Fig. 10).

The dating of the basalt by the Korean Basic Science Institute indicates an age of 0.55 ± 0.01 Ma by the K-Ar method (Zeitoun et al., 2013). Therefore, the oldest Thai material would be no older than this chronological limit.

Fig. 8. Location map of the Ban Don Mun (BDM1) site modified from Rasse in Zeitoun et al. (2013). (1). a) undifferentiated quaternary deposits; b) quaternary basalts; c) tertiary deposits; d) undifferentiated pre-tertiary deposits; e) sites mentioned in the text. (2). Localisation of Ban Don Mun (BDM1) site. (3). 1) alluvial plain; 2) coarse alluvial sands; 3) alluvial gravel formation; 4) basalt; 5) lithic artefact; 6) dating location; 7) Ban Don Mun temple; 8) altitude in meters. (4). Trifacial pick found *in situ* in the basaltic floor at the Ban Don Mun site (Photo: V. Zeitoun).

*Carte de localisation du site de Ban Don Mun modifiée d'après Rasse dans Zeitoun et al. (2013). (1). a) dépôts quaternaires indifférenciés; b) basaltes quaternaires; c) dépôts tertiaires; d) dépôts pré-tertiaires indifférenciés; e) sites mentionnés dans le texte. (2). Localisation du site BDM1. (3). 1) plaine alluviale; 2) sables alluviaux grossiers; 3) formation de gravier alluvial; 4) basalte; 5) artifact lithique; 6) localisation de la datation; 7) temple de Ban Don Mun; 8) altitude en mètres. (4). Pic trifacial *in situ* sur le couvert basaltique sur site à Ban Don Mun (Photo: V. Zeitoun).*

Fig. 9. Cobble tools from BDM 2, Lampang Province, north Thailand. 1. Chopper with transversal linear cutting edge; 3, 10. Convergent chopper with end-bevel; 2, 5, 6, 9. Oblique chopper; 4. Convex chopper; 7. Lateral chopper; 8. Transversal concave chopper; 11. Pick; 12. Trifacial pick. (@MPFT). *Outils sur galet du site BDM 2, Province de Lampang, Thaïlande du Nord. 1. Chopper à tranchant transversal rectiligne; 3, 10. Chopper convergent à tranchant transversal; 2, 5, 6, 9. Chopper oblique; 4. Chopper convexe; 7. Chopper latéral; 8. Chopper à tranchant transversal concave; 11. Pic; 12. Pic trifacial. (@MPFT).*

Fig. 10. Example of a diacritical analysis of two sandstone pebble tools. Lampang: MTS86-1 (chopper with convergent cutting edge and lateral preparation) and MTS 86-2 (chopping tool with transversal linear cutting edge). (@MPFT).

Exemple d'analyse diacritique menée sur deux outils sur galet de grès. Lampang: MTS86-1 (chopper à tranchant convergent avec aménagement par enlèvements latéraux) et MTS 86-2 (chopping tool à tranchant transversal linéaire). (@MPFT).

5.2. Sao Din

Initially identified by our Thai colleague Sayan Prisanchit in 1987, the site of Sao Din, located in the Nan Province in northern Thailand (Fig. 11), was the subject of a stratigraphic and technological study of the lithic material collected from 2006 onwards within the framework of the Franco-Thai Paleolithic Mission (Zeitoun et al., 2012).

After discovering several lithic artefacts on the surface at different localities around the town of Na Noi and a geomorphological analysis of the different Quaternary terraces (Fig. 11), an excavation was undertaken at the Sao Din site to locate the provenance of the material. The sandstone assemblage is characterised by thick unifacial pebble tools that rarely have a convergent edge (point), but whose morphology is similar to pebble tools from southern China dated between 1 Ma and 0.5 Ma (Xie and Bodin, 2007). About 300 pieces (n=289) were collected on the surface in nine different localities, and 172 from Sao Din alone. In addition, 34 pieces were collected in excavation sector (Table 4).

The raw material at Sao Din is composed of light brown sandstone cobbles with a minor quantity of quartzite. Lithic artefacts from different localities in the Na Noi Basin include choppers, chopping-tools, denticulates, scrapers, convergent unifacial tools, pick, unifacial cobble with transverse edge, and thick retouched flakes. Most of them are over 10 cm, and some have been classified as 'Large Cutting Tools' (LCTs) associated with a giant prismatic core (Fig. 12 and 13).

Sao Din raw material comprises 90% sandstone cobbles with rare blocks of which the largest (20-30 kg) were used as cores to produce LCTs. Other raw materials encountered are quartz and quartzite, with some rocks of volcanic origin such as basalt. The raw material preferentially chosen by the Sao Din knappers is sandstone, which offers all the dimensions necessary to manufacture a wide range of tools, as was observed among the excavation and surface collections.

This exceptional Lower Paleolithic site, which is probably comparable with Bose in China, is currently being dated.

Fig. 11. Location map and section of the Sao Din site modified from Rasse in Zeitoun et al. (2012). (1). Geological map: a) Ante-tertiary substratum of the Nanoi basin; b) Upper Quaternary terrace; c) Plio-Quaternary fluvio-lacustrine deposits; d) Lower Quaternary terrace; e) Holocene deposits; f) Sao Din site location. (2). Topographical map of Sao Din. (3), (5). Section of the Sao Din site: 1) organic horizon; 2) alluvial horizon with sandy sediments with an uncemented matrix and highly altered gravels; 3) colluvio-alluvial horizon with sandy-clayey sediments with an uncemented matrix; 4) sandy clay containing highly altered pebbles and numerous fragments of angular to rounded pebbles (altered to slightly altered), a few blocks and several altered pebbles; 5) sandy clay with a few pebbles; 6) silt and clay; 7) lithic tools. (4). Panoramic view of the locality of Sao Din (Photo: V. Zeitoun).
Carte de localisation et section du site de Sao Din modifiées d'après Rasse in Zeitoun et al. (2012). (1). *Carte géologique: a) Substrat anté-tertiaire du bassin de Nanoi; b) Terrasse du quaternaire supérieur; c) Dépôts fluvio-lacustres plio-quaternaires; d) Terrasse du quaternaire inférieur; e) Dépôts holocènes; f) Localisation du site de Sao Din.* (2). *Carte topographique de Sao Din.* (3), (5). *Section du site de Sao Din: 1) horizon organique; 2) horizon alluvial avec sédiments sableux à matrice non cimentée et graviers fortement altérés; 3) horizon colluvio-alluvial à sédiments sablo-argileux à matrice non cimentée; 4) Argile sableuse contenant des galets très altérés et de nombreux fragments de galets anguleux à arrondis (altérés à légèrement altérés), quelques blocs et plusieurs galets altérés; 5) argile sableuse avec quelques galets; 6) limon et argile; 7) outils lithiques.* (4). *Vue panoramique sur la localité de Sao Din (Photo: V. Zeitoun).*

Fig. 12. Cobble tools from Sao Din, Nan Province, northeast Thailand. 1. Chopper with convex cutting edge; 2. Pick; 3. Horsehoof; 4. Thick uniface slug-like; 5. Convergent pointed chopper. (@MPFT).

Outils sur galet du site de Sao Din, Province de Nan, Thaïlande du Nord-Est. 1. Chopper à tranchant convexe; 2. Pic; 3. Sabot de cheval (Horsehoof); 4. Uniface épais en forme de limace; 5. Chopper convergent pointu. (@MPFT).

Fig. 13. Lithic industry from Sao Din, Nan Province, northeast Thailand. 1. Biface shaped on quartz block; 2. Flake-cleaver; 3. Prismatic giant core with unidirectional removals (25 kg). (@MPFT).
Industrie du site de Sao Din, Province de Nan, Thaïlande du Nord-Est. 1. Biface façonné sur bloc de quartz; 2. Éclat—hachereau; 3. Nucléus géant prismatique à enlèvements unidirectionnels (25kg). (@MPFT).

Table 4. Stone tools of Sao Din from the different localities surveyed by the French Paleolithic Mission in Thailand. BHF=Ban Hua Fai locality; PPC=Phrathat Phu Chae locality; KS=Kohk Sewua locality; NP=Nouvelle Pagode locality; BT=Ban Tae locality; SD=Sao Din locality; KSup=Kohk Sewa locality; BS=Ban San locality; SDsup=Sao Din sup.
Composition de l'outillage de Sao Din selon les différentes localités prospectées par la Mission Paléolithique Française en Thaïlande.

6. Cambodia

Geological prospecting on the Mekong terraces in Cambodia by E. Saurin and J.-P. Carbonnel in the 1960–1970s brought to light important elements of very early human activities. Their fieldwork resulted in the discovery of several prehistoric localities with cobble tools, over a stretch of about one hundred kilometres between Stung Treng and Kratie: Chhep, Sre Russey on the right bank of the Mekong, Sre Sbau, Kantuot and Khsim on the left bank in the Kratie Province (Carbonnel, 1972; Saurin, 1963a, 1966). Artefacts from four different localities (Thalaborivat, Sre Sbau, Chhlong and Kratie), in the centre of the Cambodian Mekong terraces, have been analysed with a typotechnological method; fieldwork and new finds in 2012 confirmed the presence of these artefacts made by ancient humans in this region (Forestier et al., 2014).

6.1. Geological and chronological context of the Mekong terraces

At the Dangrek mountain chain in south Thailand, the Mekong River opens into the East Cambodian Plain. This vast pediplain results from the substratum erosion of the Cambodian basin or former *Indosinias*. The age of these continental and sub-continental formations is between the Moscovian and the Upper Cretaceous described by Fromaget (1934) and Saurin (1956). This surface is covered by fluvial Quaternary formations. Alluvial terraces are particularly well represented on the left bank of the Mekong. Fieldwork conducted between Stung Treng and Snoul (Carbonnel, 1972; Saurin, 1935a; Saurin and Carbonnel, 1964) identified four terrace complexes. These complexes are situated at altitudes of 100 m (T.I), from 40 to 45 m (T.II), from 20 to 25 m (T.III) and 15 m (T.IV) above the Mekong at low water level (Fig. 14). They are made up of fluvial deposits composed of detrital sediments: sand, silt, and pebbles, which reflect strong variations in the flow rate of the river and its tributaries.

Terraces T.I and T.II have been affected by post-depositional phenomena of pedological origin: development of laterites and carbonations (Saurin and Carbonnel, 1964).

Terrace T.II contains coarse pebble formations; this sedimentary context has yielded the most abundant lithic artefacts (Saurin, 1963a, 1966). Pebble petrography is composed mainly of filonian

quartz, quartzite, laterite issued from the erosion of the terrace at 100 m, rare basalt, and abundant rolled blocks of silicified wood. In a study of these fossil woods, Vozenin-Serra and Privé-Gill (1991a, 1991b) showed that the floral association contemporary to the Pleistocene deposits represents 'a semi-humid forest covering vast surfaces in Southeast Asia since the Mio-Pliocene' (1991b, p. 87). The sediments from terrace T.II have also yielded abundant tektites (Carbonnel, 1972; Fleischer and Price, 1964; Gentner et al., 1969; Saurin, 1935b, 1964, 1966). These indochinites are part of the dispersal of Australasian tektites and are considered to be in their original position by these authors. Direct dating of these tektites gives them an average age of 0.77 ± 0.02 Ma (Izett and Obradovich, 1992), which is usually considered to date the formation of the terrace T.II, and consequently, most of the associated collected lithic material, to the beginning of the Middle Pleistocene. Nevertheless, it should be noted that old material, such as tektites, could have been transported from older geological formations. The single case where the presence of tektites and radiometric ages are corroborated is at Mata Menge (Morwood et al., 1998).

6.2. The cobble tool collection of Mourer (1968)

The majority of the 16 confirmed stone tools gathered in the 1960s from the localities of Thalaborivat, Sre Sbau, Chhlong, and Kratie (Table 5, Fig. 14) are cobble tools and flakes issued from cobbles of sandstone, quartz, quartzite, but also a piece on silicified wood (Fig. 15 n. 6). The raw materials are local, as in most Early Paleolithic Asian sites, where milky quartz, chert, and pale fine-grained quartzite were used with silicified wood to create an active cutting edge, as mentioned by Movius (1948). The 16 worked pieces from the collection reflect a technical system of shaping (chopper-chopping tool) and a basic core reduction system with alternating striking platforms, as shown by a core geared towards the production of cortical flakes and the use of large flakes as support. Quartz and fine-grained quartzite predominate; chert is a rare but a valuable raw material for its knapping ability.

Fig. 14. Sites/stations located on the Quaternary terraces of Cambodia, modified from Forestier et al. (2014). (1). a) Paleolithic site; b) road; c) regional border; d) altitude in metres. (2). Schematic section of the quaternary terraces. 1) recent alluviums; 2) pinkish sands; 3) sand; 4) pebble; 5) basalt; 6) clay/sand; 7) trias substratum. (3). General view of the material on the Thalabovirat terrace.

Localisation des sites/stations des terrasses Quaternaires du Mékong, Cambodge, modifié d'après Forestier et al. (2014). (1). a) Site paléolithique; b) route; c) frontière régionale; d) altitude en mètres.

(2). Coupe synthétique des terrasses quaternaires: 1) alluvions récentes; 2) sables rosés; 3) sable; 4) galets; 5) basalte; 6) argile/sable; 7) substrat du triasique. (3). Vue générale du matériel sur la terrasse de Thalabovirat.

North of the Mekong (Fig. 14), in the Stung Treng district, the most important locality is Thalaborivat, with nine artefacts. Most of the tools are made of pebbles or cobbles of quartzite, white quartz and more rarely chert, such as a massive chopper on a block. None of the nine pieces is over 15 cm long. Most of the tools are chopper-chopping tools, but there are also several flakes struck from cobbles, including a milky white quartz flake with continuous retouch on the right edge. Flakes and thick half cobbles are also present and can be large, such as a piece knapped by direct hard hammer percussion along the long axis of the cobble. All these flakes bear a totally cortical dorsal face, which proves that the core reduction sequence was short, fast, and elementary, with an aim to produce large, heavy, and thick blanks.

The Thalaborivat series provides information on two associated themes: the selected raw material (no calcareous cobbles, being the most numerous material in the deposits, were knapped) and the production sequence (shaping and debitage/flake production).

The site of Sre Sbau is located between the Stung Treng and Preah Vihear districts. The site has only yielded five pieces, including a heavily blunted flake, which is not illustrated here. We observed

two technical systems: shaping and core reduction. The most remarkable piece is a chopper (Fig. 15 n. 3) which presents a classic morphology: the upper face of this tool, on a thick and heavy quartzite cobble, has been shaped to delimit a circular, denticulate, protruding cutting edge, with scalar retouch. Another marker tool from the Early Paleolithic is an artefact made of silicified wood (Fig. 15 n. 6). It can be described as a shaped bifacial tool, and both ends have been regularly rounded by abrupt retouch.

At Sre Bau, a core of fine-grained quartzite is proof of simple debitage, which consists of alternating flake production surfaces. There is also a flake of fine-grained quartzite with a faceted butt to illustrate this simple debitage.

The last two localities are Kratie and Chhlong, in the district of Kratie where the Chhlong River flows. Two tools from these localities can be described. The first is a chopper made from a quartzite cobble of medium size, and the second is a unifacial tool on a partially shaped large chert block with a trapezoidal section and a thick back. The convergent retouched edge is on the distal part of the tool.

Table 5. Cobble tools discovered on the Quaternary terraces of the Mekong River by the French Cambodian Prehistoric Mission. (@MPFC).

Outils sur galet découvert sur les terrasses quaternaires du Mékong par la Mission Préhistorique Franco-cambodgienne. (@MPFC).

Fig. 15. Lithic industry discovered at different localities on the Mekong terraces, Eastern Cambodia. 1. Chopping tool with abrupt convex cutting edge (Thalaborivat); 2. Convergent chopper (Thalaborivat); 3. Massive chopper with a circular denticulate cutting edge made on a quartzite cobble (Sre Bau); 4. Scraper tool made on silicified wood (Kratie area, Phum Roloch village, reported in 1996 by H. E. Chuch Phoeurn and G. Albrecht); 5. Chopper (Thalaborivat); 6. Double tool on silicified wood with bifacial retouch (Sre Bau); 7. Chopping tool with concave transversal cutting edge (Thalaborivat); 8. Chopper (Alorch). (@MPFC).

Industrie lithique découverte dans différentes localités des terrasses du Mékong, Cambodge oriental. 1. Chopping tool à tranchant convexe abrupt (Thalaborivat); 2. Chopper convergent (Thalaborivat); 3. Chopper massif à tranchant denticulé circulaire sur galet de quartzite (Sre Bau); 4. Racloir sur bois silicifié (Kratie area, Village de Phum Roloch, signalé en 1996 par H. E. Chuch Phoeurn et G. Albrecht); 5. Chopper (Thalaborivat); 6. Outil double sur bois silicifié à retouche bifaciale (Sre Bau); 7. Chopping tool à tranchant transversal concave (Thalaborivat); 8. Chopper (Alorch). (@MPFC).

6.3. New cobble tools collected in 2012 on the Quaternary Mekong terraces

Following the reappraisal of the series gathered by C. and R. Mourer, we undertook fieldwork during the summer of 2012 in Kompong Svayou (Kratie Province), near the village of Phum Roloch. In 1996, H.E. Chuch Phoeurn and G. Albrecht (Thuy, 2010, p. 30) (Fig. 15 n. 4) identified a tool made from silicified wood from this locality.

Six new artefacts were recovered from the surface of the Mekong terraces at the Alorch and Thalaborivat localities. Bifacial pieces were not recovered during the fieldwork. These six artefacts confirm earlier discoveries and support the existence of Palaeolithic implements from the Cambodian Mekong terraces as described by Saurin (1963a) and Carbonnel (1972). These artefacts also look very similar to the archaic tools of the Burmese terraces described by Movius (1943, 1948).

Two types of raw materials are selected: quartz or quartzite cobbles and silicified wood chunks. Except for one piece that resembles a tested cobble (core?), the other cobble tools are typical choppers with convex or pointed cutting edges (Fig. 15 n. 2, n. 5, n. 8). Two chopping tools were identified with bifacial knapping at one or two ends of the cobble (Fig. 15 n. 1, n. 7). Tools made of fragments of probable dicotyledonous angiosperm wood are also present with a retouched distal/lateral side.

6.4. Summary

The typological analysis and technological reading of the material discovered in the 1960s and 2012 on the Cambodian Mekong terraces confirm the anthropic character of these artefacts. The main morphological and typo-technological characteristics of the first Paleolithic industries in Asia are present in the lithic series from the sites of Alorch, Thalaborivat, Sre Sbau, Chhlong, and Kratie. The selected raw material and cobbles, with the use of silicified wood, are similar between these sites.

7. Malaysia

Early Paleolithic discoveries in Malaysia emphasised one of the oldest and longest human occupations in Southeast Asia. Evidence found in the Lenggong Valley (North Perak) revealed archaeological sites covering a period spanning between 1.83 Ma until 1 ka (Majid, 2014). Between these two extreme datings, numerous sites complete the chronology: Bukit Jawa between 200-100 ka, Kota Tampan at 74 ka, and the numerous famous Hoabinhian sites dated back to 13 ka (e.g., Gua Gunung Runtuh, Gua Teluk Kelawan, Gua Harimau, Gua Tukang).

This anthropological evidence is linked to the geological records of some major climatic events, such as a meteorite impact and the eruption of Toba (Majid, 1990; Nor Khairunnisa Talib et al., 2009; Storey et al., 2012). Cultural interests promoted this area to a UNESCO World Heritage site in 2012 (UNESCO, 2012, p. 187-189). The first research on the Paleolithic period in the Lenggong Valley took place in Kota Tampan. It began in 1938 with the work of H.-D Collins (Collings, 1938), followed by G. de G. Sieveking (Sieveking, 1958). Since 1987 (Majid and Tjia, 1988), Malaysian archaeologists have directed research in the area. Local archaeologists from the University of Sains Malaysia (USM) have continuously increased the corpus of Paleolithic sites in the region, such as Kampung Temelong (Saidin, 1997), Lawin, Jawa, Bukit Bunuh (Saidin, 2006; Nor Khairunnisa Talib et al., 2009; AbdJalil and Abdullah, 2015; Nor Khairunnisa Talib et al., 2020), and Kota Tampan (Goh et al., 2020). In 2007, these studies led to the astonishing discovery of evidence of human occupation at Bukit Bunuh dated to more than 1.8 Ma (handaxe, choppers, flake tools) (Saidin, 2010).

7.1. Bukit Bunuh (Kill Hill)

Bukit Bunuh is located in the Lenggong Valley (5°04'30''N; 100°58'34''E), Perak Malaysia. The site was discovered in August 2000 during a survey by Professor Mokhtar Saidin from the University of Sains Malaysia (USM). This Paleolithic open-air site covers more than 4 km² (Department of National Heritage, 2011, p.42) and various researchers have recorded the impact of a meteor at this site (Nor Khairunnisa Talib et al., 2009; Jinmin et al., 2014, 2017; Nurazlin Abdullah et al., 2020). This event has been dated by the fission-track method at a Japanese geochronology laboratory to 1.74 ± 1.28 Ma (D0204006) and 1.83 ± 0.61 Ma (D0806004) (Department of National Heritage, 2011, p. 23).

Archaeological excavations led between 2001 and 2010 (Saidin, 2006; Nor Khairunnisa Talib et al., 2020) have featured different occupation phases. The first excavation on the southern part of the site (BBH2001) revealed the presence of a palaeolake terrace around 40 ka (Saidin, 2006, p. 2). In 2007, evidence (handaxe) on BBH2007 attested that a stone tool workshop was preserved in the suevite, resulting from a meteor impact, and was dated to more than 1.8 Ma (Saidin, 2012, p.11). Then between 2008 and 2010, the western part of the site was excavated, revealing undisturbed *in situ* Paleolithic sites dating respectively to 0.27 Ma (BBH2008) and 0.55-0.49 Ma (BBH2010) (Nor Khairunnisa Talib et al., 2020, p. 101).

7.2. BBH site-2007 (1.83 Ma)

The oldest occupation (BBH2007) was discovered in 2007, when researchers observed a handaxe embedded in suevite boulders among the surface artefacts (Saidin, 2010, p. 84; Department of

National Heritage, 2011, p. 42). Many artefacts (more than a thousand), such as handaxes, chopper and flake tools have also been observed embedded or concealed in suevite rocks (Saidin, 2012, p. 11). This rock is the result of shock metamorphism and high pressure and temperature; these factors change the original rock and sediment into suevite (Saidin, 2012, p.11; Nurazlin Abdullah et al., 2020, p. 9). This evidence demonstrates that the lithic workshop existed before or contemporary to the meteor impact (Saidin, 2012, p. 11). A CT scan revealed that a handaxe made in metaquartzite is embedded in the suevite (Fig. 16, (4)) (Department of National Heritage, 2011, p. 42).

The matrix (suevite) was dated to 1.83 Ma by the fission-track method as above (Department of National Heritage, 2011, p.42; Saidin, 2012, p.82). The description of the handaxe (Fig. 16, (4), (5)) is given in detail: "This handaxe is a bifacial symmetrically flaked pebble tool made from metaquartzite with a convex bottom having its sides converging to the top to end in a sharp point 20.3 cm away. Approximately the top fifth of the tool had broken off, but it remained attached in the suevite. The sharp end is probably the result of damage that happened either during manufacture or from use. At its broadest, the handaxe is 10.8 cm and this occurs approximately 9 cm from the convex end; thus, it followed the classical tear-shaped template often referred to as the Acheulean or Mode 2" (Department of National Heritage, 2011, p. 43). However, no complementary publications on the lithic industry from this period are available.

7.3. BBH site - 2010 (0.55-0.49 Ma)

In 2010, The USM team led an excavation on the slope of Bukit Bunuh, revealing an *in situ* lithic workshop on the shore of a palaeolake, estimated (OSL) to 0.55-0.49 Ma (Nor Khairunnisa Talib et al., 2020). According to the study of Khairunnisa (Nor Khairunnisa Talib et al., 2020), this assemblage of 50,451 lithic artefacts was classified into three categories: knapping tools (hammerstone, anvils, core), stone tools (flake tools, core tools, chunk tools), and debitage (waste, flake, debris). The vast majority of the artefacts are debitage (97%), while stone tools represent a tiny 2% and knapping tools only 1%. This highlights that flake tools (n=744) dominate the assemblage of tools, followed by the chunk tool (n=164), while pebble tools tend to be rare (n=23). The stone tools were associated with a few hammer stones (n=61), anvils (n=35), and numerous cores (n=143).

Fig. 16. Lenggonng Valley site, Malaysia. (1)-(3). Visit to the Bukit Bunuh site with Prof. M. Saidin, F and A.M Sémah in December 2015. (4). Handaxe embedded in suevite rock from Bukit Bunuh @ CC BY-NC-ND: Department of National Heritage (2011 - UNESCO program). (5). A drawing of a metaquartzite handaxe, dated to 1.83 Ma based on a CT scan @ CC BY-NC-ND: Department of National Heritage (2011- UNESCO program).

Site de la vallée de Lenggonng, Malaisie. (1)-(3). Visite du site de Bukit Bunuh avec le Pr M. Saidin, A. M et F. Sémah durant le mois de décembre 2015. (4). Biface encastré dans une roche de suevite à Bukit Bunuh @ CC BY-NC-ND: Department of National Heritage (2011- programme UNESCO). (5). Dessin d'un biface en quartzite datant de 1.83 Ma d'après une image Scan @ CC BY-NC-ND: Department of National Heritage (2011- programme UNESCO).

The raw material used in this assemblage is mostly local, preferentially using blocks or chunks of cherty metasediment, suevite, quartzite, and impact quartz (Nor Khairunnisa Talib et al., 2020, p. 104; Nurazlin Abdullah et al., 2020, p. 9). A technological analysis revealed that direct percussion and edge-flaking techniques were involved in the production of the stone tools (Nor Khairunnisa Talib et al., 2020, p. 102). The proposed typology of the flake tools (AbdJalil and Abdullah, 2015, p. 5; AbdJalil et al., 2016, p. 82) is based on morphology and technology, with four categories: touched, serrated, notched, and pointed. According to AbdJalil and Abdullah (2015), the production of the stone tools is highly variable: while 81% of the tools are serrated or retouched, only 19% have a specific shape, such as notched and pointed. This has also been highlighted through the use-wear analysis which demonstrated that notched and pointed tools are scrapping (100%) and drilling (95%) tools respectively. The serrated tools, despite a preferential use for scrapping and sawing, have demonstrated multi-function purposes and represent 25% of the whole collection of stone tools.

Although rarely mentioned in the scientific literature, Bukit Bunuh is nevertheless a key site to understand Southeast Asian prehistory, both at a dating and site level. This site represents not only one of the oldest occupations in Southeast Asia, but also one of the sites where a handaxe has been discovered from an early time period. This naturally raises questions about the validity of the Movius theory as well as human dispersal (Saidin, 2012, p. 11; Department of National Heritage, 2011, p. 44).

8. Conclusion and discussion

Our concluding remarks start from the Chinese data which detail numerous sites well dated for the Middle Pleistocene period. The four sites from southern Chinese provinces, dating back to the Early and Middle Pleistocene, present a diversity of technical choices. In Yunnan, the debitage with medium-small-sized cobbles and small tools seems well represented during the Early Pleistocene, while the shaping concept and large cutting tools (LCTs) are dominant in Bose (Guangxi Region) and Modaoshan (Guangdong Province) around the early Middle Pleistocene. The biface is characteristic of the latter two sites but not generalised to all the sites in this period; it is an important witness but not a common denominator or relevant to all these sites. In addition, the Bose and Modaoshan handaxes appear to be very different, especially in the distal part: rather oval, convex, and rounded for Bose and rather convergent and pointed for Modaoshan. Other sites such as Gantangjing or Yuanmou show very southern characteristics specific to the Yunnan Plateau, where the industry is generally on small flakes with a majority of scrapers (Gantangjing) and small cores in quartz (Yuanmou). These small tools (micro assemblage) contrast with the biface sites such as those of Bose.

The exploited raw materials at the four sites were mainly river cobbles and pebbles, but the size, morphology, quality, and texture change significantly between the sites. The methods of debitage and shaping are also variable, including orthogonal, bipolar, centripetal (or discoidal) flaking, bifacial, and unifacial shaping. Around the Early-Middle Pleistocene, China has highly variable stone tools and behaviours that prevent us from grouping them under a global terminology or 'technical culture'.

Table 6 shows that the other countries in mainland Southeast Asia have both similarities and differences with the Chinese data. All these assemblages are therefore comparable and incomparable, which prevents them from being grouped, and confirms that this ancient period of the Paleolithic had a great diversity of stone artefacts.

Table 6. General synthesis of the Paleolithic sites mentioned in the text with stone artefact references. *Synthèse générale des sites paléolithiques mentionnés dans le texte avec des références d'artefacts lithiques.*

What has long been called Anyathian is now used to refer to the earliest lithic evidence from the Lower Paleolithic in Myanmar, even if further investigation and chronometric dating are needed to clarify this issue (Aung et al., 2015). The Anyathian lithic assemblages are dominated by the shaping concept, while debitage is additional. Choppers are much more numerous than chopping tools, and cores generally belong to the orthogonal debitage system, exploiting the core surfaces. Handaxes are absent in the assemblages.

At the same period around 0.8 Ma, Bose sites (China) and An Khê localities in Vietnam show the existence of shaping activities according to different types of cobble raw material: handaxe and uniface are more or less pointed depending on the site. Pointed tools rather than convergent tongue-like tools appear to be more prevalent in the Vietnamese tool assemblage. In the two site complexes, tools are represented mainly by choppers and picks of various types; in contrast, there are few handaxes. Typo-technologically, the tools from An Khê resemble those from Bose but are very different from the 'Acheulian handaxes', as emphasised several times by the excavators (Derevianko et al., 2016, 2018). However, the pointed morphology of the An Khê pieces are closer to the Modaoshan handaxes than to the Bose handaxes. However, geographically they are closer to the Guangxi region than to the Guangdong Province. It can be concluded that the spatial proximity of the sites does not influence the choice of raw materials and knapping methods.

The ancient Cambodian industries found on the Mekong terraces are classical pieces on pebbles, neither too large nor too small, with chopper and chopping tools being well represented. However, it is interesting to note that the appearance of shaped silicified wood, as in the Burmese Anyathian through the work of Movius, may be an indicator of old stone artefacts. Silicified wood is a raw material no longer used by modern humans, including the Hoabinhian technocomplex (~40-4 ka) (Forestier et al., 2017; Ji et al., 2016; Zeitoun et al., 2008).

Thai sites in the northern provinces of Lampang and Nan show pebble production dating back to about 0.5 Ma. The cobble matrix is close to that of Bose, but not identical. There are LCTs and prismatic cores weighing several tens of kilograms, which demonstrate a debitage activity as prevalent as that of shaping. These two sites are undoubtedly similar regarding the size of the uniface shaped on cobble and the very low number of handaxes and cleavers.

New sites are being discovered in Southeast Asia which has a very old prehistory and deep chronology, as can be seen from the example of Malaysia and the Lenggong Valley site, whose pieces date from 1.8 Ma. A surprising diversity and technical heterogeneity contrast a background of homogeneity in the choice of pebble/cobble materials. Cobbles are not the only selected material, and researchers have proposed the hypothesis of vegetal tools ('Bamboo Hypothesis', e.g., Bar-Yosef et al. 2012; Brumm, 2010; Pope, 1988; Toth and Schick, 1993), which must also be seriously considered for the very ancient periods of the Paleolithic and in the very early stages of the settlement of *Homo erectus*.

What is striking about the Early Paleolithic of Southeast Asia is both the diversity of materials and knapping methods used. Although it has been shown that most of the time the oldest lithic pieces were not always associated with human anatomical remains (Moncel et al., 2018b), this technical-cultural diversity echoes the diversity of human taxa assumed in the region, whether *Homo erectus* or different forms of the so-called archaic *Homo sapiens* before they were given new species names.

There is no standardisation or generalisation of a particular tool such as the handaxe or cleaver: each time we are surprised by a technique that is reinvented or revised by humans. Therefore, it is paramount to reveal the local facts when studying specific materials. We must not be trapped by prejudged paradigms or simplify the local diversity by applying the global, but not universal concept, of 'Mode 1' or the chopper-chopping tool tradition.

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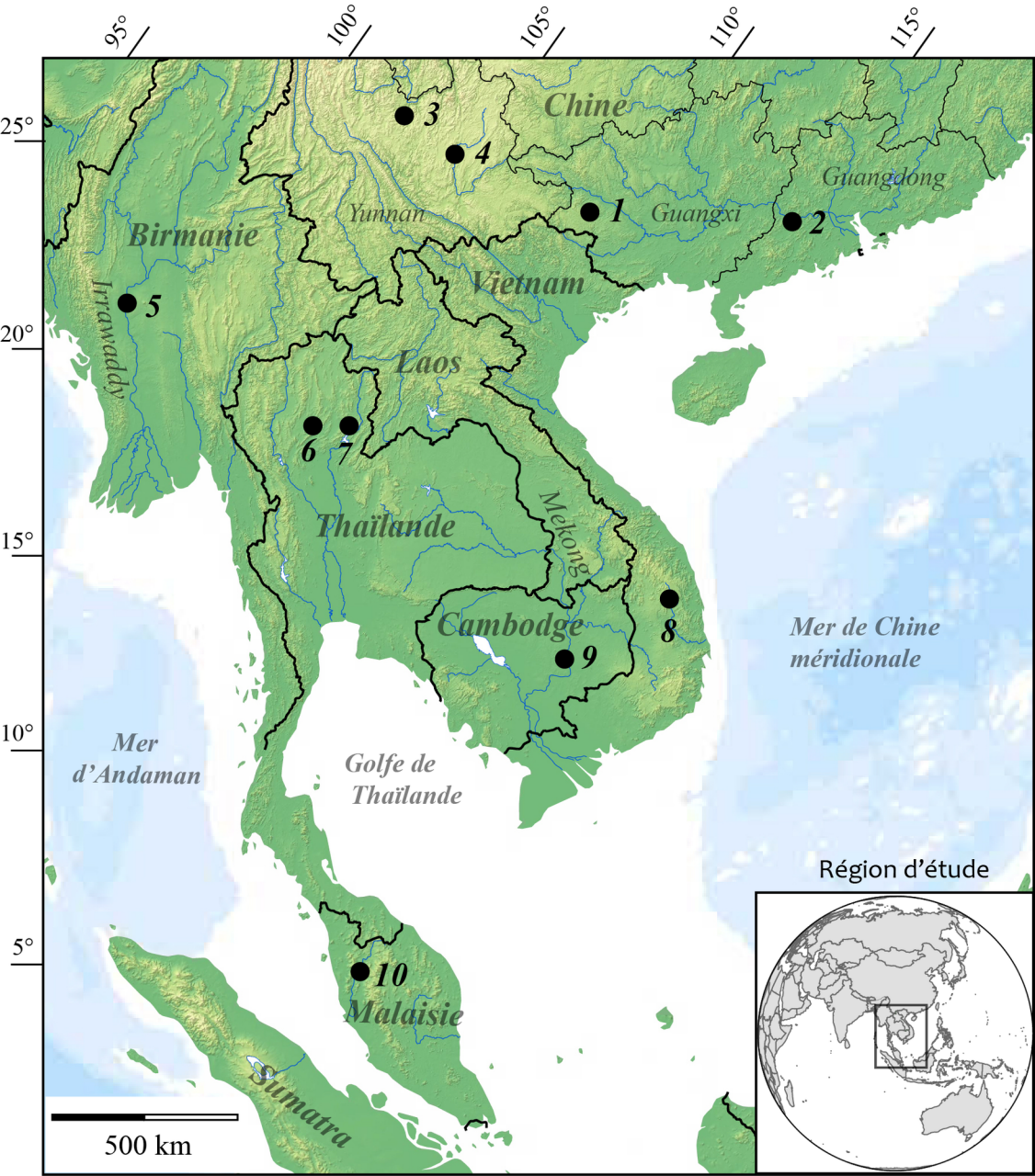
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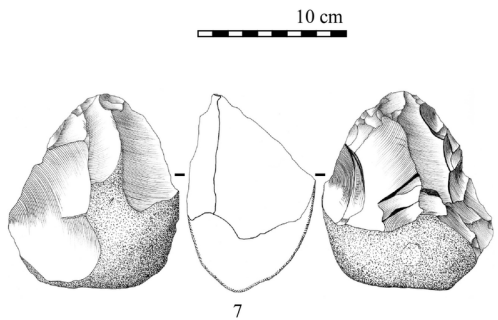
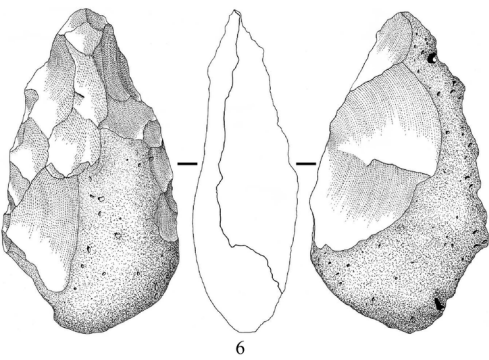
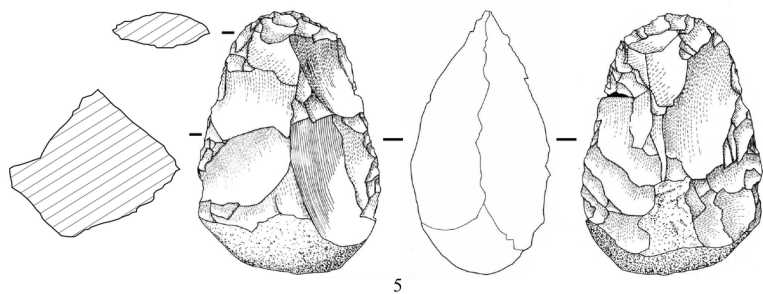
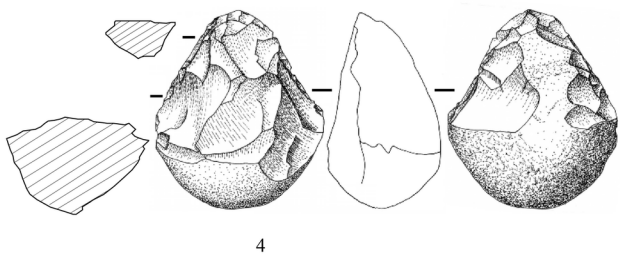
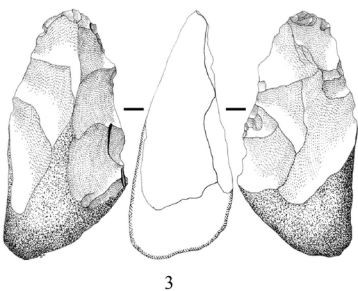
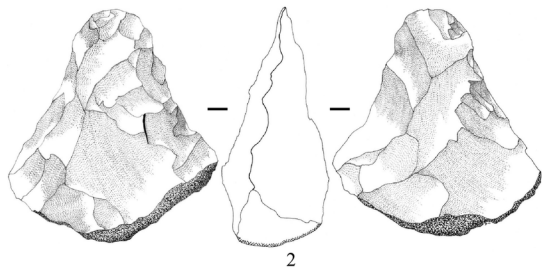
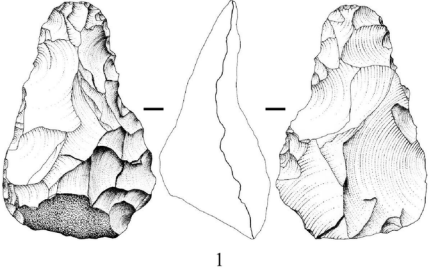
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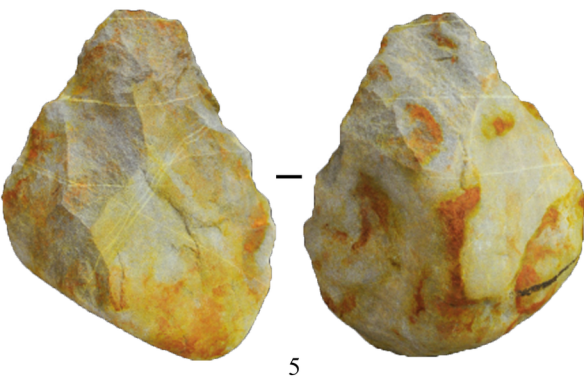
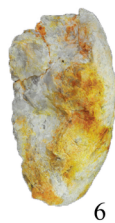
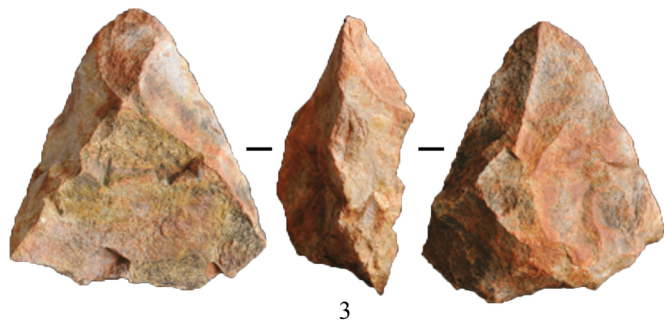
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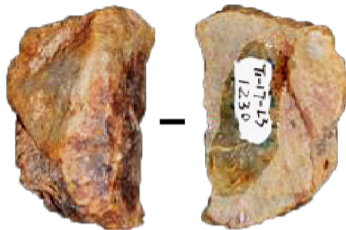
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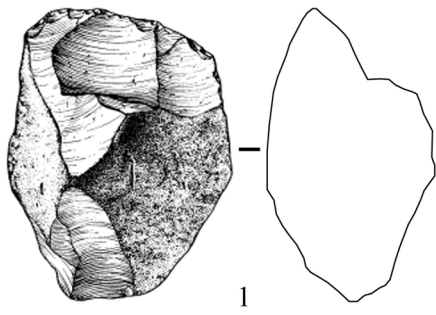
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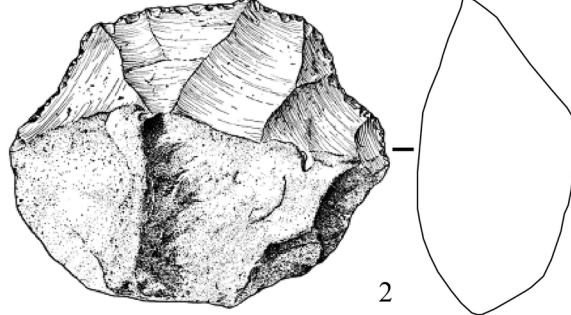
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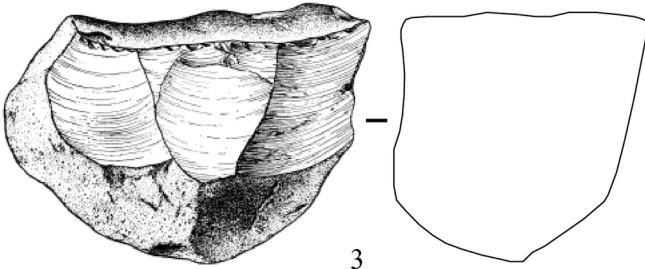
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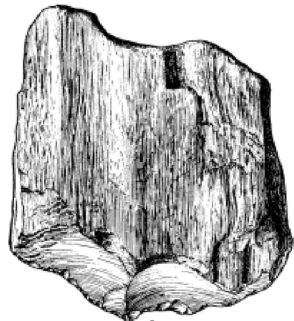
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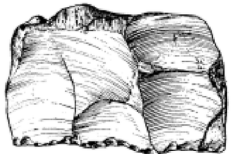
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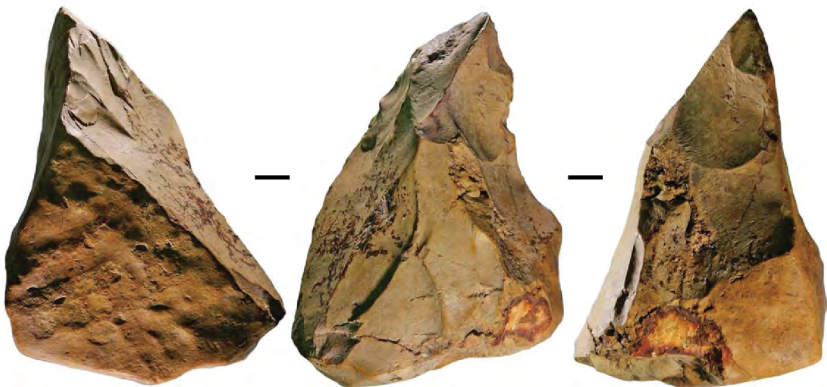


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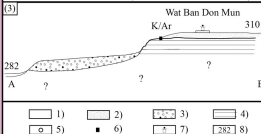
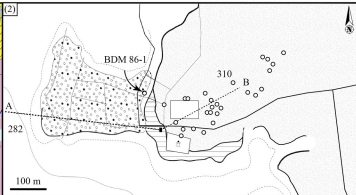
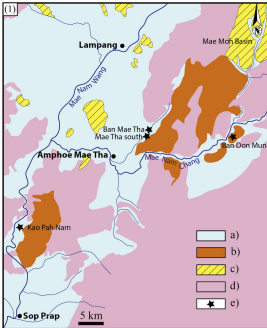


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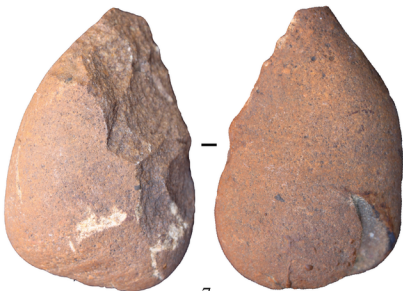
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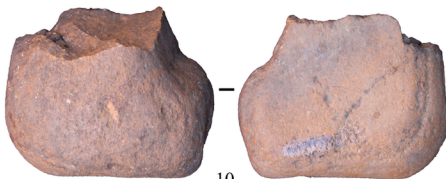
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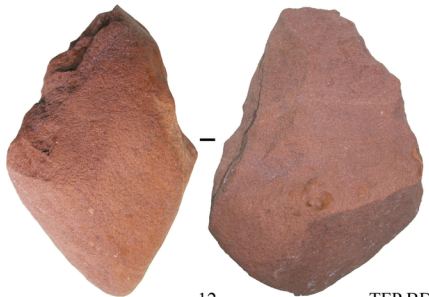
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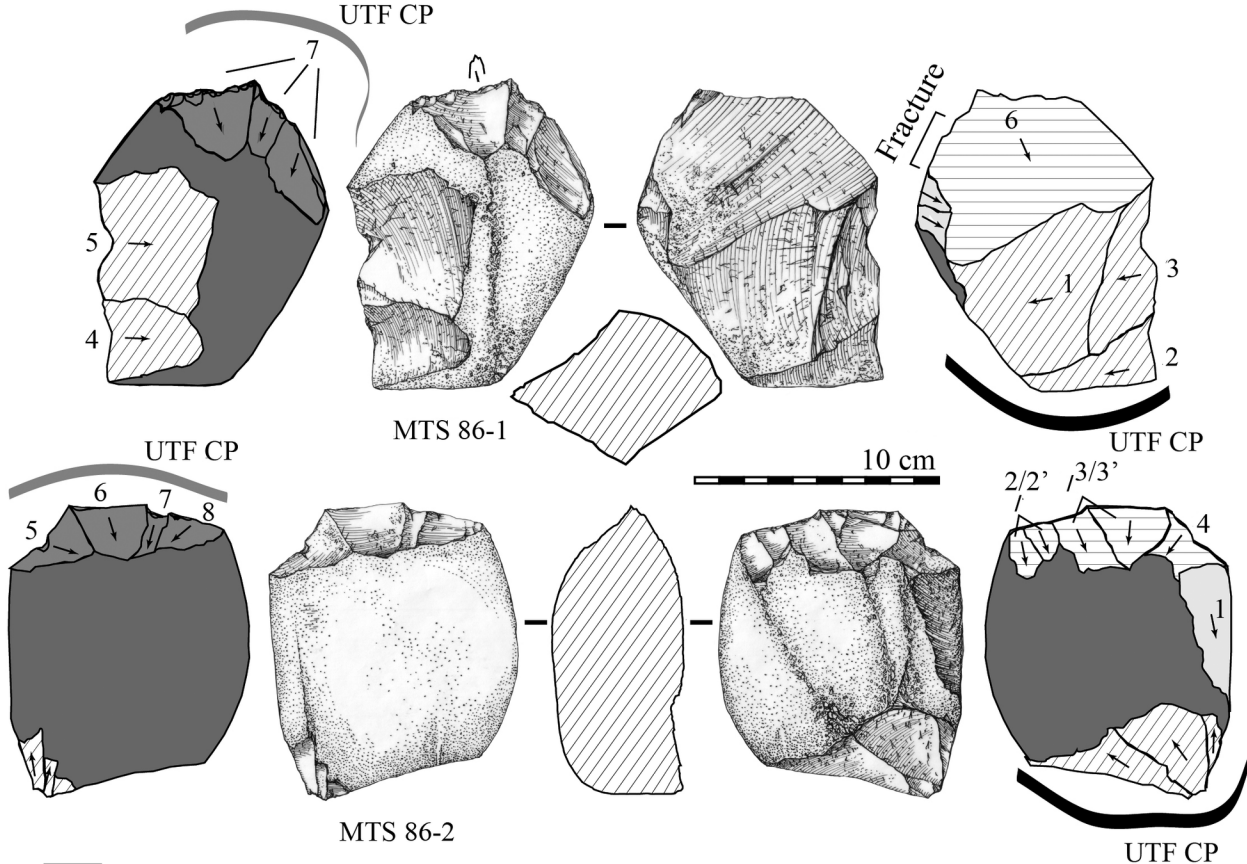





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


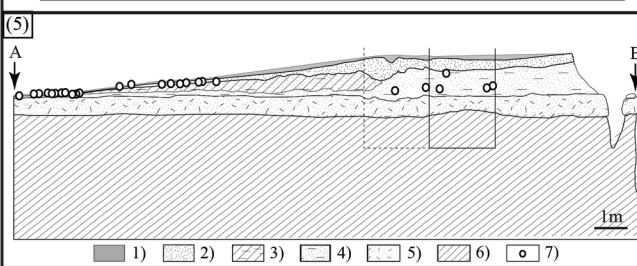
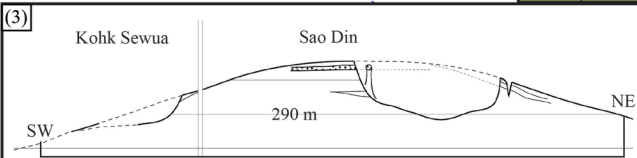
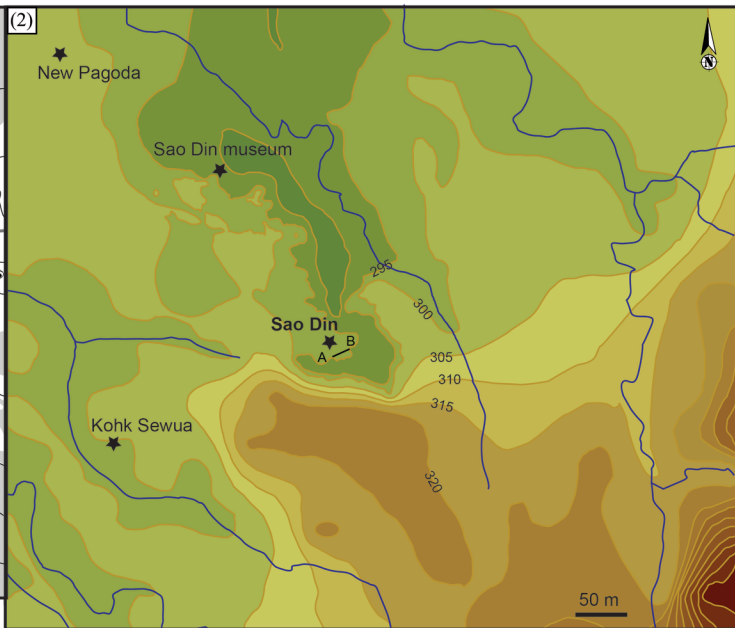
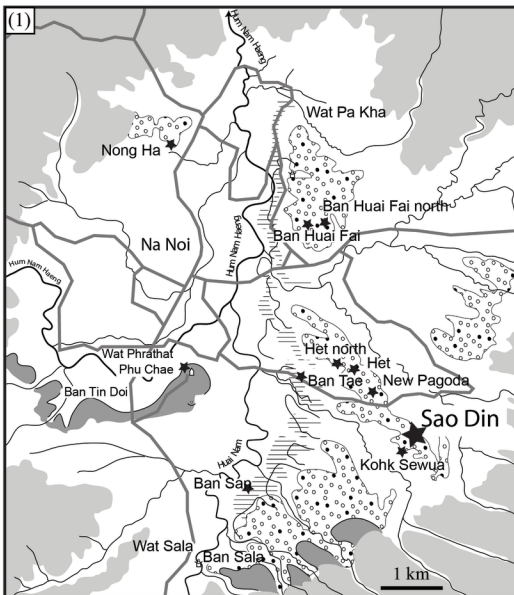
12
TFP BDM 9





-  Cortex
-  Transformative techno-functional unit
Unité techno-fonctionnelle transformative (UTF CT)
-  Prehensive techno-functional unit
Unité techno-fonctionnelle préhensive (UTF CP)

-  Shaping (Façonnage)
-  Knapping of plane surface to obtain
a correct angle for retouch
Dégagement d'une surface plane pour
obtenir un angle d'affûtage correct





1



2



3



4



5

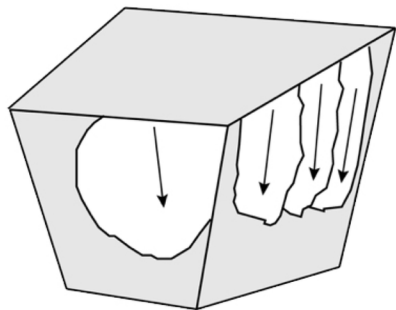
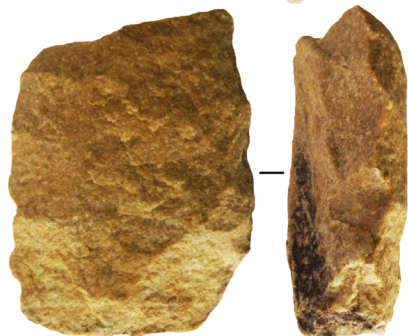


Schéma diacritique

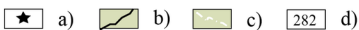
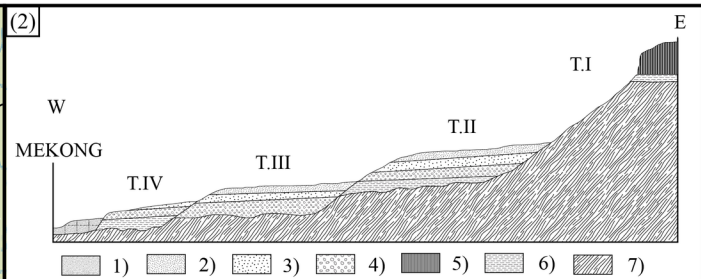
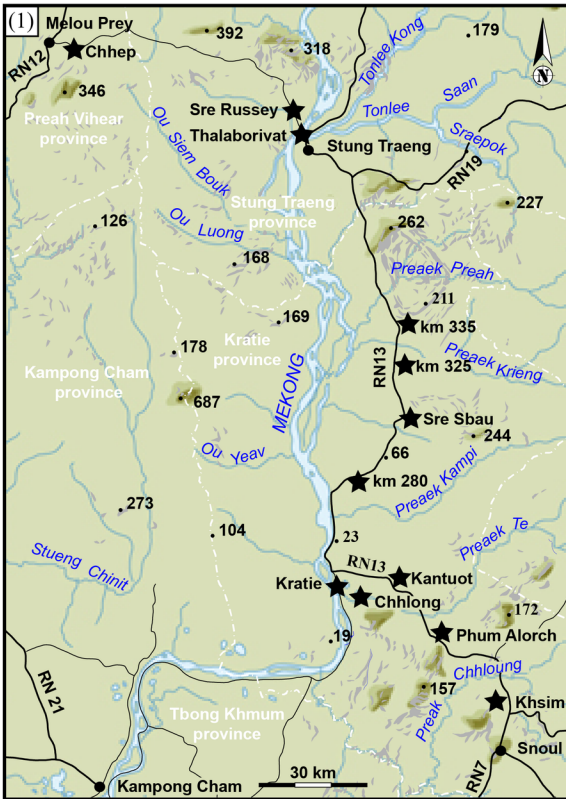


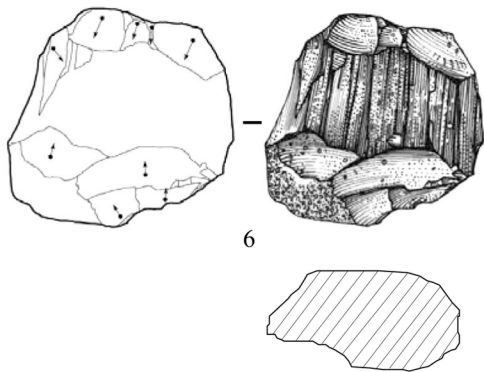
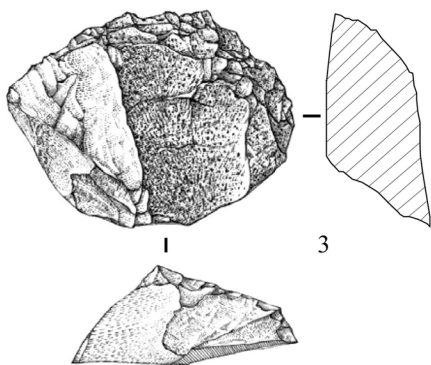
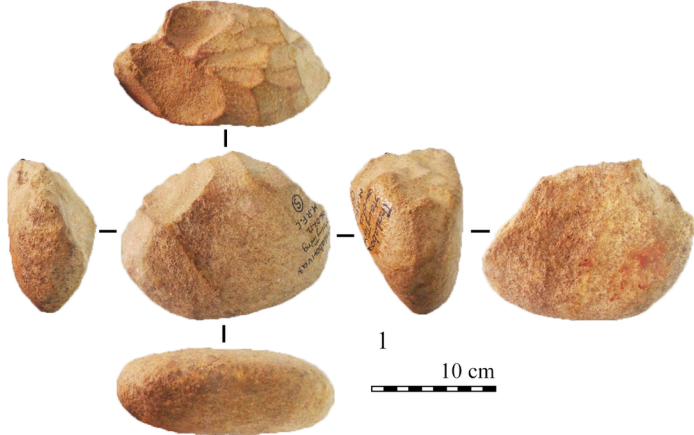
Diacritical diagram

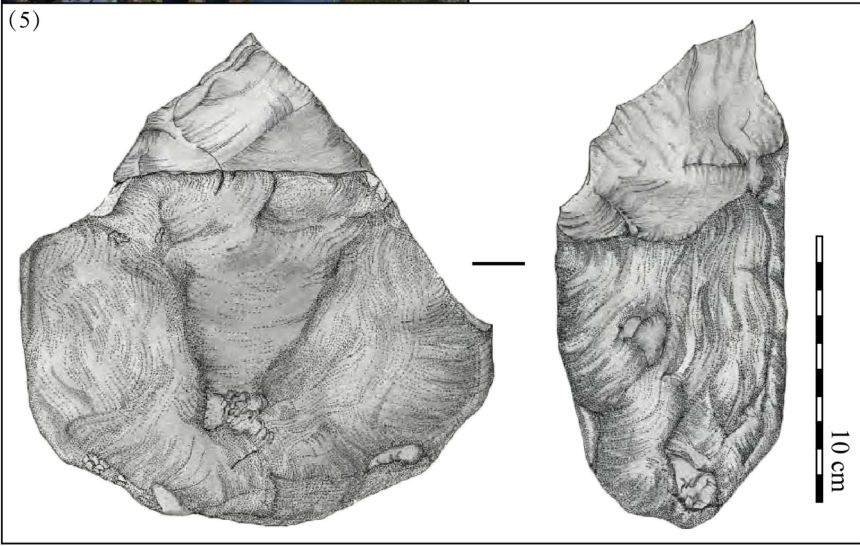
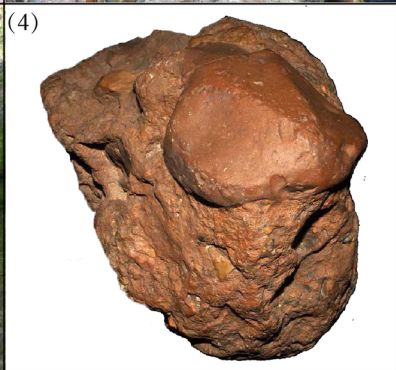
10 cm



3







	Fengshudao		Damei Nanbanshan		Baigu		Gaolingpo	
Cores	11	7.1%	17	14.4%	14	4.4%	4	1.6%
Bipolar cores	4	2.6%						
Unworked flakes	17	11.0%	34	28.9%	40	12.7%	115	46.6%
Bipolar flakes	13	8.4%						
Fragments of flakes							24	9.7%
Debris	30	19.4%			91	28.9%	16	6.5%
Choppers	3	1.9%	13	11.0%	126	40.0%	58	23.5%
Discs (unifaces)							1	0.4%
Bifaces (handaxes)	5	3.2%	2	1.7%	5	1.6%	6	2.4%
Picks	1	0.6%	9	7.6%	2	0.6%	5	2.0%
Cleavers			1	0.8%	1	0.3%		
Other shaped tools							4	1.6%
Chipped cobbles	36	23.2%					9	3.6%
Flake tools					10	3.2%	4	1.6%
Scrapers	2	1.3%	30	25.4%				
Fractured and entire cores	27	17.4%			26	8.2%	1	0.4%
Hammers	6	3.9%	12	10.2%				
Total	155	100%	118	100%	315	100%	247	100%
References	(de Lumley et al., 2020; Wang et al., 2014)		(de Lumley et al., 2020; Wang et al., 2006)		(de Lumley et al., 2020)		(Bodin, 2011)	

Implement type	Fossil wood		Silicified tuff	
Hand-adzes 1	219	83.9%		
Choppers			61	27.7%
Side hand-adzes or choppers	5	1.9%	28	12.7%
Small scrapers	1	0.4%		
Chopping-tools	13	5.0%	41	18.6%
Single and double-ended choppers	21	8.0%		
Proto-hand-axes	1	0.4%		
Pick-like implements	1	0.4%	1	0.5%
Chopping-tools or (?) cores			2	1.0%
Flake implements			33	15.0%
Cores			54	14.5%
Total	261	100%	220	100%

1 : the hand-adze was defined by Movius (1943) as a special class of chopper, but of square or rectangular rather than of round or oval shape. It is partially unifacially worked.

Tool types	Number
Choppers and chopping tools	70
Bifaces	11
Picks	56
Spurred tools	40
Carinated endscrapers	4
Side-scrapers	54
Denticulate tools	Not reported
Notched tools	Not reported

Tool type	Surface finds at different localities									Total	Excavated pieces at SD		
	BHF	PPC	KS	NP	BT	SD	KSsup	BS	SDsup				
Cores (giant and massive sub-pyramidal morphology > 20 kg)		2	1		3	1				7	2.4%		
LCTs			6	3		4				13	4.5%		
End choppers	5		12	1	9	46		1	2	76	26.3%	10	29.4%
Lateral choppers			2			11			1	14	4.8%	1	2.9%
Angular choppers			1			2				3	1.0%		
Convergent choppers			3		1	18				22	7.6%	1	2.9%
Pointed choppers			3	1	2	9				15	5.2%	1	2.9%
Double choppers						2				2	0.7%		
Unifacial cobble tools						2				2	0.7%		
Choppers with a planed front			3			3	1			7	2.4%		
Broken choppers					1					1	0.3%		
Chopping-tools			1			2				3	1.0%	1	2.9%
Unifacial cobbles			4	2	2	7			2	17	5.9%	5	14.7%
Horsehoof tools			1			3			1	5	1.7%		
Bifaces						4				4	1.4%	3	8.8%
Picks			3	2	2	11			4	22	7.6%		
Unifacial tools with a heavy thick front (Rabot)						2			2	4	1.4%		
Trifacial tools						2			1	3	1.0%		
Cleavers						1				1	0.3%	1	2.9%
Massive heavy tools with transversal cutting edge	1									1	0.3%		
Flakes	1		8		1	15				25	8.7%	7	20.6%
Flake tools			9	1	3	27				40	13.8%	2	5.9%
Tested blocks				1						1	0.3%		
Tools on block				1						1	0.3%		
Silicified wood fragments												1	2.9%
Chunks												1	2.9%
Total	7	2	57	12	24	172	1	1	13	289	100%	34	100%

Location and sample number	Artefact type
Thalaborivat 1	Chopper
Thalaborivat 2	Chopper
Thalaborivat 3	Chopper
Thalaborivat 4	Choping tool
Thalaborivat 5	Chopper
Thalaborivat 6	Flake
Thalaborivat 7	Side scraper
Thalaborivat 8	Retouched flake
Thalaborivat 9	Massive chopper
Sre Bau 1	Massive chopper
Sre Bau 2	Tool in silicified wood
Sre Bau 3	Core
Sre Bau 4	Flake
Kratie 1	Chopper
Chhlong 1	Unifacial tool
Thalaborivat 10	Retouched piece
Alorch 1	Core
Thalaborivat 11	Chopper
Alorch 2	Chopper
Thalaborivat 12	Pointed chopper
Alorch 3	Tool on silicified wood
Phum Roloch	Tool on silicified wood

Site	Location	Site type	Chronology	Lithic industry
Bose localities	Guangxi, China	Open-air	0.8 Ma	Pebble tools (pick, rabot, chopper), biface on pebble. Biface on flake is very rare. Debitage is rare but includes variable knapping methods
Modaoshan site	Guangdong, China	Open-air	Early Middle Pleistocene (0.8-0.6Ma)	Pebble (pick and chopper), biface on pebble,debitage is rare
Yuanmou	Yunnan, China	Open-air	Early Pleistocene	Core, flake tool (debitage)
Gantangjing	Yunnan, China	Open-air	Early Pleistocene	Core, flake tool (bipolardebitage dominates)
An Khe localities	Gia Lai, Vietnam	Open-air	0.8-0.78 Ma	Pebble (pick, , chopper-chopping tool), biface sur galet,debitage is far less encountered
Mekong terrace localities	Kratie to Thalabovirat - Stung Traeng, Cambodia	Open-air	Middle Pleistocene	Pebble and fossil wood (chopper-chopping tool),debitage is far less encountered
Irrawaddy localities	Mandalay, Burma	Open-air	Middle Pleistocene(?)	Pebble and fossil wood (chopper-chopping tool),debitage is far less encountered
Lampang sites	Lampang, North Thailand	Open-air	Middle Pleistocene, or <0.55 Ma	Pebble (chopper- chopping tool, convergent points, pick), occasional small flake tool and triface
Sao Din site	Nan, Northeast Thailand	Open-air	Middle Pleistocene (0.5 Ma?)	Massive unifacial pebble tool (chopper-chopping tools, pick and rare biface), LCT production
Lenggong valley Bukit Bunuh	Malaysia	Open-air	BBH-07: 1,83 Ma ; BBH-2010: 0,5 Ma	Biface, pebble tools, flake tools