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The lithic industries on the fossiliferous outcrops of the Late Pliocene Masol Formation, Siwalik Frontal Range, northwestern India (Punjab)

Les industries lithiques sur les affleurements fossilifères fin Pliocène de la formation de Masol, chaîne frontale des Siwaliks, Nord-Ouest de l'Inde (Pendjab)

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A B S T R A C T

The Quranwala zone (QZ) in the sector near Masol (Siwalik Frontal Range, Punjab) has been known since the 1960s for yielding freshwater and terrestrial vertebrates living during the late Pliocene on the sub-Himalayan floodplain. The fossils and quartzite cobbles are constantly unearthed from the core of an anticline. The basal member of QZ is about 130 meters below the Gauss/Matuyama paleomagnetic reversal, *i.e.*, 2.588 Ma. Since 2009 the Indo-French Program of Research 'Siwaliks' has surveyed 50 hectares and highlighted a dozen localities on outcrops where artefacts in quartzite occur with fossil bones, of which a few show butchering marks. A few cobble tools and a flake were unearthed from a trial trench opened along the same boundary between silts and sandstones (Masol 2) as the one that provided a bovid tibia shaft bearing cut marks (Masol 1). Some 250 artefacts were collected mainly from the surface, sometimes in the slopes of outcrops recently eroded. These were mostly heavy-duty tools that comprised a majority of choppers, end choppers rather than side choppers, among which the "simple choppers" (shaped by one single removal) are common. The light-duty tools consist of flakes that are seldom retouched. The cores are very few and the flakes generally result from the shaping of choppers, except the larger flakes that are complemented by split cobbles. The consistency of the lithic assemblages among the localities supports their chronological homogeneity. Their features do not reflect

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any lithic technical tradition known in the region, neither Acheulean nor Soanian (in which the choppers are usually classical, not "simple").

Mots clés :
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Galet fendu
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Asie du Sud

R É S U M É

La zone Quranwala du secteur de Masol (chaîne frontale des Siwaliks, Pendjab) est connue depuis les années 1960 pour ses vertébrés terrestres et d'eau douce, vivant dans la plaine d'inondation sous-himalayenne à la fin du Pliocène. Des fossiles et des galets de quartzite sont exhumés en permanence des affleurements du cœur d'un anticlinal, situés 130 m sous la limite paléomagnétique Gauss/Matuyama, datée de 2,588 Ma. Depuis 2009, le programme de recherche franco-indien « Siwaliks » a mis en évidence une douzaine de localités où des artefacts lithiques sont associés en surface aux ossements fossiles, dont certains, de bovidés, portent des traces de boucherie. Quelques galets taillés et un éclat ont été mis au jour dans un sondage ouvert dans la même limite limon/grès (Masol 2) que celle d'où provient un fût tibial portant des traces de boucherie (Masol 1). Les quelques 250 artefacts, récoltés le plus souvent en surface, parfois dans les pentes des affleurements récemment érodés, comprennent majoritairement des macro-outils et surtout des choppers, plus transversaux que latéraux, parmi lesquels des « choppers simples » (façonnés par un unique enlèvement) sont fréquents. L'outillage léger consiste en des éclats, exceptionnellement retouchés. Les nucléus sont très rares et les éclats proviennent généralement du façonnage des choppers, sauf les plus grands, complétés par les *splits* de galet. La cohérence des assemblages lithiques entre chacune des localités plaide en faveur d'une homogénéité chronologique. Leurs caractères n'évoquent aucune tradition technique connue dans la région, comme l'Acheuléen ou le Soanien (choppers classiques non pas « simples »).

1. Introduction

The sector around the village of Masol is a geological inlier in the Chandigarh anticline, and is well-known since the 1960s for yielding a Late Pliocene fauna, just below the upper boundary of the Gauss Chron (2.588 Ma) (Nanda, 2002; Ranga Rao, 1993; Ranga Rao et al., 1995; Sahni and Khan, 1961, 1964; see more in Abdessadok et al., 2016; Chapon Sao et al., 2016a, 2016b; Gargani et al., 2015; Moigne et al., 2016; Tudryn et al., 2016). One lithic artifact was mentioned on terrace T1 of the Ghaggar River, deposited on the southeastern fringes of the Chandigarh anticline (Sahni and Khan, 1964), and later on a terrace of the Patiali Rao, a seasonal river (or *choe*), which cuts through the inlier (Gaur, 1987). The Indo-French Program of Research "Siwaliks" (Dambricourt Malassé, 2016) has surveyed the sector since 2008, and has discovered 12 paleonto-archeological localities yielding artifacts on the present-day surface or on the slopes of outcrops among fossils of terrestrial and freshwater vertebrates (Dambricourt Malassé et al., 2016b; Chapon Sao et al., 2016b). These localities are situated on both sides of the Patiali Rao (Fig. 1).

During the fieldwork, many vertebrate fossils were collected (Moigne et al., 2016). A few bovid bones showed cut marks and green fractures (Dambricourt Malassé et al., 2016a). Some of the bones were recorded in stratigraphy (Masol 1: two hemi-mandibles of the same antelope and one of *Hexaprotodon*; Masol 6: a giant turtle *Colossochelys* and one bovid jaw; in the cliff of a small torrent: one skull with tusks of a proboscidean). The majority of the fossils were recovered on the fresh outcrops where they were unearthed by erosion. Artifacts were found in the same condition, either on the Pliocene outcrops (Masol 1 sub-localities, Masol 2 East, Masol 3, Masol 6, Masol 7, Masol 8, Masol 10, Masol 11, Masol 13), with a few mixed with fossil bones in old colluvium (Masol 1, Masol 2, Masol 9), and others in recent colluvium of the fossiliferous layers (Masol 1 sub-localities, Masol 5, Masol 9) (Chapon Sao et al., 2016b) (Fig. 2).

The lithostratigraphic context of these artifacts is a complex question studied by a new methodology consisting of modeling the speed of erosion, and analyzing the related factors such as tectonics and monsoons (Dambricourt Malassé et al., 2016b; Gargani et al., 2015). This paper describes the stone artifacts collected in the different localities; lithostratigraphic units and sequences are described by Chapon Sao et al. (2016b).

The Paleolithic evidence in the northwestern Himalayan foothills is a perennial issue in the search for human origins (Dambricourt Malassé et al., 2016b). In the Potwar Plateau, Pakistan, some stone artifacts belong to a very old conglomerate folded between 2.1 and 1.9 Ma; the polarity measured below the site, at the base of the sequence, is positive. Either this polarity corresponds to the upper boundary of the Reunion Subchron, nearly 2.14–2.15 Ma ago (Dennell et al., 1988; Hurcombe, 1989), or it corresponds to the upper boundary of the Gauss Chron, nearly 2.58 Ma ago (Dennell, 1998). In the sub-Himalayan foothills of India, the oldest lithic tradition is the Acheulean (Gaillard et al., 2008, 2010b; Mohapatra and Singh, 1979). Then, the Soanian, rich in cobble tools, occurs in two facies: one dominated by flake production and representing the Middle Palaeolithic, and the other dominated by the shaping of choppers with, at places, specimens recalling the Hoabinhian types of the

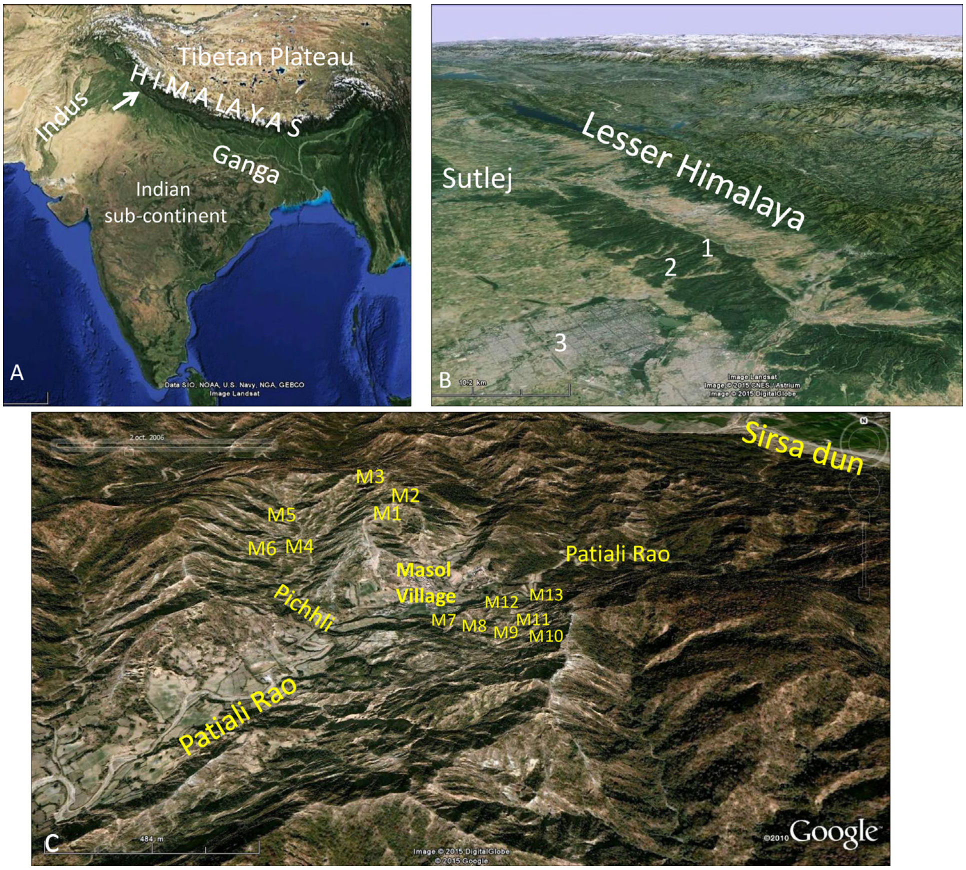

Fig. 1. A. Location of the Chandigarh's Siwalik Frontal Range, North India (arrow). B. Location of Masol site (1), Patiali Rao river (2) and Chandigarh city. C. View on the geological inlier of Masol anticline with the paleonto-archeological localities according to Google Earth (map data © Google2015).
Fig. 1. A. Localisation de la chaîne frontale des Siwaliks de Chandigarh (flèche). B. Localisation du site de Masol (1), en amont du Patiali Rao (2), au nord de Chandigarh (3). C. Vue sur la boutonnière de l'anticlinal de Masol avec les localités paléonto-archéologiques. D'après Google Earth (données de carte ©Google2015).

Late Pleistocene (Gaillard et al., 2010a, 2011, 2012, see the historical context in Dambricourt Malassé et al., 2016a). The lithic industry from the Masol inlier does not compare with these technical traditions known in the region. Further northwest, in the Siwaliks, the artifacts collected in the Pabbi Hills anticline, on deposits dated to between 0.9 and 2.2 Ma (Dennell et al., 2006) show some similarities in the strategies, like splitting cobbles, for instance, but large flakes and simple choppers do not appear as a significant feature of the assemblages and the proportion of proper cores, meant to produce flakes, is much greater (Hurcombe, 2004), while it is almost nil at Masol. The settings and the conditions of artifact collections are very similar, yet at Masol the risk of archeological palimpsest is extremely weak; polished axes and pottery shards were not found in the inlier. In the past, the plateaus were covered with jungle, which is still visible in the adjoining wild valleys, and houses animals such as tigers; today, deer, wild boars and panthers are observed at times by the villagers. Masol is the only present-day village in the upper basin of the Patiali Rao. The houses are not old: they were built by pilgrims only on the two riversides with wells; after the monsoon season there is no water available in the ravines and plateaus on either side of the *choe*. The villagers built dry stone walls with large blocks of sandstone easily available in the landscape for controlling the gullies during the monsoon or retaining the earth in the fields on the terraces of the Patiali Rao. Compared to sandstone, the quartzite cobbles are very rare, scattered, small and very hard to break; they are never used for building or as chopping tools, and the villagers cut wood around the village with metallic axes.

2. Materials and methods

Artifacts were collected in different geomorphologic and lithostratigraphic contexts, offering specific conditions for collection in each paleonto-archaeological locality. Two trial trenches were opened in the pan-shaped depression of Masol 2, which belongs to the basal sequence of the Quranwala zone (QZ) (Fig. 3; see details in Chapon Sao et al., 2016b). The trench A1 did not yield any artifacts.

The trial trench B1 (2 × 2 m) was opened at the bottom of the Masol 2 depression near a zone where several choppers had been collected on the surface. The trench cuts a small mound (Fig. 3A) made of *in situ* silt covered with a colluvium especially rich in sandstone blocks and quartzite cobbles. All the items larger than 50 mm were numbered,

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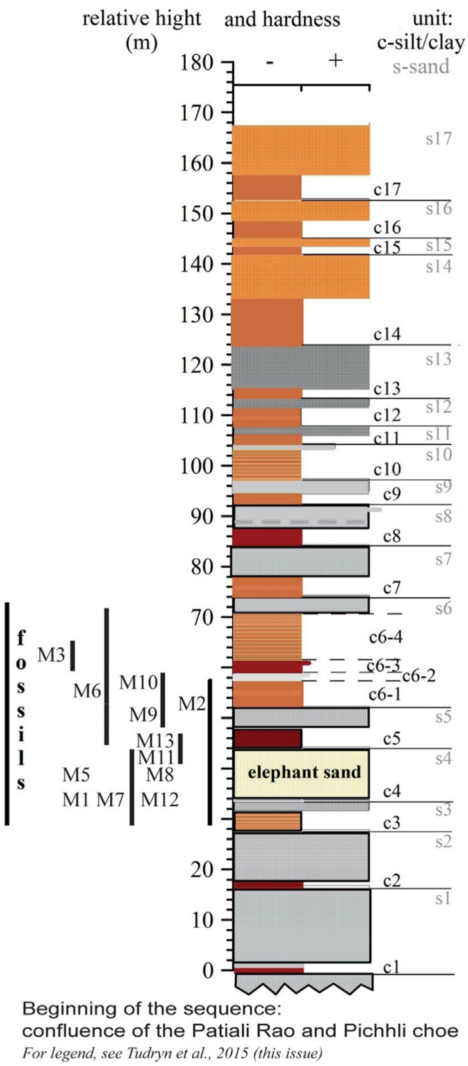

Fig. 2. Log of the Quranwala zone of Masol Formation with the location of the paleonto-archeological localities (Chapon Sao et al., 2016b; Tudryn et al., 2016).

Fig. 2. Log de la zone Quranwala de la formation de Masol avec les localités paléonto-archéologiques (Chapon Sao et al., 2016b ; Tudryn et al., 2016).

counted (Fig. 4), and coordinated (Fig. 5), and the sediment was sieved. The stratigraphy was best exposed on the western section of the trench, in the middle of the mound (Fig. 3C), while the other sections were tapering due to the slope of the surface and deposits (Fig. 5). The lithostratigraphic sequence is composed of two layers: the upper layer 1 is a colluvium mostly comprised of sandstone blocks and nodules with many quartzite cobbles and little brownish sediment between; the underlying layer 2 is the *in situ* pink silt, still including smaller blocks and pebbles in the upper part. This pink silt corresponds to the base of the unit c3 of the general lithostratigraphic column (Fig. 2), and layer 1 results from the dismembering of silts c3, c4 and sandstones s3, s4 ('Elephant sand'); the abundant cobbles and pebbles accumulated in the layer 1 originate from the dismantled layer or lens of cobbly gravel that can be correlated with the one observed in the section at Masol 12 within the silt c3 (Chapon Sao et al., 2016b).

The three artifacts unearthed from the layer 1 are an "odd" simple chopper (No. 61), a broken cobble with a damaged edge (No. 43) and a hammerstone. From layer 2, except the two hammerstones, the artifacts look more convincing: an end chopper shaped by two removals (No. 17, Fig. 6-1), a simple chopper with damaged edges (No. 166, Fig. 6-3), an obliquely broken cobble with a damaged cutting edge (No. 43, Fig. 6-2) and a flake (No. 133). These artifacts were found in the upper part of layer 2, where sandstone blocks and nodules, and quartzite cobbles and pebbles still occur (Fig. 5); the lower part of this layer was a sterile pure pinkish silt (Fig. 3C).

The artifacts at Masol are well-preserved. The most abraded of them were found in the trial trench and were classified as "moderately abraded". From the surface, the extreme grade is "slightly" abraded and most of the specimens are "fresh" even sometimes "very fresh". It is to be noted that, on the right bank of the Patiali Rao, the artifacts are mostly fresh and the proportion of slightly abraded specimens is around 12% in the three main localities (Masol 1, Masol 2 and Masol 6), while, on the left bank, this proportion reaches 50%. As the state of preservation can be considered globally homogenous in each locality, the artifacts have been studied together. It is to be noted that, sometimes, whatever the preservation state, artifacts bear some encrustation like [but not only (Fig. 8-1)] those unearthed from layer 2 in the trial trench B1 (Fig. 6).

Two major groups of artifacts are distinguished in the lithic assemblages: small/light-duty artifacts and large/heavy-duty artifacts; the boundary between both groups is admittedly fixed around 10 cm, especially for the flakes (Kleindienst, 1962). Ergonomically, these are finger-held tools and hand-held tools, respectively (Mishra, 2007), in the sense that a "tool" is used in prehistory versus primatology, *i.e.*, any blank flake or debris secondarily modified after production or selection. The small artifacts from Masol mainly comprise "ordinary flakes" as opposed to the "large flakes" measuring more than 10 cm and accounted for within the heavy-duty tools (Table 1). Ordinary flakes are rarely retouched into proper tools, and there are very few of these at Masol. Conversely, the large artifacts mostly include shaped tools, especially choppers of various types. The heavy-duty tools are dominant in all the paleonto-archeological localities (Table 1). However, at Masol 2, especially Masol 2-West-B (another pan-like depression, but smaller than Masol 2), the proportion of light-duty artifacts is rather high, nearly reaching half of the assemblage. There are fewer small artifacts in locality 6, maybe in relation to the uneven topography.

The raw material of these lithic assemblages from Masol is a fine to medium-grained quartzite of various shades of beige, brown or gray. It occurs in the present-day topography as clusters of cobbles and pebbles spread on the eroding slopes; these are well-localized, suggesting that they originate from cobbly lenses recently exposed and eroded. It is rare to see these in stratigraphy: they were only observed at Masol 12, yet where no artifact was found. However, the conglomeratic layers occurring at the top

Fig. 3. A. View on Masol 2, with Masol 1 behind the crest, and two trial trenches (A1 and B1). B and C. The trench B1 in dismantled sandstone with many blocks on the wine-color silt *in situ* (Chapon Sao et al., 2016b; Dambricourt Malassé et al., 2016b).
Fig. 3. A. Vue sur Masol 2 avec Masol 1 derrière la crête, et deux sondages (A1 et B1). B et C. Sondage B1 dans le grès démantelé, avec de nombreux blocs sur le limon lie de vin en place (Chapon Sao et al., 2016b ; Dambricourt Malassé et al., 2016b).

of the Masol Formation (Ranga Rao et al., 1995) might have also provided clusters of cobbles accumulating as lag deposits in gullies or any depression. From a small excavation in this conglomerate at the top of the sequence, it could be observed that marks of contact occur when the cobbles touch each other and these cobbles were very easy to break with the hammer inside the sandy matrix. They broke or split along a pre-existing fracture plane. This may be due to the heavy pressures in the sediment induced by the tectonic activity as observed on the fossil bones (Moigne et al., 2016). However, after exposition in the air, immediately, their brittleness changed and they became very hard like the cobbles selected for experimentation (Dambricourt Malassé et al., 2016a and here below). Yet, in places, as at Masol 12, for instance, such broken cobbles are frequent. Breaks are usually perpendicular or inclined on the long axis of the cobble and they clearly show a pressure point looking like a percussion point. However, splits along the grand plane of the cobbles were not observed at

Table 1
Number of artefacts collected on the different paleonto-archeological localities (1 to 13) on the Masol Formation.
Tableau 1
Effectif des artefacts collectés sur les différentes localités paléonto-archéologiques (1 à 13) de la formation de Masol.

	Heavy-duty tools		Light-duty tools		Total
	n	%	*n*	%	*n*
Masol 1	14	82	3		17
Masol 2	73	59	51	41	124
Masol 2W-B	7	54	6	46	13
Masol 3	1		0		1
Masol 4	0		1		1
Masol 5	2		0		2
Masol 6	50	76	16	24	66
Masol 7	7	78	2		9
Masol 8	5		0		5
Masol 9	0		1		1
Masol 10	1		1		2
Masol 11	4		1		5
Masol 13	4		0		4
Total	167		82		250

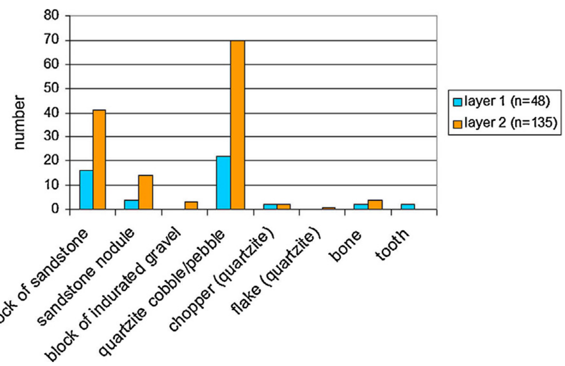

Fig. 4. Distribution of the different categories of items coordinated in the B1 trial trench at Masol 2: blocks and various nodules > 50 mm, artefacts and faunal remains.
Fig. 4. Distribution des différentes catégories d'éléments coordonnés dans le sondage B1 de Masol 2 : blocs et nodules divers > 50 mm, artefacts et restes fauniques.

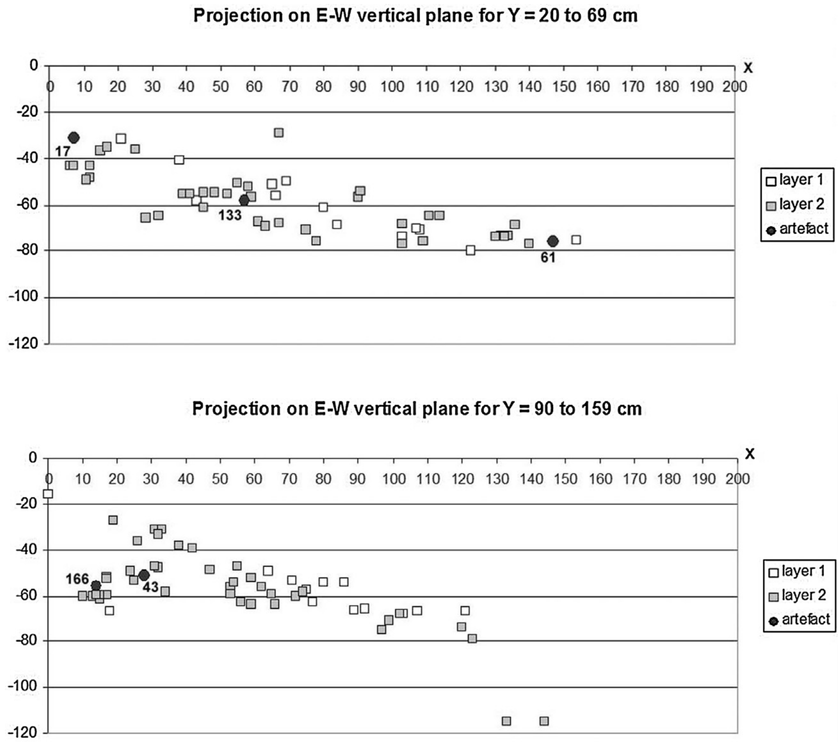

Fig. 5. Selected east-west profiles of the trench B1 in Masol 2, showing location of the artefacts among the natural clasts > 50 mm.

Fig. 5. Sélection de profils est-ouest du sondage B1 à Masol 2, montrant la position des artefacts parmi les clastes > 50 mm.

Masol 12. Some of the broken cobbles collected in the very beginning of our survey had been considered intentionally fractured due to a percussion point and hackles, but they were finally discarded for their ambiguous origin, as the percussion point may rather be a natural pressure point. These cobbles and pebbles never reach the size of boulders (250 mm), and it is clear that the largest of them were selected for the manufacture of the lithic industry (Fig. 13).

3. Flakes

Among the flakes, especially large flakes, a few specimens (three at Masol 1, nine at Masol 2 and five at Masol 6) have a very flat ventral face and a cortical dorsal face. They may actually be split cobbles, but they show either a point of percussion or some marks allowing them to be technically oriented and described like the flakes (flake *s.l.* or flake/split). Nonetheless, many split cobbles are accounted for among the tools on cobbles, as they do not display these technical features, which are either lacking or removed due to shaping (Table 2).

Altogether, the flakes amount to 112, of which 76 were found at Masol 2. In this locality, the large majority (70%) are ordinary flakes (Table 2), but in the other localities, the ordinary flakes do not overcome the large flakes. It is interesting to observe that the distribution of the maximal dimension of the flakes is multimodal (Fig. 7). In all the three richest localities (Masol 1, Masol 2 and Masol 6), there is a group of smaller flakes around 40–60 mm long, usually unretouched; however, at Masol 2 and Masol 6, there is a group around 70–90 mm and a larger group around 100–120 mm, often shaped (mostly into "choppers" on flakes). Actually, the 100 mm bounds commonly used for separating large flakes from ordinary flakes is slightly too high in the case of the Masol industry: 90 mm would be more appropriate. The latter two groups, especially that of larger flakes, match well with the size range of the tools made on cobbles. It is to be noted that some of these large flakes might have been struck not from cobbles but from boulders (> 250 mm) to be that big; although they are not very typical of flaking activity from the technical point of view, they have been considered intentionally produced due to the selection of the raw material (Figs. 7 and 9-4).

The dorsal face of the flakes is entirely cortical or almost entirely cortical on most of the large flakes, but among the ordinary flakes, there is a balance between the cortical and the non-cortical dorsal faces of the flakes. The latter are only observed on ordinary flakes, except one single large specimen at Masol 6. In both groups, the striking platforms are mostly cortical; non-cortical platforms, again, only occur among the ordinary flakes. The few lineal or punctiform platforms in both groups result from strokes applied on a ridge or corner of the cores, or of the large tools; when in continuity with an entirely cortical dorsal face, they probably correspond to flakes accidentally detached from cobbles used as hammers (a few specimens). Platform angles vary within a large range of values when the lineal and punctiform platform low values (50° to 80°) are considered. Apart from these lineal or punctiform platforms and apart from the platforms of the splits/flakes,

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Fig. 6. Cobble tools from the layer 2 of the trial trench B1 in Masol 2: (1) B1–17, end chopper; (2) B1–43, obliquely broken cobble with chipped cutting edge; (3) B1–166, simple chopper with chipped edges.
Fig. 6. Outils sur galet de la couche 2 du sondage B1 de Masol 2 : (1) B1–17, chopper transversal ; (2) B1–43, galet à cassure inclinée dont le tranchant est ébréché ; (3) B1–166, chopper simple aux bords ébréchés.

which are usually close to 90°, the angles show a normal distribution centered around 110°, with mean values of 107.8° at Masol 2 ($n = 50$) and 106.5° at Masol 6 ($n = 10$). It is interesting to note that many flakes (three at Masol 1, 14 at Masol 2 and 10 at Masol 6) have been obtained by heavy strokes characterized either by an incipient cone with a percussion circle or by crushing marks around the striking point. This occurs mostly among the ordinary flakes, except at Masol 1.

There are many first flakes ("entames") corresponding to the beginning of the reduction sequences. They occur not only in the group of large flakes or splits (more than half), as splits necessarily display the characters of first flakes, but also among the ordinary flakes: 1/4 at Masol 2, 1/3 at Masol 6 and all at Masol 1, except for one Kombewa ordinary flake. Next in the reduction sequence are the flakes with one or two scars of earlier removals; they are mostly ordinary flakes and represent 1/2 at Masol 2 and 1/4 at Masol

Table 2
Distribution of the large and ordinary flakes on the main paleonto-archeological localities on the Masol Formation.
Tableau 2
Distribution des grands éclats et éclats ordinaires sur les principales localités paléonto-archéologiques de la formation de Masol.

Blank	Masol 1	Masol 2	Masol 6	Masol 7	Masol 8 to 11
Ordinary flake					
Unretouched	2	49	13	2	3
Retouched/shaped (small tool)	0	4	2	0	0
Large flake/split					
Unretouched	0	11	4	1	0
Shaped (large tool)	4	12	4	1	0
Total	6	76	23	4	3

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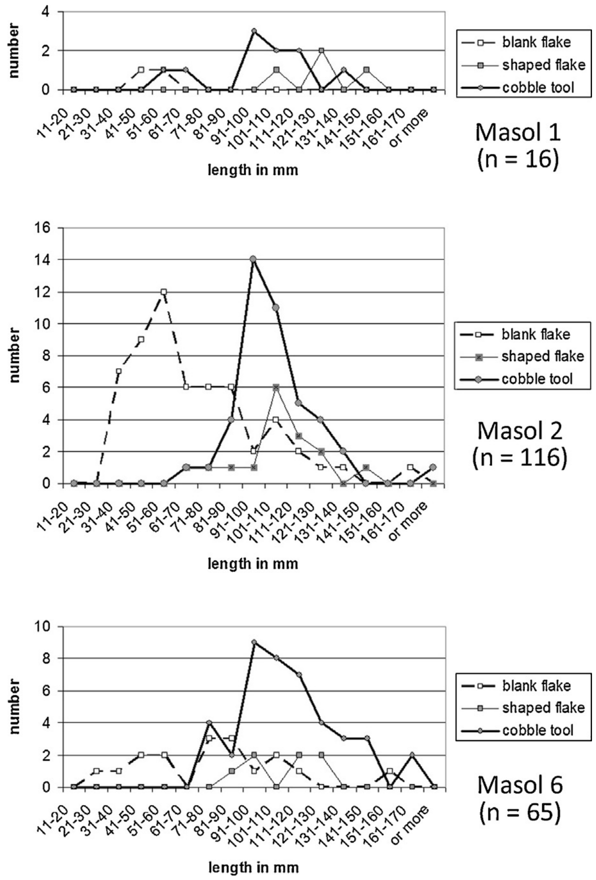

Fig. 7. Distribution of maximal dimension of the different artefact categories from the main paleonto-archeological localities of Masol Formation.

Fig. 7. Distribution de la dimension maximale des différentes catégories d'artefact des principales localités paléonto-archéologiques sur la formation de Masol.

6. Finally, the number of negatives can reach six, indicating a rather long reduction sequence for a few flakes. The scar pattern is dominantly longitudinal-unipolar at Masol 2 (2/3 of the flakes with identifiable scars), with other patterns like transversal uni- or bi-polar, orthogonal or tridirectional being much fewer. At Masol 6, all patterns are equally distributed, but occurrences are very few besides the undetermined cases.

To characterize their morphology, all flakes are considered to have four sides, which can be categorized as sharp (< 60°), medium or bevel-shaped (60°–80°) and steep; when the outline is triangular, one of the sides is a point, sometimes rounded. Among the blank flakes, if all the sides, including that of the striking platform (usually steep), are combined, the majority of them are steep; their frequency is the same at Masol 2 and Masol 6 (41%). Sharp edges appear to be more frequent at Masol 6 than at Masol 2, while the opposite is true for the bevel-shaped edges (Table 3). Points are rare. Nevertheless, many of the unretouched flakes bear damages, especially chipping (scars of a few millimeters), on their edges, not only on the sharp edges, which are the most fragile, but also on the bevels and steep sides. This chipping of the flakes is more frequent at Masol 6 than at Masol 2 on all the edge types (Table 3). Its origin may be anthropic or natural; the uneven and gullied topography at Masol 6 might have contributed to increasing the frequency of natural edge damage. Besides the common chipping, flaking may occur on the edges. However, such flaking is not regular enough to be seen as intended to make tools. In these cases, the flakes or splits have been considered "utilized" (Fig. 8-1–8-3; Table 5), while keeping in mind that such modification may be of natural origin. In few cases, the edges also show pounding marks.

4. Cores

Cores, in the strict sense, *i.e.*, not having a preferential cutting edge, and probably meant to only produce flakes, are very few in the series collected from Masol. A few artifacts classified as debris, bearing flake negatives and fractures (three from Masol 2 and one from Masol 6) may be broken cores; they are not informative regarding the core reduction strategies. The only three cores of the studied series were collected from Masol 2 and Masol 5. They are polyhedral cores reduced according to a system of orthogonal surfaces, one face being used as a striking platform for exploiting the next face. They show, respectively, four and three exploited faces at Masol 2 and only two at Masol 5, the other faces being cortical. The flake negatives are mostly unipolar on each face, but they are in perpendicular directions between two adjoining faces.

The two cores from Masol 2 measure 93 and 107 mm in their maximal dimension; the one from Masol 5 is about 110 mm (see Dambricourt et al., 2016a, fig. 20). These cores have produced flakes with both cortical and non-cortical platforms; at the beginning of the sequence, the flakes had a cortical dorsal face, then, at the end, as inferred from the cores, the flakes had a dorsal face showing two scars of longitudinal or orthogonal directions. The total visible flake negatives reach seven on one of the cores. The length of the negatives, hence of the last products from these cores, ranges from 55 to 95 mm.

5. Small tools on flakes or fragments

The small tools (< 10 cm) on flakes from Masol are not standardized. They include Clactonian notches (Table 4) that can always be suspected of being natural, although not frequent at Masol. Clactonian notches may also be seen as single removals, comparable to the flake removals shaping the large tools. Thus, apart from the one denticulate and the scrapers (Fig. 8-4) shaped by retouch, the so-called small tools are shaped in the same way as the large tools. The occurrence of "small" choppers among them suggests continuity between large and small tools and confirms what has been noticed about the dimensions of the flakes in relation with the other categories of artifacts.

6. Heavy-duty tools

As noted above (Fig. 7), the concept of large tools cannot be taken very strictly as far as dimensions are concerned.

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Table 3
Edge/side morphology and frequency of damage on the blank flakes (all four sides combined) at Masol 2 and Masol 6.
Tableau 3
Morphologie des bords et fréquence des ébréchures sur les éclats bruts de taille (en considérant chacun des quatre côtés) dans les localités de Masol 2 et Masol 6.

	Masol 2 ($n = 60 \times 4$)		Masol 6 ($n = 17 \times 4$)	
Edge morphology	Rate of occurrence	Rate of damage	Rate of occurrence	Rate of damage
Sharp	35%	66%	43%	79%
Medium	21%	35%	12%	63%
Steep	41%	6%	41%	29%
Pointed	3%	4/7	3/17	1/3

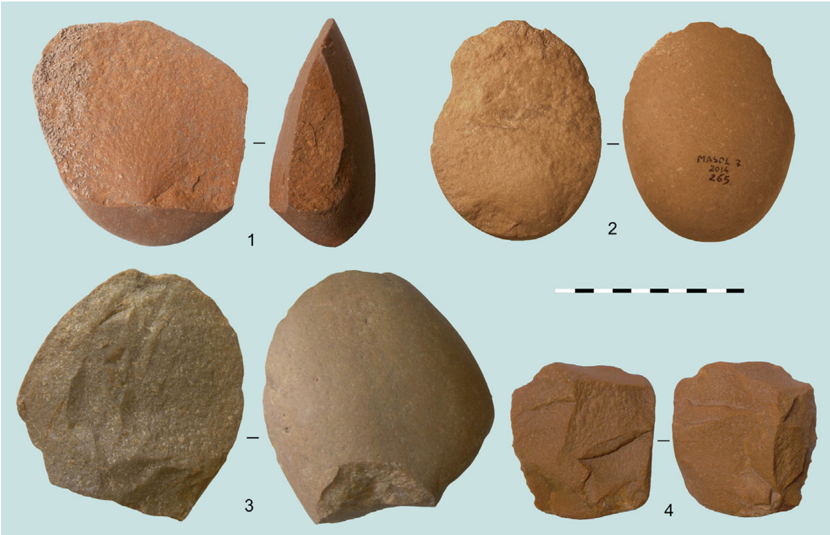

Fig. 8. Examples of flakes from Masol 2: (1) Masol 2-1, (2) Masol 2-265, (3) Masol 2-247: utilised large flakes; (4) Masol 2-236: small end chopper with side scraper on flake.
Fig. 8. Exemples d'éclats de Masol 2 (1) Masol 2-1, (2) Masol 2-265, (3) Masol 2-247 : grands éclats utilisés ; (4) Masol 2-100 : petit chopper transversal et racloir latéral sur éclat.

The concept of heavy-duty tools is preferred in this chapter because it refers to tools made on rather massive supports and shaped by flaking rather than retouching. Besides the typical end choppers and side choppers, where one side only is shaped into a cutting edge, more elaborated choppers occur such as convergent choppers (with two adjacent edges), extended choppers (more than half perimeter shaped), double or multiple choppers, etc. Chopping tools (bifacial choppers) are much less frequent than choppers. These tools may be made from whole cobbles, split cobbles (broken along their grand plane), fractured cobbles (broken perpendicularly or obliquely to their grand plane), and sometimes cobble fragments (less than 1/4 of the original volume) or flakes, mostly large flakes. Choppers and heavy-duty tools, in general, are shaped by flaking, *i.e.*, by the removal of flakes, which usually belong to the group of "ordinary flakes". Therefore, these original by-products may actually be used as finger-held tools. Correlatively, heavy-duty tools are often named "core-tools" when it is difficult to decide whether they are tools meant to be used, or cores meant to produce flakes. Here, the shaped tools with a preferential edge are considered tools rather than

Table 4
Small tools on flake, small cobble or fragment from the different paleonto-archeological localities on Masol Formation.
Tableau 4
Petits outils sur éclat, petit galet ou fragment des différentes localités paléonto-archéologiques sur la formation de Masol.

	Type of tool	Support	Dimensions in mm
Masol 1	Clactonian notch	Fragment	51 × 48 × 14
Masol 2	Scraper + notch = beak	Broken flake/split cobble	96 × 59 × 39
	Convergent scraper	Flake fragment	56 × 33 × 20
	End chopper + side scraper	Flake	73 × 69 × 35
	End chopper	Broken flake	82 × 70 × 31
	Simple end chopper	Flake	68 × 65 × 42
Masol 6	Notch or hammerstone flake	First flake	92 × 63 × 27
	Denticulate	Flake	93 × 63 × 33

Fig. 9. "Simple" choppers (shaped by one single removal) and a chopping tool from the paleonto-archeological localities of Masol Formation: (1) Masol 2-97: chopping tool on split cobble; (2) Masol 7-263: simple end choppers on cobble; (3) Masol 2-84 and (4) Masol 1-9: simple end choppers on flake/split.
Fig. 9. Choppers « simples » (façonnés par un unique enlèvement) et un *chopping tool* collectés sur les affleurements de la formation de Masol : (1) Masol 2-97 : *chopping tool* sur galet fendu ; (2) Masol 7-263 : chopper transversal « simple » sur galet ; (3) Masol 2-84 et (4) Masol 1-9 : choppers transversaux « simples » sur éclat/galet fendu.

cores; this is the case of the large majority of the heavy-duty artifacts from Masol, and the proper cores are found to be very few. The specificity of Masol is that many choppers are only shaped by only one removal that creates the cutting edge. As for the light-duty tools, their shaping is limited to a retouch along the edge; the resulting by-products, usually less than 15 mm, are often too small to be held and utilized.

Most of the heavy-duty tools are choppers, always unifacial, except a few (chopping tools). Some of these choppers are shaped by one removal only (Fig. 9). As underlined above, this is quite common at Masol and appears to be a specific feature of the lithic industry. Therefore, in the present study, this type of chopper is considered a separate type named "simple chopper" as opposed to the "classical choppers"; all these choppers and chopping tools will be called "cobble tools", even though some are made on flakes. The end choppers are more frequent than the side choppers in all the localities (Table 5) but, at Masol 2, the difference is less and these are mostly simple end choppers implying less technical investment than in the other localities. This may be related to the easy availability of the cobbles accumulated in the fluvial deposit outcropping at Masol 2; if ever the severe reduction by shaping represents the re-sharpening of previously simple choppers, in this context of abundant raw material, selecting a new cobble for making a simple chopper may be more frequent than re-sharpening an old, worn out tool.

Many of the stone tools are made on cobbles, which have been preliminary fractured or split (Table 6). They are also often made on flakes at Masol 1 and Masol 2, especially the simple choppers (half of them), while, at Masol 6 and at the localities on the left bank of the Patiali Rao, flakes are much fewer among the chopper's supports, but split cobbles are well-represented (Fig. 10). The most common category of supports (about 40%) is that of the cobbles on which only flake negatives can be observed, without any visible fracture plane. These supports are classified as whole cobbles. However, when the proportion of the remaining part of the original cobble is assessed by scores ranging from four (whole cobble) to one (less than 1/3), it appears that many of the cobble tools considered made from whole cobbles actually score a two, representing 1/3 to 2/3 of the original cobble. Such cobble-supports account for more than half at Masol 2 and Masol-left bank, and 1/3 at Masol 1 and Masol 6. To reach such a degree of reduction, either the tools must be fractured before being flaked for final shaping, or it is a matter of repeated flaking, possibly for re-sharpening.

The length of the choppers (and chopping tools) vary within a large range, from about 70–80 mm to 130–140 mm, even more at Masol 6, but their distribution is normal (bell-shaped; Fig. 7) and suggests that the choppers from Masol represent a homogenous group of tools measuring around 100 mm long. The length is quite similar between the cobble tool types. The simple choppers do not significantly differ from the classical choppers, nor do the side choppers from the end choppers, except at Masol 2 where the classical end choppers are slightly shorter (Table 7).

When they are made on fractured cobbles, split cobbles or flakes, the cobble tools are always shaped on the non-cortical face, except in three cases (at Masol 2, Masol 6 and Masol 11). Therefore, the by-products of the shaping sequences bearing on these supports, which account for about 60% among the cobble tools, must be flakes having a non-cortical dorsal face, right from the beginning of the sequence. The difference with the frequency of non-cortical dorsal faces among the ordinary flakes, representing about 40%, may result from the higher "productivity" of the cobble tools made from whole cobbles. Regardless, these speculations hold only if the artifacts belong to the same period and

Table 5
Distribution of the artefact types in the richest paleonto-archeological localities on Masol Formation.
Tableau 5
Distribution des types d'artefacts dans les principales localités paléonto-archéologiques sur la formation de Masol.

Artefact type	Masol 1	Masol 2	Masol 6	Masol 7 to 13
Heavy-duty tools				
End chopper	7	10	17	6
Side chopper	3	14	10	3
Convergent chopper		7	1	
Extended chopper	2	6	1	5
Double or multiple chopper		1	6	
Simple end chopper	1	10	4	3
Simple side chopper		3	1	
Chopping tool		1	2	1
Simple chopping tool		1		
"Square tool"		2		1
Big uniface				1
Utilised split cobble	1	1	2	
Utilised broken cobble		1	2	
Core		2		
Hammerstone		10		
Large flake/split		8		
Utilised large flake		3	4	1
Total heavy-duty tools	14	80	50	21
Light-duty tools				
Flake	2	42	9	5
Flake fragment		4	0	
Small tool on flake or fragm.	1	5	2	
Utilised flake or split		3	3	
Split cobble (< 10 cm)			1	
Debris/residual core		3	1	
Total light-duty tools	3	57	16	5

Table 6
Support of the choppers and chopping tools from the main paleonto-archeological localities on Masol Formation.
Tableau 6
Support des choppers et *chopping tools* des principales localités paléonto-archéologiques sur la formation de Masol.

Type of support	Masol 1		Masol 2		Masol 6		Masol 7 to 13	
	Classical chopper	Simple chopper	Classical chopper	Simple chopper	Classical chopper	Simple chopper	Classical chopper	Simple chopper
Cobble	3	0	18	4	15	2	5	1
Fractured cobble	3	0	8	3	11	3	2	0
Split cobble	3	0	7	0	6	0	7	2
Cobble fragment	1	0	1	0	2	0	1	0
Flake or flake/split	2	1	8	7	3	0	1	0
Total	12	1	42	14	37	5	16	3

to the same phase of human occupation; however, the consistency of the lithic assemblages in each locality supports their chronological homogeneity.

The longest flake negative shaping the cobble tools was measured on each tool and on each face. On the upper face, their average ranges from 43 mm at Masol 1 to 55 mm at Masol 6, with intermediate values at Masol 2 (49 mm) and Masol 7 to 13 (52 mm). On the lower face, these measurements are slightly smaller. The upper face is, by definition, the most convex face, but actually, the shaping creates the convexity; therefore, in most cases, the upper face is the shaped face, except at Masol 6, where 1/3 of the unifacial

Table 7
Average maximal dimension of the cobble tools from the main paleonto-archeological localities on Masol Formation.
Tableau 7
Moyennes des dimensions maximales des *cobble tools* des principales localités paléonto-archéologiques sur la formation de Masol.

	Masol 1		Masol 2		Masol 6		Masol 7 to 13	
	Number	Mean in mm	Number	Mean in mm	Number	Mean in mm	Number	Mean in mm
End chopper	7	112	12	95.9	19	105.9	6	102.8
Side chopper	3	71.3	14	105.1	10	108.1	4	91.3
Simple end chopper	1	143	10	101.4	4	113.8	3	114.3
Simple side chopper	0	–	3	109.3	1	125	0	
Extended/multiple chopper	2	101.5	14	102.1	8	124.3	5	109
Total	13		53		42		18	

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Fig. 10. Cobble tools on split cobbles or flakes: (1) Masol 2-3, (2) Masol 6-211, (3) Masol 5-229: end choppers on split cobbles; (4) Masol 2-2, (5) Masol 2-72: side choppers on flake.
Fig. 10. *Cobble tools* sur galets fendus ou éclats : (1) Masol 2-3, (2) Masol 6-211, (3) Masol 5-229 : choppers transversaux sur galets fendus ; (4) Masol 2-2, (5) Masol 2-72 : choppers latéraux sur éclats.

cobble tools are shaped on the flattest face, yet have the longest removals, reaching the same average length as for the upper face. It is interesting to note that the distribution of the longest removal length is slightly bimodal, with one major mode at 50–60 mm and a secondary mode at 20–30 mm. Although the number of specimens is low, the recurrence of this feature in each locality makes it statistically significant and suggests the existence of two groups as far as the shaping strategies are concerned. Careful scrutiny of the data shows that it is not a matter of tool type, as the end choppers and side choppers are comparable, as are classical choppers and simple choppers. It appears that, actually, the type of support may induce these differences, at least at Masol 2, where item numbers can be considered statistically significant: the average length of the longest shaping removal is shorter on the flakes (36 mm) and on the split cobbles (43 mm), while it is longer on the fractured cobbles (50 mm) and even more so on the cobbles (60 mm).

The sharpness of the shaped edges varies notably between the localities (Table 8). Everywhere, it is mostly medium (60° to 80°); sharper edges account for 40% in the left bank localities, but they are absent at Masol 6, where it is yet to be noted that, among the unretouched flakes, the sharp edges are more frequent. Then, steep worked edges are less common, but they are well-represented at Masol 6. The acuteness of the edges is independent of the tool type (side/end/multiple/extended chopper) and from the degree of elaboration (classical/simple chopper). Almost all the shaped edges of the cobble tools are chipped, as are a large number of the blank edges. It is tempting to consider this chipping of the edges as resulting from utilization, which is probably only true in some cases (Fig. 11); however, it is difficult to distinguish the use-wear from the natural chipping resulting from taphonomic processes. Percussion marks occur on the cortical surfaces in the form of small circles or small depressions. Half of the cobble tools bear such percussion marks at Masol 2 (Figs. 9-3 and 10-1) and 1/3 at Masol 6, but in the other localities, these marks are very rare. These percussion circles are quite large (up to 10 mm in diameter) and they imply very heavy strokes. It is possible that the cobbles were used as hammers before being turned into tools, or the cobble tools themselves were used as hammers, or rather anvils, as they are flat.

Table 8
Shaped edge acuteness on the cobble tools from the main paleonto-archeological localities on Masol Formation.
Tableau 8
Acuité du bord façonné sur les *cobble tools* des principales localités paléonto-archéologiques sur la formation de Masol.

	Masol 1	Masol 2	Masol 6	Masol 7 to 13
Sharp	2	19	0	12
Medium	14	53	30	12
Steep	1	13	19	4
Round-pointed		2		0
Total shaped edges	17	87	49	28

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Fig. 11. Chipping and flaking, probably due to utilisation, on the sharp edge of an end chopper from the locality 8 at Masol.
Fig. 11. Ébrèchement et éclatement, probablement dus à l'utilisation du bord tranchant d'un chopper transversal de Masol 8.

7. Flake production or tool production?

Flakes may originate from two types of sequences: definite flake production from cores, and tool-shaping from cobbles, splits or large flakes. These two sequences, even three sequences with the very short sequence of splitting cobbles, can occur independently or follow each other, producing different categories of artifacts according to their development stage. It appears that the large flakes, and, of course, the splits, mostly represent the first stage of the reduction sequences, while the ordinary flakes are produced all along the sequences. Actually, the size of the available quartzite cobbles, which are never much bigger than 15 cm, only allows for producing large flakes at the beginning of a sequence. In the near absence of cores, it is probable that most of the flakes result from the shaping of the large tools. The large tools made on flakes, split cobbles or broken cobbles are usually shaped by hitting the cortical face, hence removing flakes from the non-cortical face. Flakes resulting from this shaping sequence have a cortical striking platform and a non-cortical dorsal face.

At Masol 2, the flakes with dorsal scars of previous removals refer to unipolar flaking. Associated with cortical platforms and, in the context of many first flakes, they may result from the shaping of choppers on cobbles (Fig. 12) or, for the few flakes with non-cortical or dihedral platforms, from the shaping of chopping tools. Actually, the average length of the longest removals shaping the large tools at Masol 2 is around 50 mm (face A) or 36 mm (face B). It is slightly higher at Masol 6: 55 and 53 mm for face A and B, respectively. These measurements match the dimensions of the smallest group of flakes (40–60 mm; Fig. 7), which, therefore, may result from the shaping of the large tools. The more complex scar patterns on the flakes' dorsal face may indicate sequences of definite flake production from cores or they may result from the shaping of convergent or extended choppers. There are no cores except two from Masol 2 and one from Masol 5; they are missing at Masol 6, where, however, the identifiable dorsal scar patterns are more complex than just unipolar.

Fig. 12. Cobble tools on cobbles collected on the outcrops of Masol Formation: (1) Masol 8-267: end chopper; (2) Masol 6-207: extended chopper; (3) Masol 6-206: end chopper; (4) Masol 2-65: extended chopper.
Fig. 12. *Cobble tools* sur galet récoltés sur les affleurements de la formation de Masol : (1) Masol 8-267 : chopper transversal ; (2) Masol 6-207 : chopper étendu ; (3) Masol 6-206 : chopper transversal ; (4) Masol 2-65 : chopper étendu.

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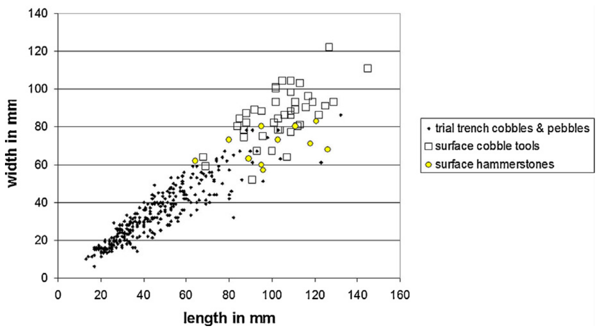

Fig. 13. Comparison of the dimensions of the cobble tools and hammerstones from Masol 2 with those of the natural cobbles and pebbles from the trial trench B at Masol 2.

Fig. 13. Comparaison des dimensions des galets taillés et percuteurs de Masol 2 avec celles des galets du sondage B à Masol 2.

8. Hammerstones

Some of the blank cobbles have been considered witnesses of human activity, for they show marks of percussion on the cortex. These marks are similar to those observed on the cobble tools: small pits or small circles, lighter in color, representing the roots of conical fractures resulting from the strokes. These circles are quite large and indicate very heavy strokes. They raise the question of which activity might have created them. This may be a natural phenomenon, but then their occurrence would be higher at all the localities and they would not be as frequent on the cobble tools. It is noteworthy that hammerstones have been found only at Masol 2, and they seem to be absent in the other localities. Their dimensions are included in the size range of the cobble tools from the trial trench at Masol 2, but they are clustered towards the lower values (Fig. 13).

9. Discussion

The artifacts collected in the 12 localities on the outcrops of the Masol Formation are quite fresh, and some are just slightly abraded. Yet, it must be noted that the latter are more frequent on the left bank of the Patiali Rao, and have eroded for longer than on the right bank, where the richest localities are found, with new fossils unearthed every year. The raw material is a fine to medium-grained quartzite in the form of cobbles occurring in clusters scattered locally on the outcrops. A lens of cobbles is visible in a natural section of silts (c3 of the general stratigraphic column, Fig. 2), at locality 12, 130 meters away from Masol 13, where cobbles are lying on the outcrops with bones, two choppers and a bone splinter with cut marks. A true conglomerate is visible in the higher part of the QZ, where fossils are still present; one chopper was collected among its dismantlement and some in the ravine below the conglomerate.

The lithic industry collected on the outcrops of the Masol Formation or in the trial trench of B1 at Masol 2 in the basal sequence of the QZ is mainly comprised of choppers and, especially at Masol 2 and Masol 6, of flakes and split cobbles, of which the largest are shaped into choppers.

Altogether, the stone tools share approximately the same technical and typological characteristics. Three processing sequences can be distinguished; they occur independently or successively. The production of flakes from cores is probably the less commonly performed, as the proper cores and the supposed residual cores are very rare, and as the flakes rather fit into the pattern of by-products from chopper shaping (unipolar dorsal scars). The second processing sequence consists of splitting cobbles along their grand plane or fracturing them obliquely; this provides blanks having rather sharp edges that can be used as such or shaped into choppers. Intentional fracturing may or may not display the marks that are characteristic of flaking such as a striking point and radial rays. Therefore, there is no clear boundary between the products of flaking and those of fracturing or splitting. Finally, the major process is that of shaping cobble tools, either on whole cobbles or on preliminarily split or fractured cobbles, which seems to have produced all flakes, except perhaps the larger ones. The severe reduction of the choppers supposedly made from whole cobbles (no visible fracture) may imply a preliminary fracture hidden by the flake removals, or may result from intensive re-sharpening.

Besides the various types of choppers, there are some more elaborate and standardized specimens, rectangular in shape with a preferential transversal edge; they are made on split cobbles or large flakes. Two of these tools were found at Masol 2 (Figs. 14-1 and 14-2), and one at Masol 11. Similar tools are known further northwest in the Siwalik Frontal Range (Gaillard et al., 2010a, 2011, 2012), in the context of Soanian sites, where they are provisionally called “square tools” and are comparable to Hoabinhian tool types known in Southeast Asia (earliest descriptions by Colani, 1927, 1929). Some of the extended choppers from Masol, shaped on more than half of their periphery, with an oval outline (Fig. 14-3) also recall the same tradition, as they are comparable to the “sumatraliths”, the typical unifacial oval tools of the Hoabinhian. A small end chopper, almost an end-scraper, made on an obliquely fractured cobble is also rather recent. The lateral edge resulting from the fracture shows a well-developed polish, about 5 mm wide, possibly due to use (Fig. 14-4). These well-shaped tools, sometimes used in such a way that they get polished, suggest Late Pleistocene or Early Holocene human activity in the oldest sectors of the Masol anticline, which have long been exposed to erosion. Moreover, it must be kept in mind that the villagers of Masol can pick up choppers to sharpen their iron axes or sickles when they are in the field to cut bush branches or large grass for the fodder.

The simple choppers, shaped by only one removal, represent the major feature of the lithic assemblages from the Masol area. They are usually made on whole cobbles, fractured cobbles or flakes, and the shaping (if any) extends on the non-cortical face, which is usual for all the choppers. They are mainly end choppers, like the classical choppers, but they have nothing in common with accidentally flaked hammerstones. This type of tool is not common in the lithic industries made on cobbles, as, for instance, in the Soanian, which is well-represented in the Siwalik Frontal Range and on the river terraces; the Soanian is characterized by classical choppers, probably Late Pleistocene in age since, in places, it includes tool types referring to the Hoabinhian. Such a simple technology seems to be specific of Masol,

Fig. 14. Most elaborated cobble tools collected on the outcrops of Masol Formation: (1) Masol 2-79, (2) Masol 2-114, (3) Masol 8-266: rectangular or oval unifacials on split cobbles or flakes; (4) Masol 2-100: small end chopper with polish-wear on the lateral edge.
Fig. 14. *Cobble tools* les plus élaborés, collectés sur les affleurements de la formation de Masol : (1) Masol 2-79, (2) Masol 2-114, (3) Masol 8-266 : outils unifaciaux rectangulaires ou ovalaires sur galets fendus ou éclats ; (4) Masol 2-100 : petit chopper transversal à bord latéral poli par usure.

but is similar to that of very early sites like, in Asia, the site of Longgupo (Boëda and Hou, 2011), dated to the very beginning of the Early Pleistocene at 2.48 Ma (Han et al., 2015).

During the experimentation conducted for testing the butchery activity, it was observed that such a simple chopper could be obtained by the percussion of a cobble on an anvil with a hammer in quartzite. The tool made to cut the muscles of a metapodial of *Sus scrofa* was split into two symmetric parts along its great axis. The sharp edge of the split cobble was sufficient to cut the skin, muscles, tendons and the periosteum. The edges were easy to break (Fig. 15). This is a simple technology applicable for scavenging activity.

Another specific feature of Masol is the abundance of percussion marks on the tools, usually on the cortical surfaces and sometimes on the edges too. These percussion marks in the form of small circles or small holes often reach 10 mm in diameter and, therefore, imply very strong impacts. These seem to occur preferentially on the artifacts, but actually, no systematic comparison has been made with the blank cobbles. Some of the flakes also result from similar strong impacts. While conducting experiments in order to compare our cut marks with the fossilized marks of Masol (Dambricourt Malassé et al., 2016a), it was observed that the hardness of the quartzite cobbles was so high that it was necessary to use hammers and anvils to break them. The exercise required very high energy and repetitive movements to reach the threshold of fracturing. The bones covered with aponeurosis and periosteum cannot create such impacts on a quartzite cobble. At Masol, where the geological environment is composed of silts and sandstones, the only one material able to create percussion marks on the cobbles are the quartzite cobbles. Similar marks are visible on quartzite cobbles that were unearthed from unconsolidated sandstones and, in which, they were connected; the origins of these marks are probably due to the tectonics of compression as observed on long bones of the Proboscidean. However, at Masol 2, the frequency of these percussion marks is higher on the cobble tools than on the unshaped cobbles considered hammerstones, which probably result from an intentional activity rather than a natural process. Moreover, many ordinary flakes show crushing marks at their point of percussion, which may result from accidental breaks produced by intense striking activity. The percussion implements are usually abundant in the early sites, and the recent publication on the Pliocene industry from Lomekwi at 3.3 Ma (Harmand et al., 2015) also stresses this feature. Apart from this similarity regarding percussion, the industry from Masol clearly differs from that from Lomekwi, where the technical activity was fully oriented towards the production of flakes from very big cores, whereas, at Masol, it was oriented towards the production of cobble tools, along with a few large flakes and splits.

Fig. 15. The experimental tool in quartzite after the test of cut marks on a foot of *Sus scrofa*. The cutting section is a segment of the upper edge visible on the picture (Dambricourt Malassé et al., 2016b).
Fig. 15. Outil expérimental en quartzite après le test des traces de boucherie sur un pied de *Sus scrofa*. La section coupante est un segment du bord supérieur visible sur la photo (Dambricourt Malassé et al., 2016b).

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10. Conclusion

At Masol, technical activity was mainly oriented toward the production of large tools with a robust cutting edge. These tools appear to be adapted to the size of the vertebrates present in the QZ and on the outcrops where they occur together. This systematic co-occurrence may indicate that some of the artifacts, especially the simple choppers, so far unknown in the Siwalik Frontal Range, may be contemporaneous with these terrestrial and freshwater vertebrates, such as the mid-size bovid of which a bone bears cut marks. These marks observed on three bones attest to anthropic activities in a flourishing biodiversity at the very end of the Pliocene (Dambricourt Malassé et al., 2016b). This activity required the use of tools in quartzite to cut muscles and tendons, or to break bones to reach the marrow; the simple choppers and flakes collected in the trial trench B1 at Masol 2 and on the outcrops of the QZ could be associated with this scavenging activity evidenced 200 m apart at Masol 1.

Regardless, the cut marks on bovid bones from the basal member of the QZ, located around 130 meters below the Gauss-Matuyama reversal (2.588 Ma), were made by the sharp edges of quartzite implements. The recent discovery of 149 lithic artifacts at Lomekwi, West Turkana, Kenya (dated to 3.3 Ma) confirms the very old age of human-like cognitive capacities. This assemblage is composed of a majority of cores, along with flakes, hammers and anvils collected on the Pliocene outcrops, and thus, it is associated with tools recorded in a trial trench in sand (Harmand et al., 2015). The cut marks of Masol imply tools in quartzite and support the date of 2.5 Ma already suggested for the artifacts from Riwat in the Siwaliks of Pakistan (Dennell, 1998, 2004; Dambricourt Malassé et al., 2016b) as well as the dates around 2.5 Ma for Longgupo (Han et al., 2015) and 2 Ma for the assemblages from the Pabbi Hills, also in the Siwaliks (Dennell, 2004), and Renzidong in Central East China (Hou and Zhao, 2010; Zhang et al., 2000).

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