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Tham Lod rockshelter (Pang Mapha district, north-western Thailand): Evolution of the lithic assemblages during the late Pleistocene

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ABSTRACT

Tham Lod (Pang Mapha district, Mae Hong Son Province) is one of the rockshelters in the limestone karst of north-western Thailand. The site was excavated from 2002 to 2006 under the direction of one of us (R.S.) in the context of The Highland Archeological Project. The stratigraphical sequence of the site provided dates ranging from late Pleistocene (35 ka, TL), to late Holocene (3000 BP). Thousands of lithic and faunal remains occur throughout the sequence; ceramics and metal items appear in the upper layer (Holocene). Noteworthy are the few human burials in the late Pleistocene layers.

This paper presents the lithic material from area 2, sectors S20W10 and S21W10, unearthed from the stratigraphic layers 3 to 10 (late Pleistocene). Artefacts are mostly made in locally available grey sandstone, which is overwhelming in all the layers. The lithic assemblage includes a large proportion (2/3) of rock fragments brought to the site and artificially (or thermally?) broken. These are mostly small fragments (<100 mm) while the big fragments are rare and even absent in the middle layers. Flakes are well represented in the Pleistocene upper and middle layers. Cores proper (meant to produce flakes) are extremely rare and tools proper (shaped) are less than 10% of the material, half of them being larger than 100 mm. All of them, the large and the small tools are mainly shaped on cobbles and cobble fragments and mostly with unifacial shaping. Typical sumatraliths, the signature of the Hoabinhian technical traditions, are conspicuous in the middle layers 6 to 4; they are associated with partial sumatraliths (not shaped all around), especially in the layers 6. They are much less in the lower layers and seem to be absent in the bottom layer. Conversely, the cobble tools are almost exclusively choppers in the lower layers 10 to 8. The scrapers are the major type among the small tools and they are quite constant in number throughout the stratigraphy.

As some of the artefacts are definitely considered as "Hoabinhian", the detailed technological study of the lithic industry will help in understanding this "techno-cultural" facies and in tracing how the stone artefacts were manufactured, used, maintained and finally discarded by the hunters–gatherers. Analysis of the whole sequence in Tham Lod aims at reconstructing the technical evolution in the context of the late Pleistocene climatic changes in this part of Eurasia.

1. Introduction

North-western Thailand includes many limestone hills with karst due to weathering and tectonic structure. Therefore, the region is rich in caves and shelters. Formerly, two main sites, Spirit Cave (Gorman, 1972) and Banyan Valley Cave (Gorman, 1971; Reynolds, 1992) were well documented for their archaeological remains, especially for the Hoabinhian culture, around 12 ka to 3 ka BP. In Mae Hong Son Province, the site of Tham Phaa Chan provided a rich lithic assemblage that was analyzed in detail (White and Gorman, 2004). Recently, in the beginning of the 21st century, intensive work has been conducted along the border between Thailand and Myanmar. These explorations and excavations were undertaken in the frame of two main programs, the Highland

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Archaeological Project in Pang Mapha led by of one of us (R.S.) and the Franco-Thai Palaeolithic Mission led by V. Zeitoun. Many new sites belonging to various prehistoric or early historical periods have been discovered, and some of them yielded Hoabinhian assemblages (Shoocongdej, 2002, 2003, 2004, 2006, 2007; Forestier et al., 2005, 2013; Pureepatpong, 2006; Zeitoun et al., 2008).

Among these sites, Tham Lod (Tham Lot) is the one where the stratigraphic sequence is the longest, over more than 4 m. It is located in the Pang Mapha district of Mae Hong Son province, close to the border between Thailand and Myanmar, near Shan state (Fig. 1). The neighboring site of Ban Rai also provided a rich and well stratified record but for slightly later periods (Shoocongdej, 2002, 2004, 2006; Treerayapiwat, 2005; Marwick, 2008a, 2008b, 2008c). Both these sites are the most significant in the region not only for their well preserved and abundant archaeological material, but also for their well dated stratigraphic sequence allowing construction of the cultural chronology within the corresponding environment (Shoocongdej, 2002, 2004, 2007; Marwick, 2008a, 2008c).

The relief in Pang Mapha district is marked by limestone ranges extending north–south. The topography varies in altitude from 400 m to 1200 m above sea level, and is approximately 90% limestone mountains and 10% valleys, comprising high and low alluvium (Kierman et al., 1988). The physical landscape is characterized by various types of forest, especially deciduous forests, and controlled by tropical monsoon climate, with well-pronounced wet and dry seasons and approximately 1300 mm of average annual rainfall (Shoocongdej, 2006; Wattanapituksakul, 2006). The high diversity of habitats in this region and the abundance of accessible natural resources could be attractive for hunter–gatherers during the late Pleistocene, favoring various activities (Shoocongdej, 2003; Khaokhiew, 2004), particularly in the vicinity of Tham Lod.

2. Tham Lod rockshelter

Tham Lod is one of the abundant archaeological caves and rockshelters in the limestone karst region of north-western Thailand, at 19°34′ N, 98°16′ E (about 150 km northwest of Chiang Mai). It was excavated from 2002 to 2006 under the direction of one of us (R.S.) in the context of the Highland Archeological Project in Pang Mapha supported by Thailand Research Funds (TRF) and Silpakorn University. It is a small rockshelter at the

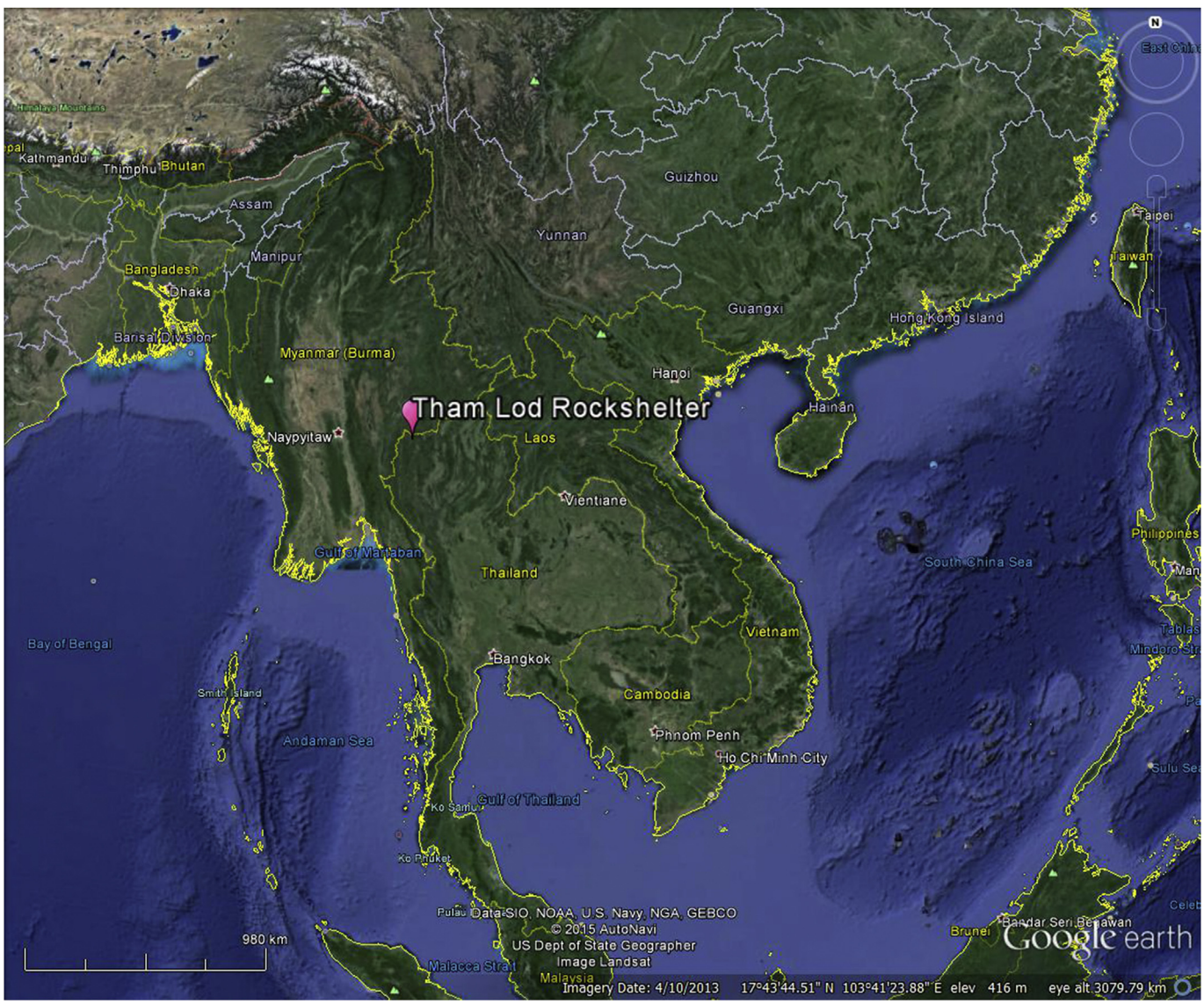

Fig. 1. Map of Southeast Asia showing the location of Tham Lod (Pang Mapha district, Mae Hong Son province).

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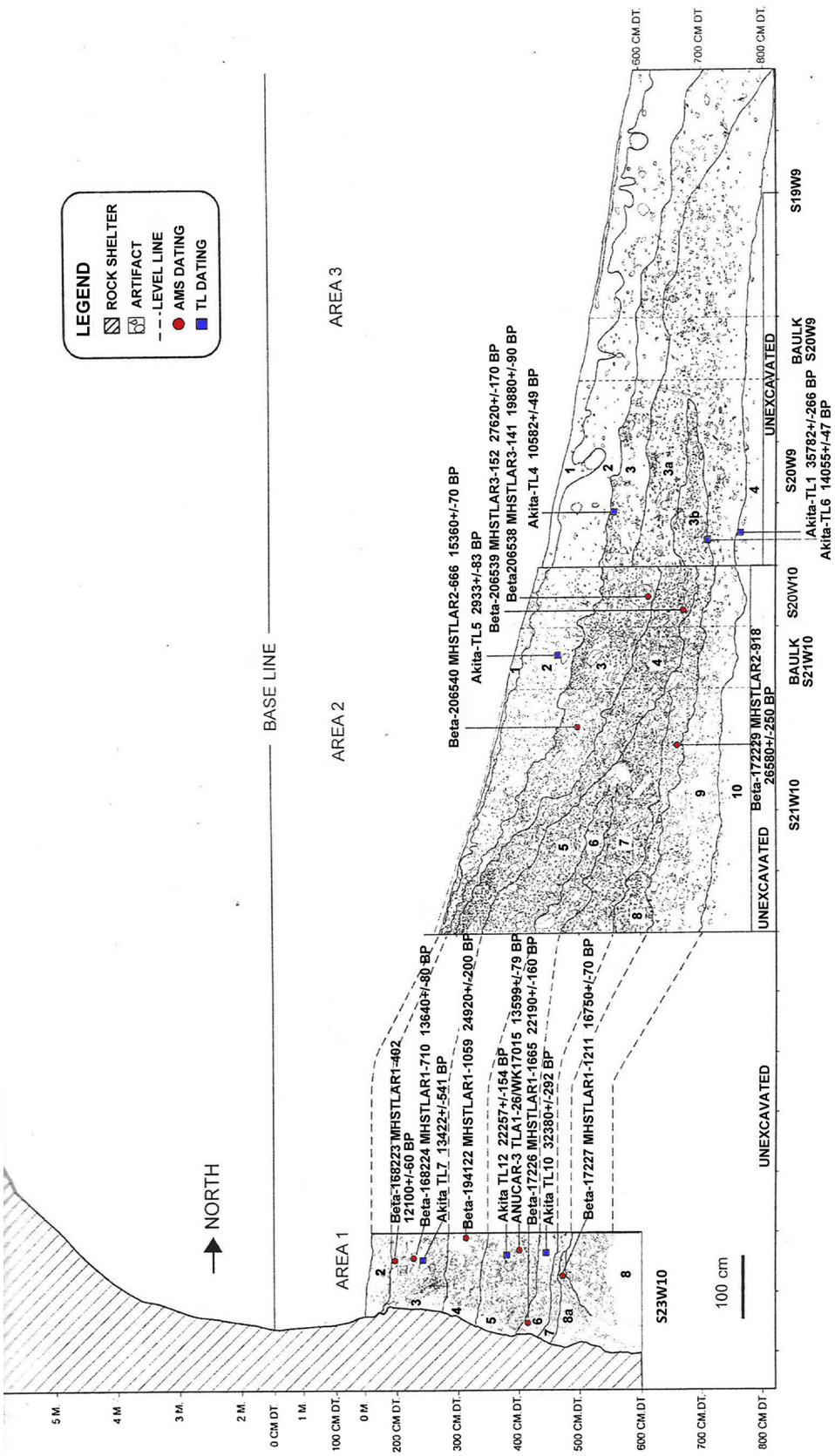

Fig. 2. Stratigraphy of Tham Lod (Shoocongdej, 2007).

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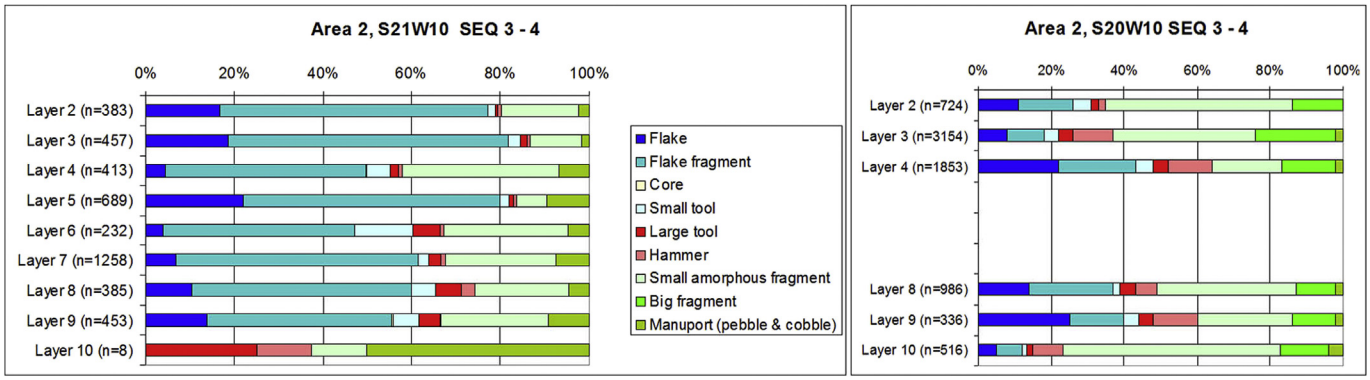

Fig. 3. Distribution of the main artefact categories across the stratigraphic sequence of Tham Lod in area 2, sectors S20W10 and S21W10.

base of an overhang of Permian limestone cliff, 640 m above sea level. The shelter is facing north and opening onto a forested landscape, approximately 250 m away from a Nam Lang River tributary, which is a part of the large Salween River drainage basin (Khaokhiew, 2004; Shoocongdej, 2006). Nowadays, the site is well preserved and easy to access as it is located in the vicinity of the Tham Lod Natural and Wildlife Education Center (Khaokhiew, 2004; Marwick, 2008a).

Tham Lod rockshelter was discovered by the Australian John Spies, a local resident, who has investigated the caves and rockshelters in north-western Thailand. Tham Lod is well a known prehistoric site in north-western Thailand, mainly for the burials it yielded.

It has preserved a 4 m thick, well stratified archeological sequence. More than one hundred thousand archaeological remains were unearthed from the late Pleistocene and Holocene layers, including stone artefacts, faunal and floral remains (with numerous freshwater shells), as well as potshards and some metal items in the Holocene upper layer (Shoocongdej, 2003; Kheawtaya, 2005). The multidisciplinary studies conducted so far indicate that this site was utilized as a temporary settlement, where activities such as food preparation and lithic production were practiced (Shoocongdej, 2004, 2006, 2007). Two burials and two more fragmentary skeletons were discovered in area 1, near the wall of the rockshelter, in the youngest Pleistocene layers. Several remains of fauna, shells, flakes, and used cobble tools were associated with these burials (Khaewkamput, 2003; Shoocongdej, 2004; Wattanapituksakul, 2006).

Three areas had been defined for the excavation within a single horizontal grid system. The first area is near the wall of the shelter, and the trench here is approximately 4 × 1.5 m. The second area is about 10 m to the north, with a trench of 2 × 6 m, and the third one is about 15 m away and excavated on a 2 × 9 m trench (Khaokhiew, 2004; Shoocongdej, 2006; Marwick, 2008a). The sedimentological studies allowed correlation of the stratigraphy of the three areas and, finally, to identify 10 layers over a depth of 4.50 m. The layers are sloping down from the wall of the cliff (south to north). Some taper to ~10 m away from the wall (Fig. 2). The Pleistocene deposits correspond to layers 3 to 10, which yielded a high in density of archaeological remains, especially lithic and faunal material (Khaokhiew, 2004).

Many dates have been processed on different materials with different methods, and have provided a remarkable range of dates. The lower layers represent the oldest prehistoric occupation in this region with a date of 35,782 ± 266 (Akita-TL1) in layer 10. Nearly one meter above in layer 8, there are dates of 27,620 ± 170 B P (Beta-206539 MHSTLAR3-152) and 26,680 ± 250 B P (Beta-172229 MHSTLAR2-918). In the other layers, the discrepancies among dates call for caution. Towards the top of the sequence, layer 3 provides ages between 20 ka and 10 ka, while the only date for the upper layer 2 is around 3 ka (late Holocene). The Middle Holocene period is missing.

In order to have an idea of the technical evolution throughout the sequence of Tham Lod, it was decided to focus on area 2 as it is located in the center of the site. This area comprises three sectors of excavation, S21W10 closer to the cliff (south), S20W10 further away (north) and in between the "baulk S21W10". The lithic industry from the first two sectors is analyzed in the present study, excluding that from the upper layer 2, which is Holocene.

The stratigraphy of this area 2 is interspersed by a large limestone rock fall (Khaokhiew, 2004). It occurs in the sector S21W10 and makes up layers 7 to 5, which are almost as rich in archaeological material as the other layers. These layers are tapering towards the north (away from the cliff) and they are missing in sector S20W10 (Fig. 2).

3. Overall composition of the lithic assemblage from area 2, sectors S21W10 and S20W10 in Tham Lod

The lithic industry from Tham Lod has been classified into different artifact categories: flakes, small tools/light-duty tools (<100 mm), large tools/heavy-duty tools, hammerstones, large fragments, small fragments, and unmodified manuports. Tools imply modification of any support, either by retouch (small tools) or by shaping (large tools).

Altogether, the studied lithic material amounts to 10,740 artefacts, excavated from stratigraphic layers 3 to 10. Layer 3 is by far the richest, providing 35% of the whole series, followed by layer 4, with about 20% (Table 1). The other layers are not as rich, but some of them (7–5) are present in one sector only (S21W10), and all layers do not have the same thickness (Fig. 2). Layer 4 provided many flakes in the sector S20W10 (411) but very few in the next sector (19). The lowest layer (10) is by far the poorest in the sector S21W10 (8 artefacts only) while it is quite rich (516 artefacts) in sector S20W10 (Fig. 3), farther away from the cliff towards the north.

Numerous artefacts are made in grey sandstone (around 90%) in all the layers, with black sandstone, quartzite, siliceous shale and quartz as complementary raw materials. The main artefact category consists of fragments, especially small fragments, representing nearly 70% of the whole series. Among them, the flake fragments exceed the amorphous fragments in the sector S21W10 while they are proportionally less in sector S20W10. They are overwhelming in the middle layers, especially layer 7 (83%) while the lowest

proportion is in the upper layer 4 (56%). Comparatively, large fragments are somewhat rare. Unbroken flakes account for around 13% of the studied material, but their proportion varies from layer to layer. The tools (large and small tools) together do not reach 10% except in layer 6. The hammers are in similar proportions (around 7%) except in layer 6 where they are very rare. Cores are almost absent in these sectors.

occur on 10–15% of the flakes. Linear or punctiform platforms resulting from strokes applied on the ridge or the corner of the cores or large tools vary considerably from layer to layer and from sector to sector. They may be linked to the shaping or re-sharpening of the large tools (stroke applied on the edge and not on a surface).

The flakes devoid of cortex on their dorsal face are the majority

Table 1
Distribution of the main artefact categories in the stratigraphic sequence of sectors S20W10 and S21W10, area 2 of Tham Lod rockshelter.

Artefact categories	Flakes (blank, unbroken)	Core	Small tools	Large tools	Hammers	Big fragments	Small fragments	Manuports (pebbles & cobbles)	Total
Stratigraphic layers	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	N
Layer 3	345 (10)	2	128 (3)	138 (4)	341 (9)	184 (5)	2409 (67)	64 (2)	**3611**
Layer 4	430 (19)	1	121 (5)	79 (4)	231 (10)	85 (4)	1271 (56)	48 (2)	**2266**
Layer 5	151 (22)	0	14 (2)	7 (1)	5 (1)	0	501 (73)	11 (1)	**689**
Layer 6	9 (4)	0	31 (13)	14 (6)	2	0	165 (71)	11 (5)	**232**
Layer 7	89 (7)	2	28 (2)	38 (3)	9 (1)	0	1043 (83)	49 (4)	**1258**
Layer 8	179 (13)	0	43 (3)	60 (5)	73 (5)	25 (2)	961 (70)	30 (2)	**1371**
Layer 9	147 (19)	2	39 (5)	36 (5)	41 (5)	11 (1)	475 (60)	38 (5)	**789**
Layer 10	27 (5)	0	7 (1)	11 (2)	43 (8)	14 (3)	397 (76)	25 (5)	**524**
Total	1377	7	411	393	745	319	7222	276	**10,740**

4. Blank flakes

A total of 1377 (13%) flakes are present in these sectors. Their proportion is particularly high in layer 5 (151/689: 22%) and particularly low in layer 6 directly below (9/232: 4%). The large majority of the flakes are in grey sandstone (more than 90%). However in the lower layers, especially in the bottom layer 10, the rocks are slightly more diversified, with use of the black sandstone (6/127: 22%). The average dimensions of the flakes are rather homogenous along the sequence, with a value of 42 mm for the average length around 40 mm for the average width and 12 mm for the thickness. The longest flakes occur in the bottom layer 10 (47 mm) and the smallest is in the middle layer 5 (36 mm). In the other layers, they vary between 39 and 45 mm. The flakes are fairly short, not elongated possibly due to the quality of the rock available around Tham Lod rockshelter, or due to the process of flake production. In the near absence, of core many of the flakes may result from the shaping of the large tools.

Most of the butts are totally cortical with proportions ranging from half of the flake assemblage in the lower layers to two-third in the middle and upper layers. Butts without cortex represent about 30% in the lower layers, slightly less in the layers above. Partly cortical platforms are not so common (10–20%). They are usually planar in shape. Bifacetted/dihedral platforms (50–60%), and they are accompanied by the flakes with little cortex (20–30%). In layer 5 which is the richest in flakes of the sector S21W10, these two groups reach 90%. Flakes with a totally cortical dorsal face are very few in the sector S21W10 while they represent 10–15% in the adjoining northern sector. They correspond to the first states of core reduction or tool shaping. These variations suggest that the activities were not the same in the different sectors of the site.

The scar pattern on the dorsal face of the flakes is mostly unipolar (50–75% without considering the undetermined items). Otherwise they are bipolar opposite (10–20%) and less frequently orthogonal or multidirectional. A convergent pattern is noted in layer 4 of sector S20W10 (37/268 = 14%). Generally, the unipolar pattern is provided by reducing cores from one single striking platform or by shaping choppers. There are usually two scars on the dorsal face of the flakes, and otherwise one scar or three scars, rarely more except in layer 4 as well in layer 3.

5. Small tools

The small tools or light-duty tools total 411, and all of them are usually measuring less than 10 cm. Their proportion (less than 5%) is rather similar along the stratigraphy when the whole assemblages are considered (Table 1). When referring to the tools only, their frequency increases upwards, slightly in the middle

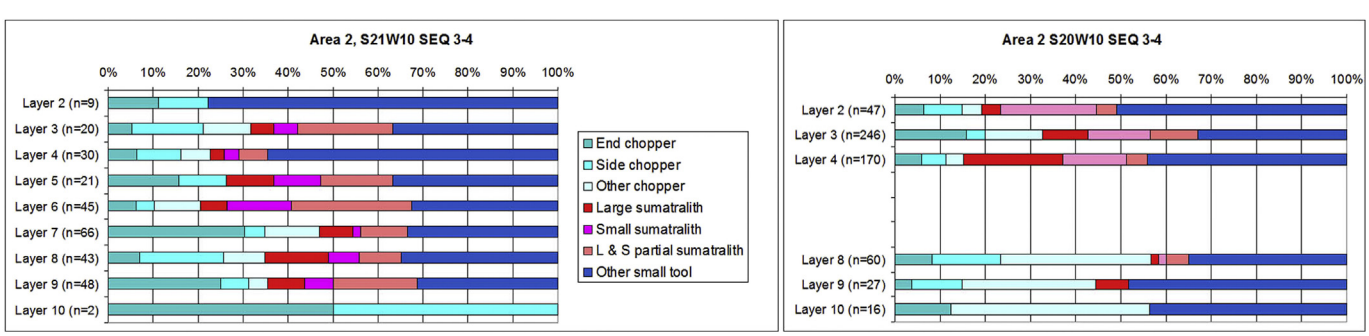

Fig. 4. Distribution of the main tool types across the stratigraphic sequence of Tham Lod in area 2, sectors S20W10 and S21W10.

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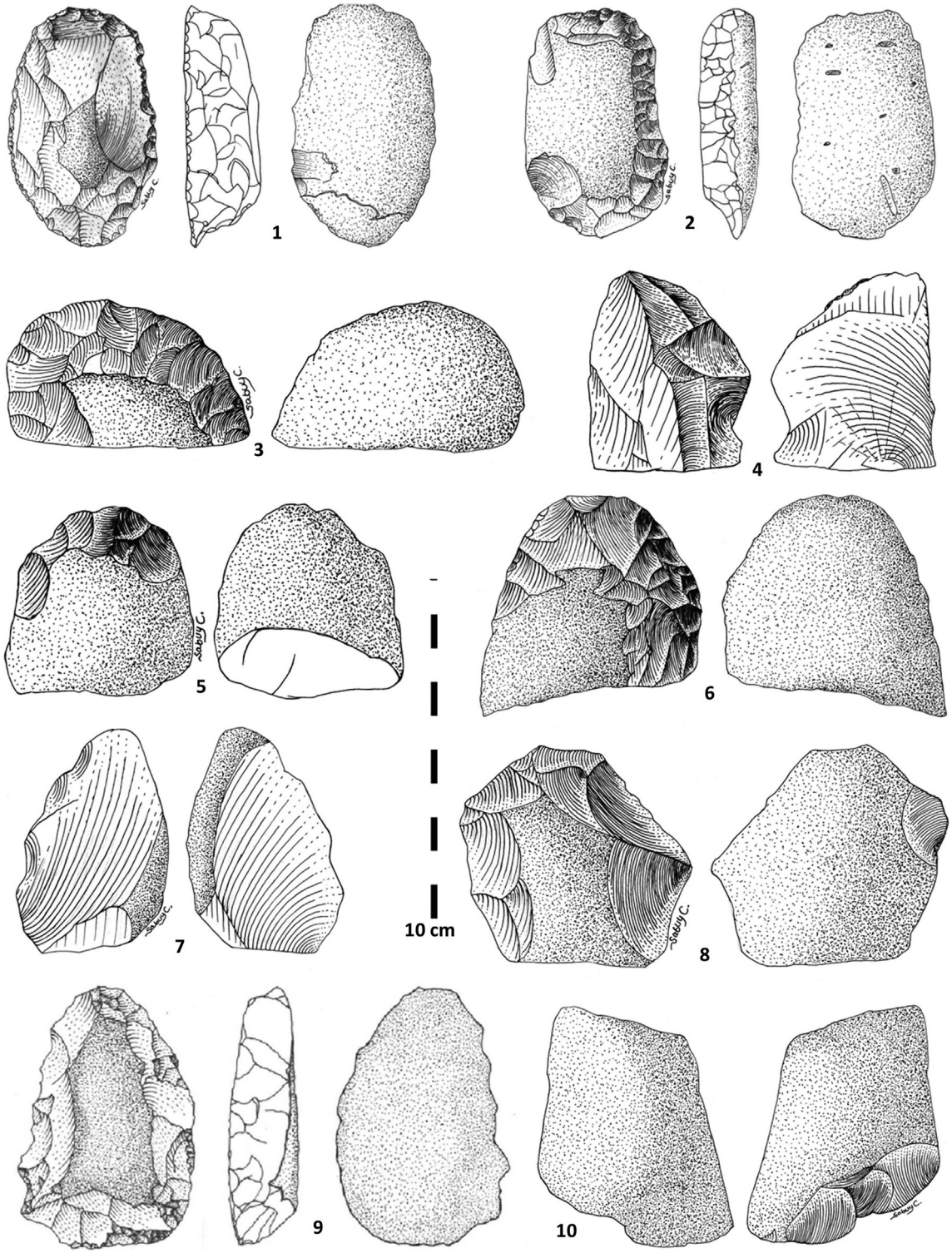

Fig. 5. Small tools from Tham Lod rockshelter area 2, sectors S20W10 & S21W10 (drawings T. Chitkament). 1: Layer 3 (S20WV10), 2: Layer 3 (S20W10), 3: Layer 5 (S21W10), 4: Layer 5 (S21W10), 5: Layer 6 (S21W10), 6: Layer 6-5504 (S21W10), 7: Layer 7 (S21W10), 8: Layer 8 (S21W10), 9: Layer 9-8683 (S20W10), 10: Layer 9-065 (S21W10).

layers 6 and 5, then clearly in layer 4, visible in both sectors (Table 2, Fig. 4). Small tools are comprised of several types (Fig. 5): scrapers, denticulates, pointed or convergent tools, atypical small tools, unifacial discoids, and small sumatraliths (typical and partial, unifacial and bifacial). The latter, both typical and partial, are numbered in this group but will be considered along with their larger counterparts (more than 10 cm) when analyzed in detail.

Table 2
Distribution of the main tool types (large tools & small tools) in the stratigraphic sequence of sectors S20W10 & S21W10, area 2 of Tham Lod rockshelter.

All tools (large and small)	Choppers	Sumatraliths	Partial sumatraliths	Scrapers	Other small tools	Total
Stratigraphic Layers	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	N
Layer 3	86 (32)	37 (14)	57 (21)	53 (20)	33 (12)	**266**
Layer 4	33 (16)	41 (20)	34 (17)	56 (28)	36 (18)	**200**
Layer 5	5 (24)	4	3	7 (33)	2	**21**
Layer 6	10 (22)	10 (22)	13 (29)	8 (18)	4	**45**
Layer 7	31 (47)	6 (9)	7 (11)	18 (27)	4	**66**
Layer 8	49 (47)	11 (11)	7 (7)	23 (22)	13 (13)	**103**
Layer 9	29 (39)	8 (11)	10 (13)	19 (25)	9 (12)	**75**
Layer 10	11 (61)	0	0	4	3	**18**
Total	**254**	**117**	**131**	**188**	**104**	**794**

5.1. Scrapers

The large majority of the small tools are scrapers, with a total of 188. They represent 20–25% of all the tools (large and small) therefore showing a rather constant frequency (Table 2) but they show noticeable variations from 25 to 50% between layers with regard to the small tools only (Table 3). Generally, they are comprised of various types: double scraper, steep scraper, nose scraper, multiple scraper etc., but two main types such as the end and side scrapers are significant. The large majority are made in grey sandstone, nearly 90% in all the layers, except in the bottom (layer 10: 50%). Most of them are made on broken cobbles (around 52%), especially in the layer 5 (72%). Their average measurements are: length 79 mm, width 62 mm and thickness 36 mm. They ordinarily range between 50 and 400 g, but they are generally between 151 and 200 g, especially in layer 3. Their outline (frontal view) is usually trapezoidal or irregular (24 and 26%) and their transversal view trapezoidal. The lateral edges are mostly medium to open angled (60°–80°) and essentially sharp to medium (30°–60°) on the distal side. The proximal side is more open (80°–100°), whether cortical or not. Regarding their nature, the edges are markedly unifacially retouched in the distal position, while in the lateral position, fractures are preponderant.

Table 3
Distribution of the light-duty tool types in the stratigraphic sequence of sectors S20W10 & S21W10, area 2 of Tham Lod rockshelter.

Small tools	Scraper	Denti-culate	Pointed tool	Atypical small tool	Small sumatralith	Unifacial discoid	Small partial sumatralith (unifacial)	Small partial sumatralith (bifacial)	Total
Stratigraphic layers	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	N
Layer 3	53 (41)	15 (12)	5 (4)	13 (10)	11 (9)	2	28 (22)	1	**128**
Layer 4	56 (46)	12 (10)	11 (9)	13 (11)	5 (4)	0	22 (18)	2	**121**
Layer 5	7 (50)	0	0	2	2	0	3	0	**14**
Layer 6	8 (26)	0	1	3	7 (23)	0	11 (35)	1	**31**
Layer 7	18 (64)	1	1	2	1	0	5 (18)	0	**28**
Layer 8	23 (54)	2	1	10 (23)	4	0	3	0	**43**
Layer 9	19 (49)	3	2	4	3	0	8 (20)	0	**39**
Layer 10	4	1	2	0	0	0	0	0	**7**
Total	**188**	**34**	**23**	**47**	**33**	**2**	**80**	**4**	**411**

5.2. Denticulates

Denticulates (34 in total) are significantly present in upper layers 3 and 4 only (Table 3). The large majority of them are in grey sandstone, and made on broken cobbles (43%) and broken pebbles (24%). The other supports are seldom seen on cobbles, flakes and fragments. Classes of denticulate tools are identical with those of atypical small tools, mostly between 51 and 100 g. Their general morphology is often irregular in frontal view and triangular in transversal view. The angle of edges is more medium (60°–80°) on the lateral and proximal sides and more sharp to medium (30°–60°) on the distal side. These features may be related to the nature of the edges, which is more often a fracture for the lateral and proximal sides while the distal side is often unifacially retouched.

5.3. Pointed tools

The pointed tools (n = 23) are less common than the denticulate (Table 3). They are mainly made in grey sandstone and black sandstone. They are between 51 and 250 g, and their average measurements are quite similar to those of other types in the small tools group. Their edges are somewhat more open (80°–100°) on the lateral sides, medium (60°–80°) on the proximal side and quite "acute" (30°–60°) on the distal side.

5.4. Atypical small tools

Atypical small tools are roughly shaped blanks that cannot be called scrapers or notches. They show little modification, but apparently intentional rather than accidental. They are almost as rare as the previous types (47: 11%) except in the lower layer 8 (10/43: 23%; Table 3). Many are in grey sandstone in all the layers. Their supports are broken cobbles (34%) and broken pebbles (11/47: 24%) besides flakes (9/47: 19%).

Masses are concentrated between 51 and 100 g and sizes are rather smaller than for other tools: length 64 mm, width 53 mm and thickness 26 mm. The edges are mostly sharp to medium

(30°–60°) on the lateral sides and essentially medium to open (60°–80°) on the proximal side. The lateral and distal sides are overwhelmingly unifacially (but partially) retouched, while fractures occur on the proximal side.

6. Large tools: choppers

The choppers belong to the large tool category (measuring more than 10 cm) (Fig. 6). Their total number in the studied sectors is 254. They represent about one third of the whole series of large and small tools but in the lower half of the sequence (layers 10 to 7) they are more than 40% while in the upper part (layers 6 to 3) they are less than 32% (Table 2). Variations between both sectors also occur (Fig. 4). The large tools are at maximum in the bottom layer 10, where they are the only heavy-duty tools, and their minimal frequency occurs in layer 4 (41%). In the other layers, their frequency ranges between 62 and 80%.

Three main types of choppers are distinguished (Table 4): end chopper, side chopper and a group of "other choppers" including various types represented by very few examples in the studied series. End choppers are more common in the sector S21W10 while side choppers and "other choppers" are more in S20W10, at least at the base of the sequence (Fig. 4). Choppers are mostly in grey sandstone (more than 90%) in all the layers, except the lower layers, where the raw materials are more diversified. The principal supports are broken cobbles (77%) or whole cobbles (47/254: 19%); some flakes, fragments or broken boulders were also used for shaping the choppers. Masses range between 201 and 1000 g and the class where cluster most of choppers is between 401 and 600 g, especially in layers 3, 4 and 8.

6.2. Side choppers

The side choppers total 56 (15% of the large tools, one fourth of the choppers). Their attributes are rather similar to those of the end choppers but their cutting edge is almost straight, located on one side of the tool while the opposite side is cortical. These tools are slightly shorter and wider than the end choppers: average length 121 mm, width 93 mm and thickness 52 mm. Their shaping usually results from 2 to 6 removals. The angle of the cutting edge is usually medium to open (60°–80°).

6.3. Other choppers

Various types of chopper are combined in this group: double chopper, multiple chopper, extended chopper, pointed chopper, nosed chopper, corner chopper, giant chopper and horsehoof, totalizing 96 items (25% of the large tools). Their frequency is quite variable not only between the layers (Table 4) but also between the sectors: they are well represented in the sector S20W10 in comparison with S21W10, closer to the cliff (Fig. 4). They are principally made on broken cobbles (around 75%) or whole cobble (17/96: 18%) by unifacial shaping. Their general morphology is broadly similar to that of the end and side choppers, with the exception for the transversal view, more triangular than trapezoidal. The classes are clustered around 201–600 g. The average dimensions are consistent with those of the end and side choppers: 126 mm for the length and 85 mm for the width. The shaping of these tools is often made with more than 8 removals, rather marginal (51%). The longest removal length is between 31 and 40 mm on the upper face and between 21 and 40 mm on the lower face. The lateral sides are rather steep (80°–100°), the distal sides medium to open (60°–80°) and the proximal sides usually cortical.

Table 4
Distribution of the large tool/ heavy-duty tool types in the stratigraphic sequence of sectors S20W10 & S21W10, area 2 of Tham Lod rockshelter.

Large tools	End chopper	Side chopper	Other choppers	Sumatralith	Partial sumatralith (unifacial)	Partial sumatralith (bifacial)	Discoid	Total
Stratigraphic layers	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	Nb (%)	N
Layer 3	40 (29)	13 (9)	33 (24)	26 (19)	20 (15)	6 (4)	0	**138**
Layer 4	12 (15)	12 (15)	9 (11)	36 (46)	5 (6)	3	2	**79**
Layer 5	3	2	0	2	0	0	0	**7**
Layer 6	3	2	5 (36)	3	1	0	0	**14**
Layer 7	20 (53)	3	8 (21)	5 (13)	2	0	0	**38**
Layer 8	8 (13)	17 (28)	24 (40)	7 (12)	3	1	0	**60**
Layer 9	13 (36)	6 (16)	10 (28)	5 (14)	1	0	1	**36**
Layer 10	3	1	7 (64)	0	0	0	0	**11**
Total	**102**	**56**	**96**	**84**	**32**	**10**	**0**	**383**

6.1. End choppers

Most of the choppers are end choppers (102: 27% of the large tools, 40% of the choppers). Their main supports are broken cobbles (77%) or whole cobbles (19/102: 19%), and seldom flakes or fragments. Masses are clustered between 401 and 600 g and the average dimensions are: length 132 mm, width 87 mm and thickness 55 mm. End choppers are almost always unifacial rather than bifacial. The delineation of the edges is often incurved and non-symmetrical in sagittal view. They are usually shaped by 2 or 3 removals and the extent of the shaping is mostly marginal (61%). The length of the longest removal is between 21 and 30 mm. When occurring on the lower (flattest) face, the longest removals are shorter, between 11 and 20 mm; the shaping nearly always remains marginal (93%). Angles of the distal edges are sharp to medium (30°–60°) and the lateral and proximal sides are usually cortical.

7. Sumatraliths (large and small tools)

7.1. Typical sumatraliths

Typical sumatraliths number 117 in the studied sectors of Tham Lod. These tools are commonly made on oval or almond, rather flat cobbles, with removals all around the upper face forming the working edge. As they correspond to a remarkable tool type, it appeared irrelevant to separate them into small tools and large tools. However, nearly 30% of them belong to the small tool group (Table 3). Their maximal frequency occurs in layer 4 (41/200: 20% of all tools) and also in the middle layers 5 and 6 (around 20%, keeping

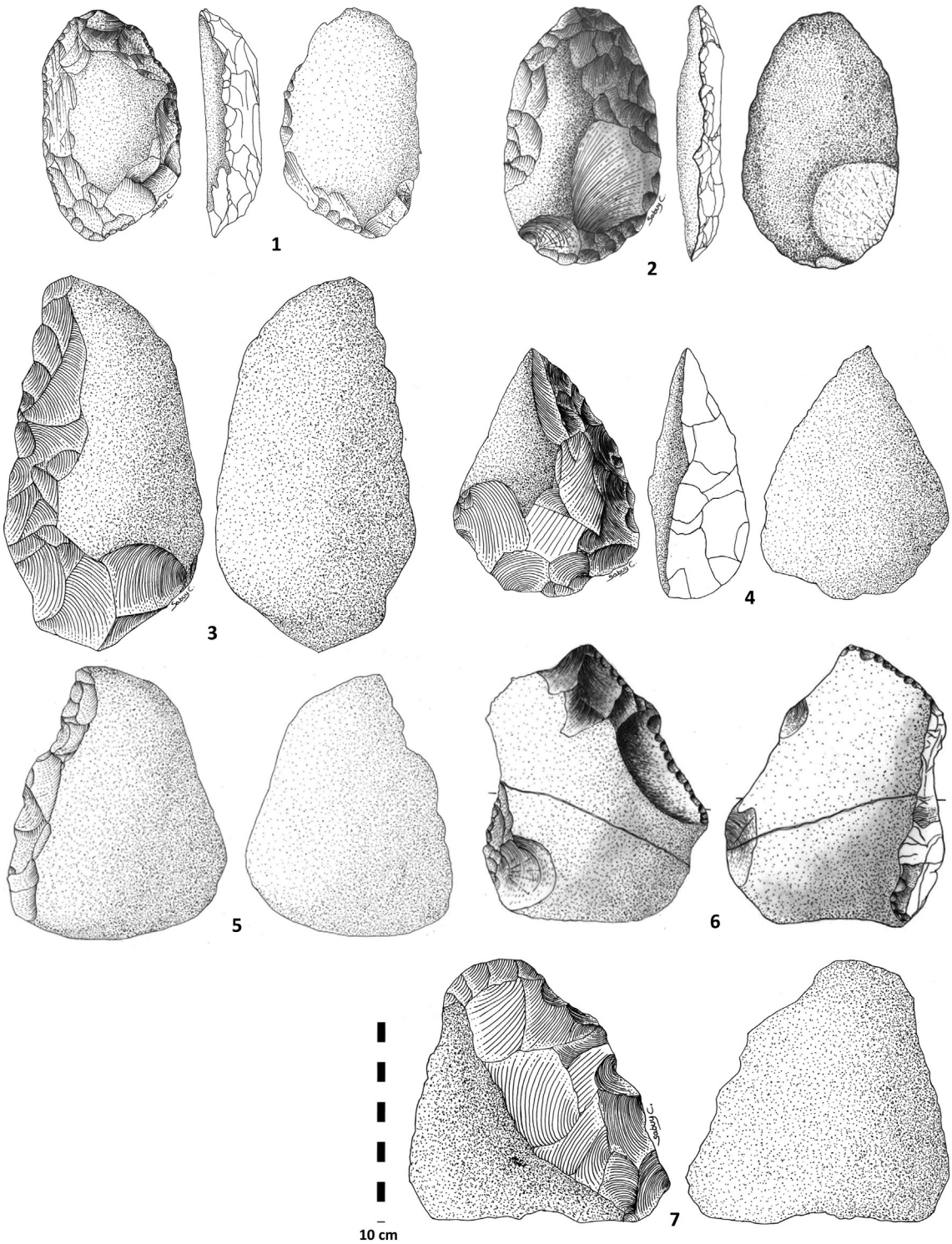

Fig. 6. Large tools from Tham Lod rockshelter area 2, sectors S20W10 & S21W10 (drawings T. Chitkament). 1: Layer 3-7689 (S20W10), 2: Layer 4-8736 (S20W10), 3: Layer 5-2111 (S21W10), 4: Layer 7-5666 (S21W10), 5: Layer 8-10447 (S20W10), 6: Layer 9-10406 (S20W10), 7: Layer 10-10565 (S21W10).

in mind the small amount of specimens, thus lacking statistical significance). In the lower layers, this tool type accounts for about 10% of the tools, although absent in the lowest layer 10, and in the upper layer 3 around 15% (Table 2).

Their preponderant raw material is the grey sandstone (95%). Most of them are made on whole cobbles (80%) or broken cobbles (14/117: 12%) and are mostly unifacially shaped. Masses range between 200 and 1000 g, but are concentrated between 201 and 600 g, mainly in layers 3 and 4. Their average dimensions are: length 112 mm, width 74 mm and thickness 41 mm. The typical sumatraliths are therefore smaller than the choppers, with a ratio length/width similar to that of the end choppers but a ratio

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width/thickness close to that of the side choppers. The frontal view (contour) is mostly elliptical or oval, especially in the upper layers (about 40–50%); the transversal view is more trapezoidal. The upper face is often non-cortical (37%) and usually shaped by more than 8 removals especially in the upper layers 3 and 4 (about 94–98%). The longest removals have an average length around 31–40 mm. Conversely, the lower face is mostly totally cortical (around 65%). The edges are mostly sharp to medium (30°–60°).

7.2. Partial sumatraliths

These tools resemble the sumatraliths but are not shaped all around and, thus, are not typical. They are termed "partial sumatralith" (sumatralith partly shaped), a few of them being bifacially shaped. Like the typical specimens, the small and large tools of this group have been studied together. They are comprised of several sub-groups of tools: ½ sumatraliths, ¾ sumatraliths, partly unifacial, partly bifacial and unifacial discoid. They amount to 131 (15% of all the tools). They are quite frequent in layer 6 (nearly 30%) where they rather belong to the group of small tools (Tables 3 and 4), secondly in layer 3 and then layer 4. In the lower layers, their frequency is below 15% with regard to all the tools (Table 2). They are made in grey sandstone (more than 90%) in all the layers and are made on broken cobbles (65%) and broken pebbles (17/131: 13%). They mostly are between 200 and 400 g. Their average length is 76 mm, width 83 mm and thickness 38 mm. Therefore, they are considerably smaller than the typical sumatraliths and are much closer to the scrapers as far as their dimensions are concerned. Further analysis should shade light on the relationship between these three tool types. The frontal view of the partial sumatraliths is often half-oval (32%), especially in the layer 6 (7/10) and the transversal view rather oval (37/131: 28%). Delineation of their edges in sagittal view is more incurvated and non-symmetrical. Around 42% of these tools are "non-cortical dominant" on their upper face. They are shaped by more than 8 removals (63% of the cases) of which the maximal length averages 31–40 mm. The lower face is mostly "totally cortical" (62%) and if shaped it is by 2 or 3 removals measuring 11–20 mm for the longest of them. The edges are more "acute" (30°–60°) on the lateral and distal sides while the proximal side, it is more open (80°–100°) and often formed by fracture.

8. Discussion

Analysis of the lithic material from two sectors of area 2 in Tham Lod site shows that the distribution of the artefacts is highly variable in quantity and nature according to its localization in the site. However, data regarding the flake production do not differ noticeably between both sectors. It was analyzed and discussed for sector S20W10 (Chitkament et al. in press). The flake assemblage from Tham Lod matches well the by-products of experimental manufacture of Hoabinhian tools (Jérémie, Vacher, 1992; Marwik, 2008a, 2008b) with about 50% of flakes devoid of cortex on their dorsal face and less than 10% of totally cortical flakes. In Tham Lod, the average length of the flakes is around 40 cm while the longest removals observed on the choppers and the sumatraliths measure 30–40 cm in average length. There may be some flakes that are not just by-products from shaping, but these are proportionally few. Therefore, most of the flakes result from the shaping and trimming of the large tools. However the very high proportion of fragments in all the layers yet remains to be understood, which may require contribution of the other disciplines implied in the study of Tham Lod. Thermal effect is suspected for some of the specimens but it cannot explain all the fractures.

Regarding the heavy-duty tools, results from the sector S20W10 alone had given the impression that the typical sumatraliths, signature of the Hoabinhian technical tradition, first appeared in layer 4 (Chitkament et al. in press). This is not really confirmed by the study of the adjoining sector S21W10 where sumatraliths occur from layer 9 dating to more than 26,600 B P (Fig. 2; Shoocongdej, 2007). Sumatraliths seem to be absent in the lowest layer 10, but the amount of artifacts other than fragments is very small in this layer, and this observation may not be a sound proof of absence. However, the frequency of these typical Hoabinhian tools remains rather low, not more than 10% of the tools (large and small) in the lower layers 9 to 7. From layer 6 upwards it exceeds 20%, except in upper layer 3 where it again decreases. The partial sumatraliths follow the same trend. Correlatively, the choppers are dominant among the large tools in the lower layers and they decrease, conversely to the sumatraliths in the upper layers, except layer 3.

As demonstrated (Forestier et al., 2005, 2008, 2013 and Zeitoun et al., 2008) for other assemblages from the same region, three *chaînes opératoires* are used to produce Hoabinhian assemblages. They all imply the selection of cobbles as raw material, and at Tham Lod these are easily available near the site. The simplest process is to directly shape the selected cobbles into either choppers or sumatraliths. For choppers, the cobbles are slightly thicker (50–55 mm) than for the sumatraliths (around 40 mm). Thus, from the stage of support selection two technical sequences can be distinguished. The third sequence is to fracture the cobble, approximately following the grand plan (split) in order to obtain two support for shaping various types of tools, including smaller tools like scrapers.

These three processing sequences are observed throughout the stratigraphy at Tham Lod, from about 35 ka to the Holocene. The climatic changes do not seem to have affected this process. However, the typically Hoabinhian tools appear to flourish in layers 6 to 4, in a time period dating approximately from 26,000 to 20,000 B P, perhaps slightly later, when climatic conditions were quite stable (Penny, 2001; Rashid et al., 2007; Marwik and Gagan, 2011). Does the decrease in number of sumatraliths in the layer 3 corresponds to the LGM, where the vegetation was characterized by pine/oak forests (White et al., 2004)? Multidisciplinary study of the archaeological and environmental records at Tham Lod may answer these questions.

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