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Site function and lithic technology in the Acheulean technocomplex: a case study from Thiongo Korongo (TK), Bed II, Olduvai Gorge, Tanzania

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The most recent excavations carried out at the Thiongo Korongo (TK) site, in the upper part of Olduvai Bed II and dating from about 1.353±0.035 Ma, have made it possible to identify a hitherto unknown Acheulean floor. Between 2010 and 2015, we excavated nearly 175 m^2 in several areas immediately adjacent to M. Leakey's trenches. Our findings led us to reinterpret TK's general stratigraphy and to identify a hitherto unpublished floor situated between levels TKLF and TKUF (the ones recognized by M. Leakey), which we have called TKSF. The differences we note between these two floors are very significant and concern production techniques and systems, which were aimed at obtaining different types of tools. These differences are especially marked in bifaces. In TKLF, bifacial tools consist of large, very specialized items characterized by a functional point opposite a thick basal area that makes the tool easy to grasp. In TKSF, handaxes are lighter and their cutting edges extend all around their perimeter, and can thus withstand long and varied uses. Considering the stratigraphical proximity and the accumulation rate of the sedimentary processes involved, the differences we observed cannot be correlated with evolutionary developments, which would require long periods of time. The differences observed in the tools seem to be related to the different activities carried out on each of these floors, and show that TK was a complex site with a heuristic capacity that is particularly significant in the context of Olduvai and of the study of behaviour patterns in the Lower Pleistocene.

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The Thiongo Korongo (TK) site is located in the Olduvai Gorge (Tanzania), about 2 km east of the junction of the Main and Side gorges (Fig. 1A–D), at the exposed top of Olduvai Bed II; it can be related to Tuff II^D, dated to 1.353±0.035 Ma (Domínguez-Rodrigo *et al.* 2013).

The TK site has been well known since 1963, when M. Leakey excavated two trenches, about 4 m apart from each other, in a total area of 86.9 m^2. This dig made it possible to describe an approximately 5-m-thick stratigraphical sequence (Hay 1976). This sequence is made up of levels of tuff, clays and calcareous crusts. Two main archaeological levels were identified, the TK Lower Floor (TKLF) and the TK Upper Floor (TKUF), which were taken to be true clay palaeosurfaces characterized by large industrial assemblages and a smaller amount of faunal remains (Leakey 1971: p. 172–197).

M. Leakey interpreted TKLF as Acheulean and TKUF as Developed Oldowan (Leakey 1975: p. 484, 1976: p. 31, 1978). From then on, TK played a key role in the discussion about the relationships between the Oldowan and Acheulean (Bower 1977; Stiles 1977, 1979; Willoughby 1987; Sahnouni 1991; Ludwig & Harris 1998; Kimura 2002). Later studies led to the conclusion that the two industrial assemblages were technologically similar and that, although true bifaces were absent, they should both be attributed to the Acheulean technocomplex (de la Torre 2004; de la Torre & Mora 2005). The generally accepted chronology given for TK places the lithic industry found here in the Early Acheulean phase (Clark 1994; Schick & Toth 2000; Bar-Yosef 2006; Santonja *et al.* in press), within a time range conventionally set between 1.5 and 1.0 Ma (Lepre *et al.* 2011; Diez-Martín & Eren 2012; Sahnouni *et al.* 2013).

The excavations we have been carrying out at TK since 2010 in the framework of The Olduvai Paleoanthropological and Paleoecological Project (TOPPP) have made it possible, amongst other things, to establish the Acheulean character of the TKLF's lithic industry (Santonja *et al.* 2014, in press), reinterpret the stratigraphy of the site and verify that it is more complex than was thought up to now (Leakey 1971: p. 172–197), thus correcting mistakes in previous interpretations (Santonja *et al.* 2014, in press). In 2014 and 2015 we excavated a 45.3 m^2 sector west of where we had dug in previous years (Fig. 1E), and identified a new archaeological floor situated between TKLF and TKUF. We decided to call it TKSF because we

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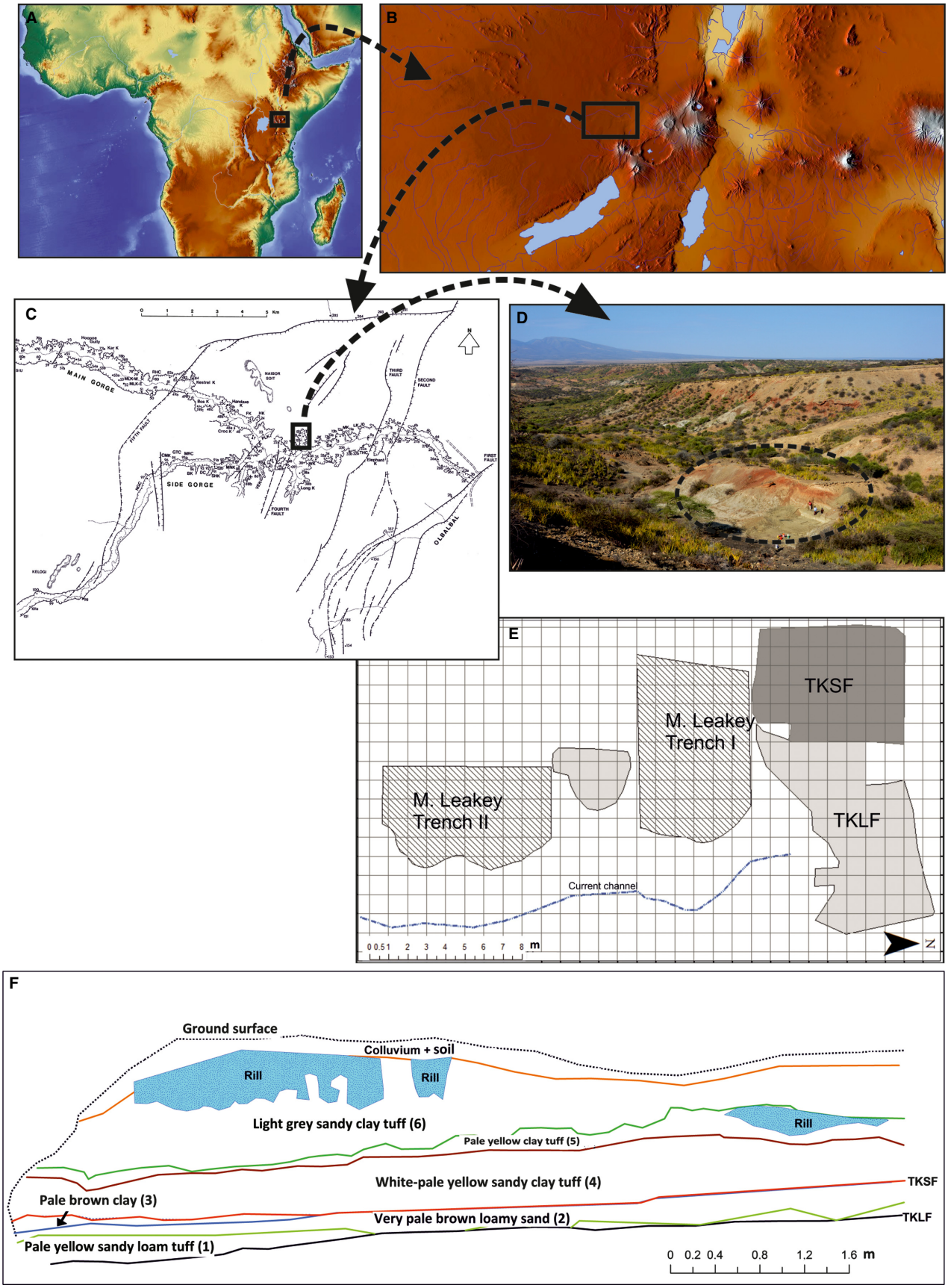
A
B
C
MAIN GORGE
SIDE GORGE
FIFTH FAULT
FOURTH FAULT
THIRD FAULT
SECOND FAULT
FIRST FAULT
OLBALBAL
KELOGI
D
E
TKSF
M. Leakey Trench I
M. Leakey Trench II
TKLF
Current channel
0 0.5 1 2 3 4 5 6 7 8 m
F
Ground surface
Colluvium + soil
Rill
Rill
Rill
Light grey sandy clay tuff (6)
Pale yellow clay tuff (5)
White-pale yellow sandy clay tuff (4)
TKSF
Pale brown clay (3)
Very pale brown loamy sand (2)
TKLF
Pale yellow sandy loam tuff (1)
0 0.2 0.4 0.8 1.2 1.6 m

Fig. 1. A. Map of Africa. B. Regional map of northern Tanzania. C. Location of Thiongo Korongo (TK) site in a lateral korongo at Olduvai Gorge (modified after Hay 1976). D. View of the TK site showing the excavated areas. E. Positions of the trenches excavated by M. Leakey (1963) and the sectors excavated by TOPPP (2010–2014), showing the areas occupied by the TKLF and the TKSF. F. Stratigraphical section showing the horizons excavated in 2014 (from bottom to top, nos 1 to 6).

found an almost complete *Sivatherium* skeleton there. The industrial and faunal contents of this new archaeological unit are markedly different from those recorded in the TKLF and analysed by our team (Santonja *et al.* 2014; Yravedra *et al.* 2016). Our study of TK was based on modern, controlled and extensive archaeological excavations; our aim was to understand the local technological variability from an interactive standpoint that includes cultural, conceptual, technological, behavioural and economical aspects (Diez-Martín & Eren 2012).

In this paper we shall first present our technological and techno-economic study of the *chaîne opératoire* phases identified in the 1161 lithic items found in level TKSF, then we shall compare these items with the 5805 specimens that our team recorded and analysed in the TKLF (Santonja *et al.* 2014, in press). Our intention is to define similarities and differences between two Acheulean floors that are very close to each other stratigraphically, with no significant temporal diachrony, and to propose methodologies that should make it possible to identify the causes of such similarities and differences. The presence of these two assemblages at TK will enable us to see the extent to which different activities and behaviours were suggested as a possible explanation of Acheulean variability (Howell & Clark 1963: p. 506; Sharon *et al.* 2011; Diez-Martín & Eren 2012).

Geological and chronostratigraphical context

The sedimentary outcrops at TK leave a part of the Olduvai stratigraphy exposed; this part corresponds to the Bed II, III and IV sequences, according to Hay's stratigraphical nomenclature (1976). The maximum thickness recorded is about 8.90 m, of which 7.25 m corresponds to Bed II, about 1.25 m to Bed III and 0.40 m to Bed IV (Santonja *et al.* 2014).

The stratigraphical section shown here (Fig. 1F) combines the western and northern faces of the sections documented by M. Leakey (1971: p. 172–174) with our previous stratigraphical column (Santonja *et al.* 2014: fig. 4) and with the findings of our most recent fieldwork in the northern part of TK.

At the bottom of the northern sector we excavated at TK is an interbedded loamy sand channel (2) facies (Fig. 1E, F). It displays planar cross-stratification, with a NW–SE flow direction; in the NNE–SSW transverse section the outcrop extends about 12 m, with a maximum thickness of 40 cm (Fig. 1F). This thin channel facies (2) rests upon and partly covers the TKLF, which in turn overlies a very pale brown calcrete layer up to 7–8 cm thick (Santonja *et al.* 2014). In the area where the TKSF was documented (Fig. 1F), the loamy sand channel facies (which in central sectors of the site lies over a very pale brown calcrete layer) also rests on a pale yellow sandy loam tuff (1), which in turn covers the TKLF (Fig. 1F). Over the loamy sand channel facies lies a white/pale yellow sandy clay tuff 25–52 cm thick (4), which covers the TKSF that overlies the loamy sand channel (2). The latter includes a pale brown clay layer (3) in the southern sector (coordinates 92.000–95.000 in Fig. 1E, F); it is a decantation layer associated with this channel as an overbank deposit. The uppermost sequence of the stratigraphical section (Fig. 1F) consists of a pale yellow clay loam tuff 2–32 cm thick (5), a light grey sandy clay tuff 20–100 cm thick (6), with several rills on its surface, and a colluvium layer 5–25 cm thick.

The moderate outcrop size of the loamy sand channel facies (2), and its limited width and thickness, indicates that it was deposited by an ephemeral and seasonal channel with low transport capacity (as shown by its low-energy internal planar cross-stratification structure), which probably was active for a short span of time, only several dozen or perhaps a few hundred years.

The TKSF rests upon both the loamy sand channel facies (2) and the pale brown clay (3), creating a floor that is covered by a horizon of white-pale yellow sandy clay (4) (Fig. 1F). The bottom of this horizon marks a hiatus of slight erosion on the loamy sand channel (2), which could have eroded the pale brown clay decantation sediments (3) deposited in the southern sector. In this case, the occupation floor TFSF may have undergone some erosion. However, the stratigraphical contact between the sandy clay tuff (4) and the loamy sand channel (2) facies is very planar and does not show any erosion scars.

Material and methods

Between 2010 and 2015 we excavated areas in the immediate vicinity of M. Leakey's Trench I (TI) and Trench II (TII) (Fig. 1E). Our aim was to identify the stratigraphical levels defined by M. Leakey and R. Hay (Leakey 1971: p. 172 ff.) and establish the boundaries of the site according to geological and archaeological criteria, starting with the stratigraphical sequences and the sedimentary processes identified beforehand. We followed the contacts between levels, and collected samples for a texture and facies study to determine lithostratigraphical features.

The 80.5 m^2 area we excavated east of Trench I in 2010–2012 contained 51.9 m^2 of TKLF and only 11.9 m^2 of TKUF. However, when we enlarged the excavation area toward the west we were able to docu-

ment a new archaeological floor (TKSF) that had never been identified previously at TK. It is situated between 21 and 42 cm on top of TKLF, and we excavated 45.3 m^2 of it between 2014 and 2015. As regards the TKLF, we determined the coordinates of 3630 lithic specimens and 832 bone remains, and collected 2175 small lithic items and 105 small bone fragments (whose coordinates were not recorded), which have since been published (Santonja *et al.* 2014). In the TKSF, we recorded 1161 lithic specimens, which we analyse for the first time in this paper, and 338 bone remains.

We used a Leika Total Station to determine and record the topography of the site and the data on its stratigraphy and archaeological materials. All the information was managed using Access and Excel, and was processed with Arc-GIS. The coordinates of the specimens were given with a variable number of points depending on their sizes and shapes. Small items without a defined major axis were recorded with a single point. Small items with a silhouette that could be recorded with a determinable orientation were assigned two points correlated to the major axis. All the larger items were recorded with a number of points ranging from three to 19.

The raw materials used at TK are of various types and origins. We differentiated them from a basic macroscopic standpoint. We grouped compact extrusive rocks – phonolites, nephelinite, trachyte and basalt – under the general term 'volcanic rocks' (VR) (Hay 1976: p. 182 ff.; Kyara 1999). Within this group we differentiated only vesicular lavas, whose identification is obvious, because of the questions raised by their presence at the site. In some cases we concluded that they had been brought here by natural means (de la Torre & Mora 2005). However, this type of origin is not compatible with the sedimentation processes identified at TK (Santonja *et al.* 2014). That is why we believe that these vesicular lava rocks were mostly brought to the site by humans.

Most of the TK industry is made of a quartzite rock that is unmistakably correlated to the Late Precambrian–Early Palaeozoic outcrops (Cahen & Snelling 1966 as cited in Hay 1976: p. 11), which to date are presumed to be those of the Naibor Soit inselberg, which is very close to the TK site. We cannot rule out the existence of similar outcrops that may be located closer to TK but may be hidden by Pleistocene deposits (Santonja *et al.* 2014). This raw material would have been available in the form of slabs at or close to its outcrops, not in riverbeds.

The large white crystals in the Naibor Soit outcrops were formed by recrystallization of the quartz grains contained in the original sandstone when it underwent intense metamorphism. As this quartzite is made up almost entirely of crystallized quartz (Santonja *et al.* 2014: table 3), it looks very much like mineral quartz and responds to knapping in a similar way (Mourre 1997). This could explain why some authors have identified it as quartz (Perlès 1991; Sahnouni *et al.* 1997; Mora & de la Torre 2005; Diez-Martín *et al.* 2010), instead of its first interpretation as quartzite (Hay 1976: p. 11, 180), which was accepted in many instances (Leakey 1971; Jones 1981; Feblot-Augustins 1990; Blumenschine *et al.* 2008; de la Torre & Mora 2013; de la Torre *et al.* 2013; Santonja *et al.* 2014, in press).

In our studies we have maintained the name that makes reference to its origin, Naibor quartzite (NQ), in order to highlight its specific type of crystallization and characteristics. Other fine-grained quartzites that did not come from the Naibor Soit outcrops (non-Naibor quartzite, nNQ) have occasionally been recorded at TK. These quartzites, already identified at various other Olduvai sites (Jones 1994), could have been obtained in the form of rounded pebbles in the beds of the streams that flowed close by the site.

Our analysis of TKSF's lithic industry is based on the *chaîne opératoire* concept (Böeda *et al.* 1990; Roche & Texier 1995; Soressi & Geneste 2011) and on the reading of the gestures used in knapping (Inizan *et al.* 1992, 1995). Our study is organized according to the order of the recognizable steps in the manufacturing process, from the procurement of raw materials through the various phases of production to the last ones, i.e. tool maintenance and discarding (Tables 1, 2). We shall also consider the dimensions and weights of the specimens according to the raw material that was used to make them. This information provides basic references for evaluating the technological aspects and the consistency and representativeness of the series under study.

We shall then analyse the products obtained in the first reduction processes and in the more advanced ones. The extent of the cortical surface preserved on the dorsal face of the flakes provides the basic criterion by which these products may be assigned to one sub-phase or another (Tables 1, 2). The presence of technical aspects in the flakes that can be correlated to specific core-exploitation schemes enables us to distinguish, in the full reduction sub-phase, between undifferentiated flakes (ordinary products) and flakes produced on identifiable production surfaces (special products), which in the series we studied consist solely of flakes that have a back. Our study of the cores is based on our identification of the debitage scheme through the reading of the removal sequences and the identification of hierarchized or equivalent (interchangeable) exploitation surfaces, and of the knapping mode (bipolar or freehand). We also consider the type of support (blank), its dimensions and the intensity with which it was exploited.

We identified a significant number of blanks (all of them NQ slabs) that display bipolar knapping, but were not able to clearly recognize products made with this knapping technique. We applied the criteria established in recent experimental works, based essentially on the ratio between flake thickness and length (Diez-Martín *et al.* 2011; Sánchez-Yustos *et al.* 2012), but obtained only partial results, probably due to the many fractures that knapping produces in NQ. Accordingly, we

Table 1. Chaîne opératoire phases identified in Naibor quartzite (a) and volcanic rocks (b).

Chaîne opératoire phases		Unworked items		Used, retouched or shaped items		Total	
		a	b	a	b	a	b
1. Procurement phase							
1.1	Cobbles		20		23		43
1.2	Hammerstone detachments		4		4		8
1.3	Cobbles with pits						
1.4	Slabs with percussion marks			4		4	
	Procurement phase subtotal		24	4	27	4	51
2. Production phase							
2A. First reduction phase							
2A.1	Highly cortical flakes (>90% cortex)	16		1		17	
2A.2	Cortical flakes (50–90% cortex)	10	1	2	1	12	2
2A.3	Cortical flake fragments	3				3	
2B. Full reduction phase (ordinary products)							
2B.1	Decortical flakes (<10% cortex)	218	13	9		227	13
2B.2	Partly cortical flakes (10–50% cortex)	15	2	2	1	17	3
2B.3	Decortical flake fragments	24	1			24	1
2B.4	Janus flakes						
2C. Full reduction phase (backed products)							
2C.1	Flakes and flake fragments with debitage back			3		3	
2C.2	Flakes and flake fragments with cortical back	11		7	1	18	1
2C.3	Pseudo-Levallois points						
2D. Cores							
2D.1	Cores on slab	55		19		74	
2D.2	Cores on cobble		6		2		8
2D.3	Cores on flake	3				3	
2D.4	Cores on undetermined blank	3	1	2		5	1
	Production phase subtotal	358	24	45	5	403	29
3. Tool-use phase							
3A. *Façonnage* and retouched items on natural blank							
3A.1	Bifaces			30	7	30	7
3A.2	Trihedral picks			8		8	
3A.3	Cleavers			4		4	
3A.4	Large scrapers & retouched slabs			4		4	
3B. Products of *façonnage* reduction							
3B.1	Flakes from biface reduction						
	Use phase subtotal			46	7	46	7
0. Shatter (undifferentiated phases)							
0.1	Splinters	5	1			5	1
0.2	Slab and cobble fragments	582	2			582	2
0.3	Chunks	18	2			18	2
	Undifferentiated products subtotal	605	5			605	5
	Total	963	53	95	39	1058	92

grouped the flakes in a single assemblage that surely contains elements produced by both bipolar (BP) and freehand (FHP) percussion.

We consider as belonging to the use phase both debitage products that were modified by retouch (retouched tools) and items that were shaped by means of predetermined *façonnage* schemes (shaped tools). We studied the first group – retouched tools – following an analytical method (Clarke 1968) that takes into account the position, morphology, angle, extent and direction of the retouch, as well as the general shape of the piece's section of modified contour (Inizan *et al.* 1992: p. 67). The typological concepts we use in describing this assemblage are those defined by Bordes (1961).

Shaped tools constitute the most characteristic group of the Acheulean technocomplex. It usually includes handaxes, trihedral picks and cleavers, to which we must add other implements shaped on large flakes which can be defined as large or massive scrapers (Goren-Inbar *et al.* 2008), and which at TK were sometimes made on natural slabs. In this technological study of the bifaces we strictly apply the concept of bifacial shaping (Inizan *et al.* 1992: p. 41 ff.; Inizan *et al.* 1995; p. 43 ff.) that we used in our study of the bifacial component of the assemblage found in the Lower Occupation Floor of the TK site (Santonja *et al.* 2014). Accordingly, we subdivide bifacial *façonnage* into two phases: first, volumetric reduction; second, achieving bilateral symmetry in order to define the final silhouettes of these tools.

Table 2. Chaîne opératoire phases identified in vesicular lava (c), non-Naibor quartzite (d), and gneiss and metamorphic rocks (e).

Chaîne opératoire phases		Unworked items			Used, retouched or shaped items			Total		
		c	d	e	c	d	e	c	d	e
1. Procurement phase										
1.1	Cobbles		1	1		1			2	1
1.2	Vesicular lava cobbles	4						4		
1.3	Hammerstone detachments		1						1	
1.4	Cobbles with pits				2			2		
	Procurement phase subtotal	4	2	1	2	1		6	3	1
2. Production phase										
2A.	First reduction phase									
2B.	Full reduction phase (ordinary products)									
2C.	Full reduction phase (backed products)									
2D.	Cores									
	Production phase subtotal									
3. Tool-use phase										
0. Shatter (undifferentiated phases)										
0.3	Chunks			1						1
	Undifferentiated products subtotal									
	Total	4	2	2	2	1		6	3	2

We shall then examine the modifications made for tool maintenance and use, and propose a techno-functional approach (Boëda 2001) to these tools. We use J. Tixier's concept of cleaver and we follow his classification (Tixier 1956; Inizan *et al.* 1995: pp. 55–57). Hence in this group we include tools on flake of size medium to large (>10 cm) that have a natural edge. As the process used to manufacture cleavers is very specific and differs significantly from the one used to produce transverse edge handaxes, cleavers are specific to the Acheulean techno-complex and are only occasionally identified in Middle Palaeolithic contexts (Mourre 2003a).

As regards trihedral picks, we define them according to the classic basic criterion. In this group we include implements characterized by a base suitable to be grasped, and usually not knapped, opposite a tip that is totally or partly knapped so as to form a triangular point (Inizan *et al.* 1995: p. 51). The presence of large flakes (>10 cm) that have been knapped or retouched is common in various Palaeolithic contexts (Leakey 1971; Isaac 1977; Gowlett 2005); this phenomenon was recently systematized as regards the Acheulean site of Gesher Benot Ya'akob (Goren-Inbar *et al.* 2008). At TK this type of tool was often shaped starting from slab fragments: blanks whose silhouettes and sizes are comparable to those of flakes. In our study of all these groups we take into account the nature of the raw materials, the types of blanks, and the tool sizes and weights.

Lastly, we discuss the by-products that are part of the *chaîne opératoire* but are not specific to any particular phase (Diez-Martín *et al.* 2009; Santonja *et al.* 2014) because they lack features that would make it possible to assign them to a specific phase (undifferentiated products, or shatter). In particular, we analyse their raw materials, sizes and weights. We include splinters, chunks and angular fragments of NQ slabs in this group.

Results; the *chaîne opératoire* at the TKSF

The assemblage comprises 1161 lithic items, of which 91% are made of NQ and only 8% of VR; vesicular lavas, non-Naibor quartzite (nNQ), metamorphic rocks and gneiss appear in very small percentages (Tables 1, 2).

Procurement phase

This phase represents 5.7% of the TKSF industry (Tables 1, 2); its total weight amounts to 31.6 kg (Table 3). Most (77.3%) of this set consists of 20 compact volcanic rock cobbles, mainly basalt (total weight: 9 kg). They display a large range of sizes (Fig. 2A); the average maximum length is 9 cm, and their average weight is 460 g. Four of them (almost a quarter of the total) are cobbles weighing between 200 and 400 g; another four items weigh between 400 and 700 g. The depositing agents that formed level TKSF lacked the transport

Table 3. Procurement phase (whole items).

Items	N	Length (mm)		Weight (g)	
		Range	Average	Range	Average
VR cobbles	18	146/23	88.7	1264/5	461.0
nNQ cobbles	2	137/22	79.5	890/5	447.5
Gneiss cobbles	1	58	58.0	45	45.0
Vesicular lava cobbles	3	135/106	124.0	1633/436	1127.0
Vesicular lava cobbles with pits	2	138/103	120.5	1620/593	1106.5
VR hammerstones	23	126/63	93.8	1346/135	536.1
VR hammerstone detachments	8	111/28	66.0	735/2	226.6
nNQ hammerstone detachments	1	21	21.0	9	9.0
NQ slabs with percussion marks	4	110/66	90.0	602/190	386.0

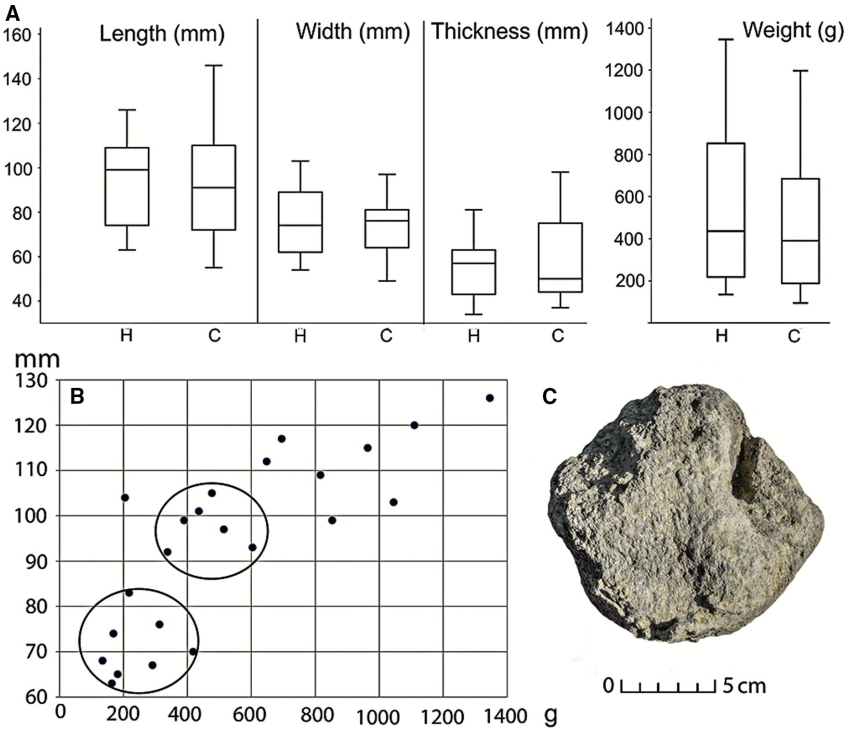

Fig. 2. TKSF cobbles and hammerstones. A. Boxplot of the typometric values of volcanic-rock hammerstones (H, n = 23) and cobbles (C, n = 18). B. Correlation between lengths and weights of VR hammerstones. C. Vesicular lava cobble with groove.

capacity to transport cobbles of this size; hence they must have been brought here by humans. We found only one item of possible sedimentary origin or that had been brought here by trampling: a small cobble (23×18×13 mm; weight: 5 g). There are also seven other rounded cobbles that did not originate in Naibor Soit: two are of quartzite, one of gneiss and four of vesicular lava. Their average size is larger than that of VR cobbles (Table 3), and they do not display macroscopic use marks on their surfaces.

We have documented two vesicular-lava cobbles with grooves on their main surfaces; in one case in the central area (103×95×93 mm; 593 g) and in the other on a side (138×121×115 mm; 1650 g; Fig. 2C). These marks may be the result of active or passive percussion, or of repeated friction (Chavaillon 1979; Goren-Inbar *et al.* 2002).

Macroscopic percussion marks are visible on 28 specimens. One is an nNQ cobble, four are NQ slab fragments and 23 are VR cobbles. In addition to these items, as we shall see below, there is a considerable number of cores that bear marks of being used as hammerstones, thus confirming the versatility of certain blanks, which in some cases were knapped and turned into bifaces. The sizes of the VR hammerstones have some typometric values similar to those of the VR cobbles, but the average values are slightly higher (Fig. 2A), hence we cannot rule out the possibility that the VR cobbles had been brought to the site to also be used in percussion activities. Even though the dimensions of the hammerstones differ, we can distinguish three groups that may be associated with different specific activities (Fig. 2B): hammerstones about 75 mm long and weighing about 250 g, items around 100 mm long and weighing about 500 g, and specimens that are longer and/or weigh more than the ones in the other two groups.

Also belonging to this phase are eight basalt fragments that have no striking platform and no bulb, which we interpret as hammerstone detachments. There is also one fragment originated from a round quartzite (nNQ) cobble, which confirms that nNQ cobbles procured from streambeds were brought to the site.

Production phase: flakes

The 341 flakes we analysed amount to 29.4% of all the items found in the TKSF level. Most of them are made of NQ and were mainly produced by preliminary flaking of slabs (94.1%); the rest (5.9%) were made from VR blanks. We found no flakes obtained from other kinds of rock (Table 2).

Of these 341 flakes, 176 are whole flakes and 137 have small fractures that do not prevent us from reading the organization of the dorsal face of the flakes. The percentage of cortex on flakes (Fig. 3A) shows that in both cases these flakes came from cores that were exploited intensely. All the VR flakes have plain butts, and so do 70% of the NQ flakes. Very few items have dihedral striking platforms (four, of NQ; Fig. 3B).

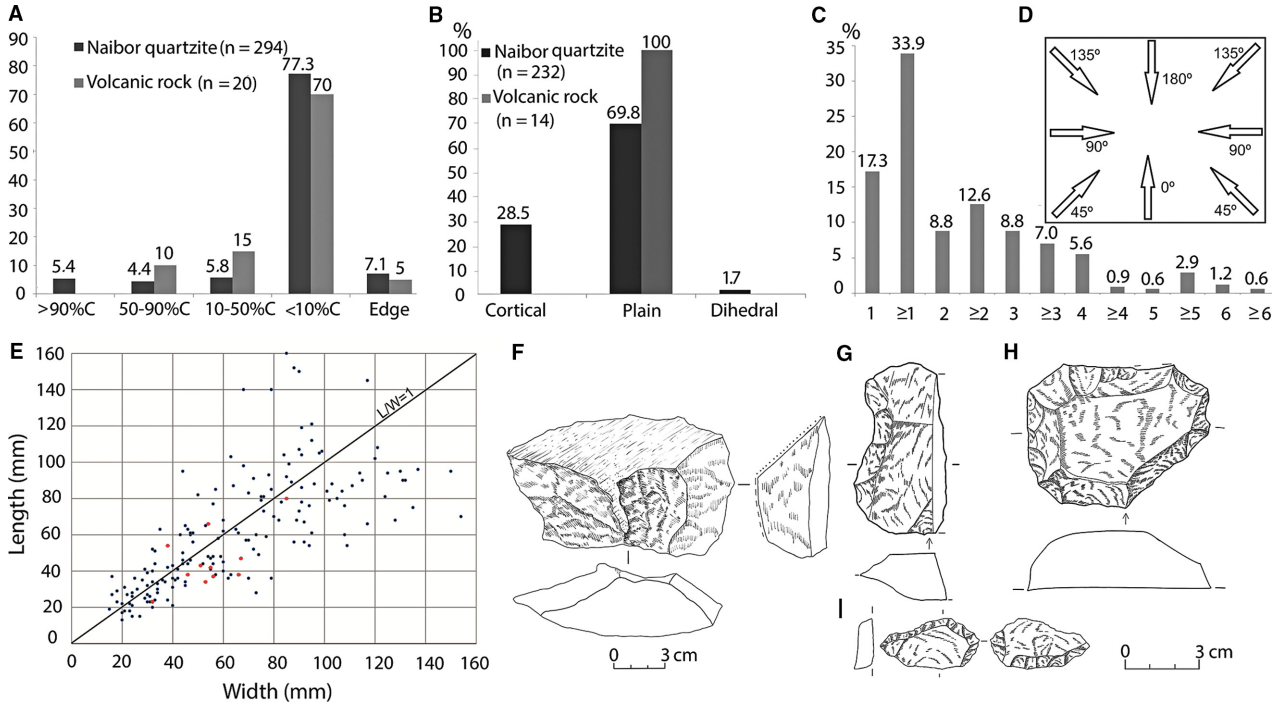

Fig. 3. Production phase: flakes. A. Percentage of cortex on whole or almost whole flakes. B. Preserved butt types. C. Polarity of earlier removal scars on the dorsal faces of flakes: 1 (unipolarity): dorsal faces with unipolar scars that follow the flake's technological axis; 2 (bipolarity): dorsal faces that have at least one scar whose polarity does not coincide with the flake's technological axis; 3 (multipolarity): dorsal faces that have at least two scars whose polarity does not coincide with the flake's technological axis; 4, 5 and 6: multipolar scars whose polarity does not coincide with the flake's technological axis. Broken flakes or flakes that have scars of undetermined polarity are represented by a ≥ symbol indicating the number of polarities that have been identified (1–6). D. Scheme applied to represent polarity. E. Correlation between lengths and widths of NQ flakes (black dots) and VR flakes (red dots). F. NQ flake with debitage back. The cutting edge shows use marks. Tool-use phase: light-duty tools (flake tools). G. Concave scraper. H. Transverse scraper opposite a retouched back. I. Convergent scraper with inverse retouch.

There are 27 NQ flake fragments (Table S1). Furthermore, a large part of the very numerous NQ fragments included in the shatter category, which account for 52.6% of the TKSF's total record, seems to be related to flakes.

The average dimensions and weight of the whole flakes depend on the raw material employed. Ten percent of the NQ flakes and none of the VR ones are more than 100 mm long, some reaching 160 mm. The sizes of the largest NQ flakes fall in the range of the Large Cutting Tool (LCT) category (Table S2; Fig. 3E).

The 22 flakes with debitage and cortical backs make up 6.5% of all the flakes (Fig. 3F). Their size exceeds the group average by 32/29.4/14.6 mm and 242.8 g. The silhouettes of the 16 whole NQ flakes are squarish, and obtaining a long active cutting edge may have been a primary goal in their preparation. Half of these 16 flakes show either use retouch (five flakes) or extensive removals (three flakes) on their cutting edges. The sizes of these pieces are similar to those of the flake scars observed on some of the NQ cores that were suitable for producing backed flakes.

We analysed the polarity of the scars that shape the dorsal surfaces of the flakes; our aim here was to identify the relationships between the exploitation schemes observed on the TKSF cores and the organization of the dorsal faces of the flakes (Fig. 3C). We distinguish amongst three types of polarity (Fig. 3D): (i) unipolarity; (ii) bipolarity; and (iii) multipolarity.

We determined the polarities of all the scars on the dorsal faces of 144 flakes, but of only some scars on another 200 flakes that are either broken or whose dorsal scars are not all legible.

As regards the first group of 144 flakes, 41% of them display unipolarity and 20.8% bipolarity, while 38.2% came from cores that were rotated to some degree during exploitation (as indicated by the three or more polarities on their dorsal faces). At least 60% of the flakes seem to have one or two exploitation polarities reflected in their dorsal faces, 29.2% have three or more, and only 11.7% have four or more polarities. This leads us to conclude that these flakes came from cores that were rotated very little during knapping.

We also identified percussion marks on the dorsal faces of seven NQ flakes and one VR flake. In five specimens these marks are close to or on the butt; in the other three flakes, the marks are grouped on a scar ridge in the inner part of the dorsal face. Considering the position of these marks, it is likely that they were produced because the core had been used as a hammerstone before the flakes were removed.

Production phase: cores

The set comprises 91 cores (7.8% of the total number, Table S3). Most of the cores were made on NQ slabs (87.1% of the identifiable ones), the shape in which this rock is easily available. The others were made on VR cobbles (9.4%) or on NQ flakes (3.5%).

Cores exploited by freehand percussion (FHP). – By reading the removal sequences on the 55 cores that were knapped by FHP, we identified the debitage schemes that had been employed and divided the cores into five groups (Table S4). We have not observed any core that had hierarchized removal and preparation surfaces. We were not able to determine the scheme employed on six specimens because they were either broken or in a very advanced stage of exploitation. The NQ cores are slightly larger, the VR ones a little heavier (Table S5).

Group I (Table S4) comprises cores whose opportunistic exploitation (occasional, unipolar or bipolar) is adapted to the morphology of the blanks; the striking platforms tend to be natural and with only one removal or, if they have more than one, the removals are spatially isolated from each other. Nine are on NQ slabs, four on VR cobbles. Most of them display occasional exploitation (subgroup I.1), with no more than four removals per specimen, independent from each other; four cores have removals on both faces. Three NQ cores were exploited by parallel or subparallel removals all in the same direction (subgroup I.2). The sizes and weights of the NQ cores in subgroups I.1 and I.2 are similar (Table S6). In the only recorded bipolar specimen (I.3), the removals are parallel to each other but in opposite directions on the two main surfaces. Two VR cores and one bipolar NQ core bear signs of having been used as hammerstones.

Group II (Table S4) accounts for another quarter of the total number of the determinable cores. In the elementary core subgroup (II.1), two specimens have three faces exploited by a linked sequence of removals. In subgroup II.2, exploitation was more intense and produced polyhedral cores; at least six were made on slabs (Fig. 4C). Their average length and weight are similar to those of subgroup II.1 (length 76 mm, weight 531.8 g), except for one item, the largest of the set (190×155× 115 mm, 5250 g; Table S6). Half of the polyhedral cores generally bear marks on several ridges that show they were used as hammerstones. In one NQ specimen (89×84 ×75 mm, 745 g), the facets cut through each other until the core's shape became rounded, nearly spherical (subgroup II.3). The ridges at one end bear percussion marks.

Subgroup III.1 contains only the four largest cores of the series (Table S6). Three have bifacial removals on one ridge, the fourth on two ridges. They were all made on large NQ slabs, have extensive reserved cortical surfaces and were not exploited much (Fig. 4E). One core (120× 68×67 mm, 498 g) fits the Clactonian scheme, or SSDA (Forestier 1993).

Group IV is cores characterized by secant or perpendicular exploitation of a main surface, which may be cortical or a schistosity plane (IV.1) or a debitage plane (IV.2). Removals are continuous all around the initial surface; i.e. this is essentially a Quina concept (cf. Turq 2000: p. 316). One core was made on a VR cobble, four on NQ slabs and three on NQ flakes; the latter are the only flakes that were exploited as cores, which highlights the singularity of this scheme. The sizes of these cores are similar to those of the other groups (Table S6), and the intensity of their exploitation is medium to high (Fig. 4D, I).

Group V comprises 11 cores that were exploited according to centripetal schemes (Mourre 2003b). Five of them have a main production surface with centripetal and chordal removals on planes oblique to the blank's main symmetry plane (subgroup V.1). Three NQ slabs were exploited starting from the cortical surfaces (Fig. 4B). Another NQ slab and a basalt cobble have two exploitation planes (independent and not hierarchized). Six specimens were knapped from the transverse ridge and show two centripetal exploitation surfaces (subgroup V.2). Two of these four still have a small bit of cortex (Fig. 4G); in the other two, the centripetal removals are positioned around a large central front removal that occupies much of the main surface (Fig. 4A).

Almost two-thirds of the cores were exploited according to not very elaborate operative schemes (Group I, 26.5%; Group II, 26.5%; Group III, 8.2%), although cores displaying discoid and to a lesser extent peripheral unipolar removal schemes are well represented (22.4 and 16.3%, respectively).

Exploitation was occasional for almost half of the nine VR cores, and discoid for one third of them. Except for the Group I cores, all the others may have produced flakes whose dorsal faces presented two or more polarities. We have not identified any pseudo-Levallois points, which may be due to the difficulty of reading the flakes' dorsal faces (for the most part of NQ). Most of the flakes that were produced from these cores would have had plain or cortical, and to a lesser extent dihedral and faceted, butts. This is consistent with the flakes' butts and dorsal faces (Fig. 3B, C).

More than two-thirds of the NQ cores (69.1%) were made on slabs and were exploited mainly by FHP (83.6%), thus differing from those found at other Olduvai sites, where this raw material mostly underwent bipolar knapping (Diez-Martín *et al.* 2009; Diez-Martín *et al.* 2011). The NQ cores have more or less the same average length and weight as the VR cores (Table S5). Consistent with the relevant conceptual scheme, the largest NQ cores are usually the ones in Groups I and III, while the smaller cores are the polyhedral and discoid ones (Table S6). If we exclude the three largest specimens in the series (Groups I.4, II.2 and III.1), exploitation intensity ranged from medium to high in almost three-quarters of the set (61.8%), and the blanks became exhausted in 10.9% of cases (Table S4).

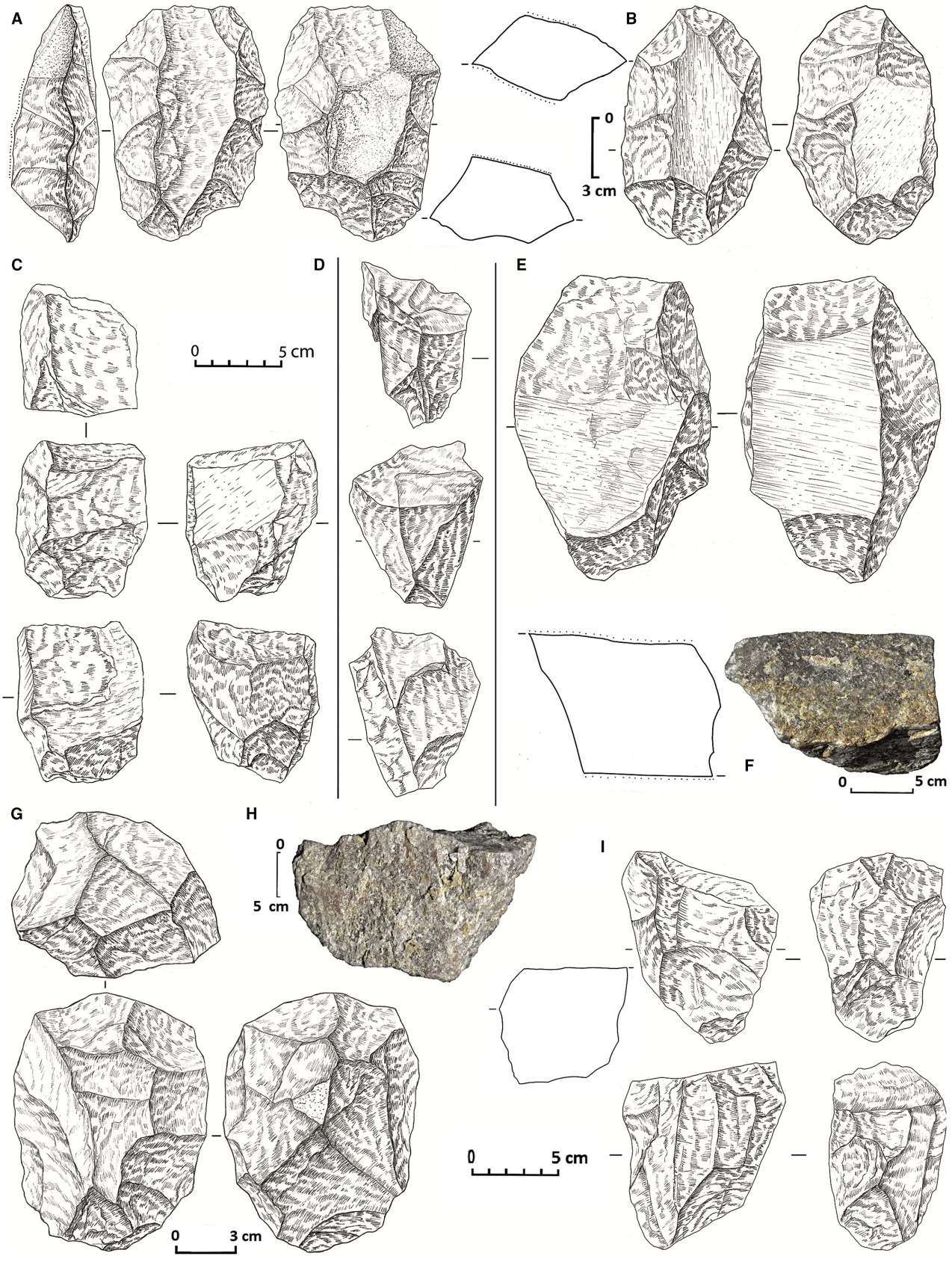
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Fig. 4. Production phase. Cores exploited by freehand percussion: A. Bifacial discoid core (subgroup V.2) made on NQ slab. B. Discoid core (subgroup V.1) made on NQ slab. C. Polyhedral core (subgroup II.2) made on an NQ slab and displaying freehand and bipolar percussion. D. Peripheral unipolar debitage NQ core. E. Bifacial core (group III) that has large bifacial removals on the smaller sides and unipolar removals on the larger sides. G. Bifacial discoid core (subgroup V.2) made on NQ slab. Cores exploited by bipolar knapping: I. Peripheral unipolar cortical (subgroup IV.1) NQ core. H. BP on one side (C1) and percussion marks on platform A. F. BP on three sides (C3) and percussion marks on a ridge.

Cores exploited by bipolar percussion (BP). – At Olduvai, bipolar knapping (Brézillon 1971: p. 75; Inizan *et al.* 1992: p. 37) was generally applied on NQ slabs (Jones 1994; Diez-Martín *et al.* 2011). While in the TKLF we have not observed BP on VR (Santonja *et al.* 2014), in the TKSF we identified it in an angular basalt cobble. The blanks were NQ slabs, generally with a subrectangular contour, and were exploited on one or more peripheral planes. We have called the main surfaces of the slabs platforms A and B. Peripheral perpendicular planes are indicated by the letter C, and the number of planes with BP is specified (C1, C2, C3, C4) (Diez-Martín *et al.* 2009, 2010).

Five of the 55 cores exploited by FHP also displayed BP. One is an occasional core made on an angular subrectangular basalt cobble. The others are NQ.

Thirty-six NQ slabs were exploited by BP. The frequencies of its use on one, two or three sides of the slabs are similar (Table S8; Fig. 4F, H); in only six cases is it documented on the whole contour (Table S7). Fifteen cores also display additional FHP knapping (Table S8). For the most part, these are isolated removals on only one side (86.7%).

Use of cores in percussion. – Almost a quarter of all the cores we analysed (22 out of 91) bear percussion marks. Based on experimental results that analysed the position of percussion marks on blanks (Diez-Martín *et al.* 2011; de la Torre *et al.* 2013), we decided to divide them in two groups.

The first group comprises items that could have been produced by active percussion. The percussion marks are located on the peripheral area or on the ends of the specimens; hence they may have resulted from active percussion on rocks and other hard materials. The second group includes blanks that seem to have undergone passive percussion (anvils).

We identified peripheral marks on 10 of the 55 FHP cores. On the only two VR cores and on two of those made on NQ slab blanks, the percussion marks are located on planes opposite to the removal planes; this indicates that these specimens were used sometimes as hammerstones and sometimes as cores. On the other six cores, the percussion marks are on several of the ridges shaped by the removals, which implies that the marks were made during or after the exploitation of the cores. Seven NQ flakes and one VR flake have percussion marks on their dorsal faces and butts, which further confirms that the cores from which they were detached had been used as hammerstones.

The presence of percussion marks scattered over surfaces A or B, or on the ridge between surface A or B and surface C, has been correlated to the use of such specimens as anvils in bipolar knapping activities (Diez-Martín *et al.* 2011; de la Torre *et al.* 2013), or perhaps in pounding certain organic materials (de la Torre *et al.* 2013). We observe this distribution on two FHP cores. Ten of the BP slabs have percussion marks on surface A or B. On eight of these cores, the marks are located on both main surfaces. One core also has marks on surface C, which suggests that this specimen was used as a core, as a hammerstone and as an anvil. The last two items bear marks on only one main surface, which may be related to bipolar knapping. Two of the slabs exploited by BP knapping also bear percussion marks on the contact area between the main surfaces and the peripheral one (C); these marks were clearly made after the core was knapped. The sizes and weights of cores that have percussion marks (Table S9), and may have been used as hammerstones or anvils, fall within the ranges observed for FHP and BP cores (Tables S7, S8).

Tool-use phase: light-duty tools (flake tools)

As regards this phase we must first of all consider retouched tools. We have studied them according to an analytical method (Clarke 1968) that describes the localization, mode (morphology and angle), extent, direction and shape of the retouched side and the appearance of the retouch (Inizan *et al.* 1992: p. 67). We included backed knives, despite the fact that sometimes they were not shaped by retouch, because they are blanks with a special morphology that creates cutting edges opposite their backs. The typological concepts we used correspond to those defined by Bordes (1961).

We found only nine retouched implements in the TKSF, including two backed knives. Seven are NQ flakes, two are VR flakes. The average measurements of the NQ tools are not significantly different from those of unretouched flakes (64.8/62.3/24.1 mm and 61.1/65/26.2 mm, respectively). The two retouched VR items, by contrast, are larger and heavier than the average for unretouched VR items (64.9/35.7/16.9 mm and 341.5 g). Seven of the nine flakes have <10% cortex.

The retouched tools comprise four scrapers, two denticulates, one notched tool and two backed knives (Table S10). The retouch in the scrapers is abrupt and continuous. On one scraper, retouch shaped a concave lateral edge (Fig. 3G); the largest scraper has convergent edges and reverse retouch (Fig. 3H); on the third, the retouched edge is convex; on the fourth specimen, retouch is transversal and opposite a shaped back

(Fig. 3I). The two denticulates were made on NQ flakes; one (87×85× 24 mm; 204 g) has very marked retouch on the transverse edge, the other one (98×68×27 mm, 153 g) has less marked retouch on the right side. The notched tool is simple and inverse, and was produced on a large VR cortical flake (119×95×34 mm, 450 g). Both of the naturally backed knives are large; one was made on VR (102×86×32 mm, 233 g), the other on NQ (90×106× 44 mm, 435 g).

Use: façonnage and retouched items on natural blanks

In this section we analyse the production and maintenance of tools made from natural blanks or large flakes with the intention of manufacturing a single piece that would fit a predetermined reduction scheme (Inizan *et al.* 1995: p. 43–57). The 53 items that fulfil these characteristics (excluding undifferentiated products) account for 9.6% of the lithic assemblage of this series. There are 37 handaxes (eight trihedral picks, four cleavers and four large shaped flakes and slabs). The proportion of tools shaped by *façonnage* is slightly higher in NQ (10.5%) than in VR (7%).

Handaxes. – Besides whole handaxes, this assemblage includes tips and preforms, that is, specimens in an intermediate phase of shaping (Table S11). Fifteen of the whole NQ handaxes were produced from slabs, and three were made on flakes. Three blanks used for VR handaxes were flakes, one was a rounded cobble, but in three cases the type of blank could not be identified (Table S11).

The sizes and weights of the handaxes are relatively homogeneous. More than half of the specimens are around 130–160 mm long, 78–102 mm wide and 40–60 mm thick, and weigh 400–800 g (Fig. 5A, B). At the low and high ends of these ranges, two NQ specimens are <110 mm long and three are longer than 180 mm. Most have a L/W ratio between 1.5 and 2, which in the longest specimens is >2 (Table S13; Fig. 5A). Although the correlations between measurement differences and raw materials are not significant, the VR handaxes are thinner (2.6 mm) but larger and heavier, and slightly longer and wider (by 9.2 mm in both dimensions) than the NQ ones (Table S13). The sizes and weights of the six handaxes fashioned from flakes (three NQ and three VR) (Table S11) are similar to those of specimens made on other NQ and VR blank types.

Bifacial and bilateral shaping. – Bifacial reduction of NQ handaxes generally affects the ends and sides of the items and tends to be invasive. Only occasionally is it limited to the apical third, with the remaining part of the tool being shaped by bilateral knapping. There is no cortex on most of the whole NQ bifaces (71.4%) or it occupies only a third of the main surface. The amount of cortex on VR handaxes is similar (Table S12). If we bear in mind the concept of bifacial and bilateral shaping, a first approximation makes it possible to group the handaxes in three basic sets according to their silhouettes and the reduction method used: pointed, oval and transverse-edge handaxes.

The pointed handaxes group comprises 16 NQ bifaces and five VR bifaces. Their sides tend to be convex and convergent, forming pointed ends that are generally somewhat rounded by use. Their bases are either thick or have a cutting edge. These silhouettes are more amygdaloid than lanceolate (cf. Bordes 1961). The average measurements (except weight) of pointed handaxes do not differ much from those of oval handaxes, even though the larger specimens are in this group (Fig. 5E). Based on their shape, we can distinguish two subgroups for each raw material, 11 NQ specimens and five VR ones.

The bilateral shaping of the NQ specimens was generally bifacial and done through extensive removals that cover nearly the whole tool, including the basal areas. Seven specimens have sharp bases, and four have thick bases. As only four items show the final finishing that gave a regular shape to the tool, bilateral shaping seems to have sufficed to achieve silhouette symmetry. A first subgroup consists of six items that underwent a finishing phase that defined the apical end through removal of sharpening flakes along the direction of the axis (four specimens) or laterally (two specimens). Four of these specimens have small fractures, perhaps due to use, on the distal end. A second subgroup is made up of five items, two produced on flake and three on slabs, with non-generalized bilateral shaping. In one case the bifacial shaping is peripheral. In the remaining handaxes, shaping was bilateral bifacial in the distal third and unifacial on the sides (two specimens), or bifacial shaping on the point and bifacial on one side (one specimen), or unifacial all around the contour (one specimen). The tips of three specimens were finished, two by sharpening removals in the axial direction in the apical area, and one by an oblique bevel removal (the latter specimen was made using both FHP and BP).

The VR pointed-handaxe subgroup (five specimens) can be further divided in two sets. As regards the three tools in the first set, shaping is invasive bilateral and bifacial. Their points were shaped by sharpening removals in the axial direction; their bases have a cutting edge (Fig. 5F). One of them has a well-balanced silhouette (152×83×46 mm, 426 g) that resembles Micoquian shapes (Bordes 1961); the base has a cutting edge and there is a narrow transverse cutting edge on the tip (Fig. 5G). The shaping of the two handaxes in the other set is bilateral and partial. One of them was fashioned from a cobble (134× 113×32 mm, 1.090 g); it has percussion marks, a broken apical end and a thick base. The other was made on a flake (137×82×32, 399 g); the shaping done to it was aimed at creating a point.

The oval-handaxe group comprises six specimens, four of them made on NQ slabs and two on VR flakes. The NQ oval handaxes are smaller but heavier (5.4/3 mm and 14.3 g) than the NQ pointed handaxes. Their bilateral shaping is mostly bifacial; it covers the distal third of one

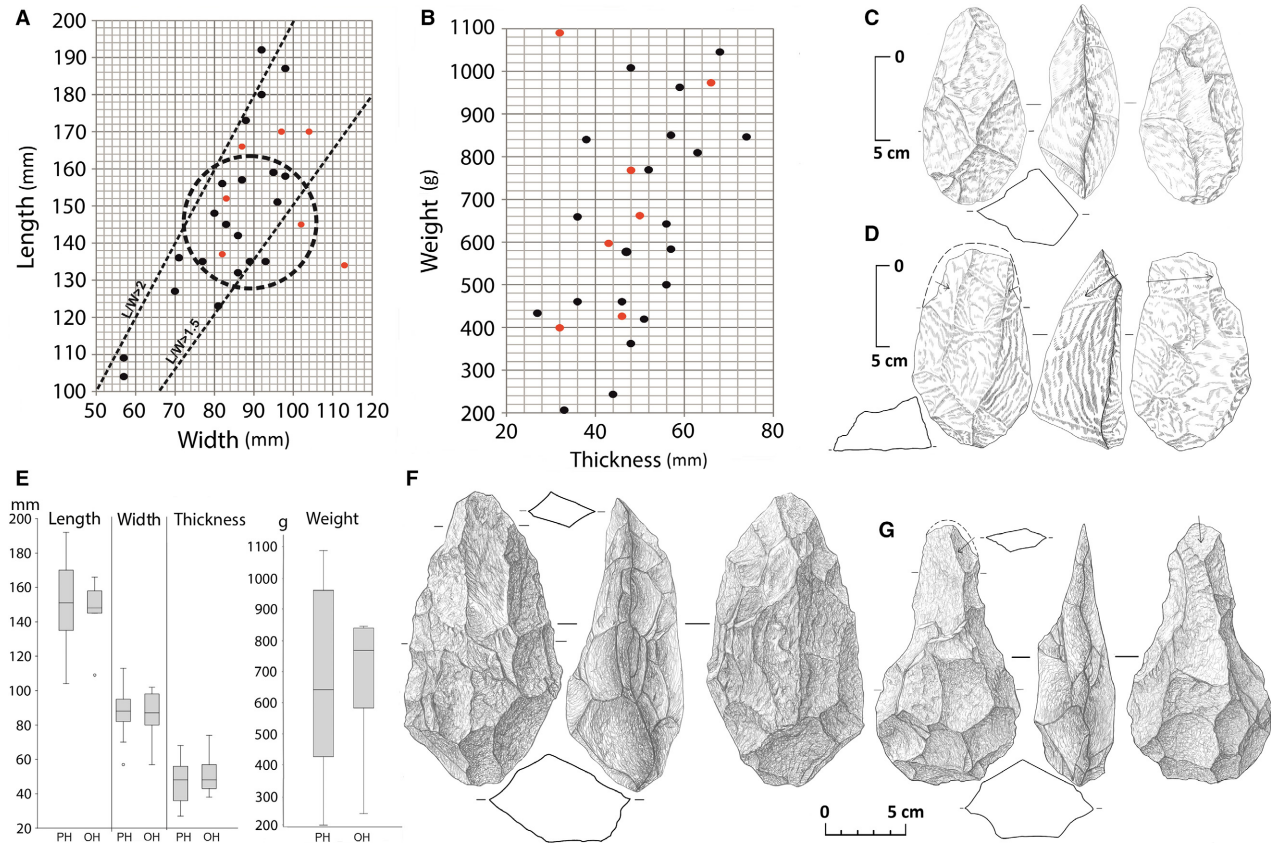

Fig. 5. Façonnage: handaxes. A. Correlation between lengths and widths of NQ handaxes (black dots) and VR handaxes (red dots). B. Correlation between weights and thicknesses of NQ handaxes (black dots) and VR handaxes (red dots). C. NQ oval handaxe shaped by bilateral bifacial knapping. D. NQ transverse-edge handaxe, with sharp base and cutting edge shaped by tranchet-blow technique. E. Boxplot of typometric values of pointed handaxes (PH) (n = 21) and oval handaxes (OH) (n = 6). F. VR pointed handaxe with sharp base and sharpening removals in axial direction. G. VR pointed handaxe with complete bilateral bifacial shaping, narrow transverse edge and sharp base. In drawings (D) and (G), the broken line shows the tool's approximate outline before rejuvenation, and the arrows indicate the removals that correspond to its final modification.

specimen, and the entire contour of each of the other three (Fig. 5C). The other two oval handaxes were made on VR flakes. Their shaping is bilateral bifacial except on two sides of both items, where it is unifacial. The distal ends of three specimens have a sharpening finish; in one specimen, lateral and oblique apical removals defined a small point at the distal end.

The transverse-edge handaxe group consists of only one specimen, which was fashioned from a NQ flake (123×81×56 mm, 500 g; Fig. 5D). It has a rectangular silhouette and it displays bilateral bifacial shaping except on the right side, with a convex outline that makes good use of the natural shape of the blank. The base has a cutting edge that was shaped by the tranchet blow technique (Inizan *et al.* 1992: p. 99).

The techno-functional approach applied to the handaxes. – According to Boëda (2001), a techno-functional unit is created when a blank is adapted to fulfil its desired or potential function, thus making the tool suitable for its desired task. Judging by the bifaces we analysed, the most evident techno-functional unit in the 21 pointed handaxes found in the TKSF is their apical area. The presence of three point fragments and one fragment of an apical third, all from well-finished handaxes, confirms that the point was very important in the use of these tools. By contrast, the six oval handaxes and the transverse-edge one were probably shaped to accomplish different tasks than the pointed ones.

The remaining portion of the contour of the handaxes is made up of cutting edge segments and backed segments. Our analysis of the sections of the basal and apical areas of the 27 whole handaxes (21 NQ and six VR) aims to understand whether these segments were conceived solely to achieve bilateral symmetry or also to achieve a functional objective. A traceological analysis is in progress. In the meantime, the techno-morphological study of the sections of the basal and apical areas of the handaxes makes it possible to give a tentative answer to this important question. We shall follow the same method we used for the TKLF handaxes (Fig. 6A; Santonja *et al.* in press).

Based on the degree of corticality and on the type of shaping (unifacial or bifacial) and of percussion (bipolar

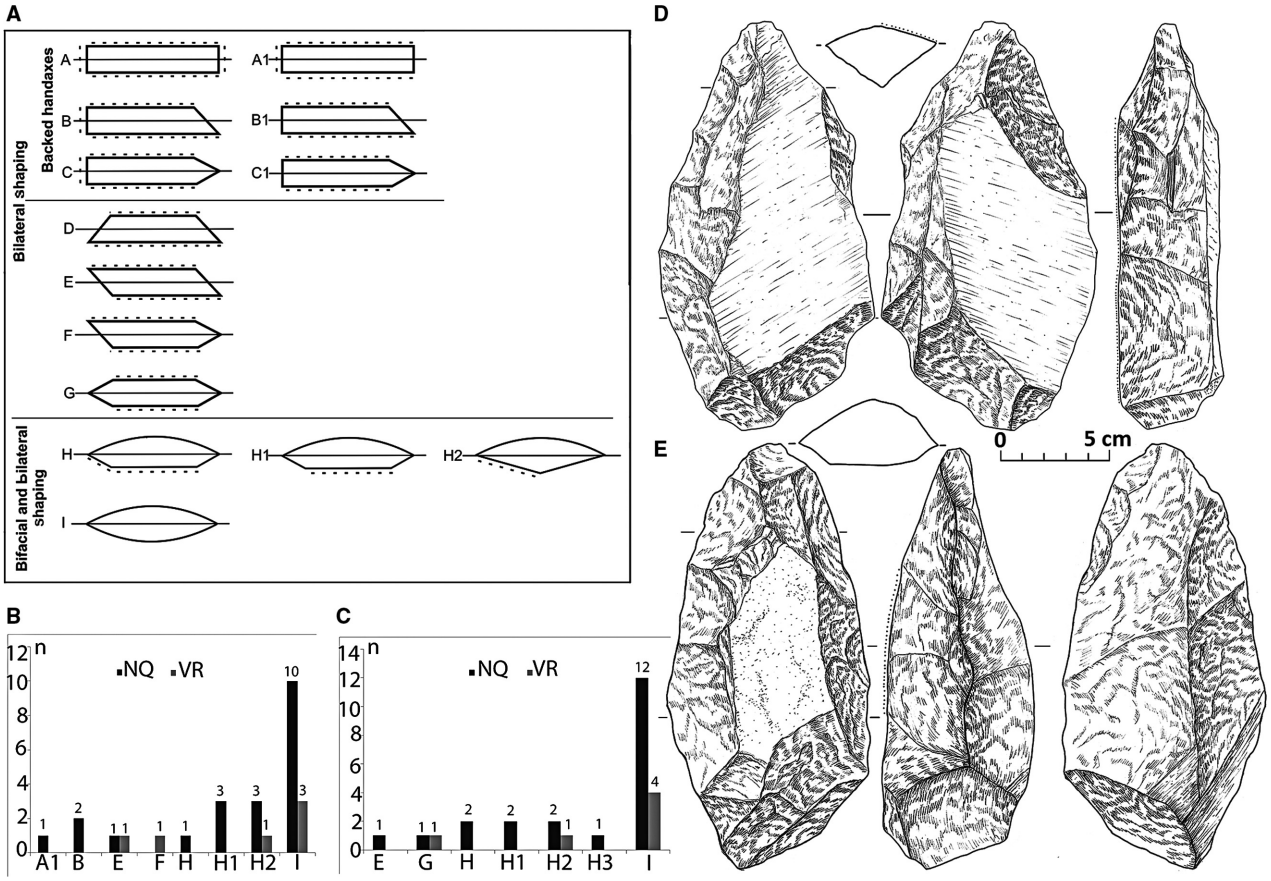

Fig. 6. Façonnage: techno-functional approach applied to the handaxes. A. Transversal cross-sections (basal and apical areas) of the handaxes found in the TKSF, showing their corticality, shaping (unifacial or bifacial) and type of percussion (bipolar or freehand). Dotted lines indicate cortical and/or bulbar areas. Bipolar percussion (BP) is represented by lines perpendicular to the bifacial symmetry plane (e.g. A1), freehand percussion (FHP) by lines at an angle with the bifacial symmetry plane (e.g. B). Bifacial shaping is represented by two slanting lines converging onto the bifacial symmetry plane (e.g. C). A = Cortical faces and sides, or shaped by bipolar percussion. B = Cortical faces and one side cortical or shaped by BP, the other side by unifacial FHP. C = Cortical faces and one side cortical or shaped by BP, the other shaped by bifacial FHP. D = Cortical faces and both sides shaped by unifacial FHP produced starting from the same face. E = Cortical faces and sides shaped by unifacial FHP starting from opposite faces. F = Cortical face, one side shaped by bifacial FHP and the other by unifacial FHP. G = Cortical faces and sides shaped by bifacial FHP. H = One cortical face cortical and another shaped by FHP; sides shaped by unifacial or bifacial FHP. I = Faces and sides shaped by bifacial FHP. B. Transversal cross-sections of the bases of the 27 whole handaxes. C. Transversal apical cross-sections of the 27 whole handaxes. D. NQ handaxe with transversal base cross-section E and apical section G. E. NQ handaxe with basal section H1 and apical section I.

or freehand), we identified nine sections (labelled from A to I), some of which present variations (Fig. 6A). In sections A to G, shaping is limited to the bilateral finishing phase, while in sections H and I it also affects bifacial symmetry. The sides are formed by backs or cutting edges, or by a combination of both. The backs may be cortical (A, B and C) or shaped by bipolar percussion (A1, B1 and C1), while the edges are shaped by unifacial (D, E) or bifacial freehand percussion (F, G, H, I).

Backs are the element that more than others may be correlated to the ease with which the tools could be gripped. Three NQ handaxes have backed sectors in their basal area. The cutting edges of the 18 unbacked handaxes (sections D to I) extend over the whole contour and were shaped by unifacial or bifacial knapping or a combination of both. Only one tool was fashioned solely by unifacial knapping (section E, Fig. 6D). The other 17 underwent bifacial knapping (seven H sections, Fig. 6E, and 10 I sections), so it is very likely that in these cases the knappers intended to create functional cutting edges, which take up most of apical sections H and I (Fig. 6B).

Of the six VR handaxes, only one has cutting edges shaped by unifacial knapping (proximal section E). Another has one cutting edge shaped by unifacial and one shaped by bifacial knapping (proximal section F). Both cutting edges of the other four specimens were shaped by bifacial knapping (one distal section G and three distal section I), which could be related to the production of functional cutting edges (Fig. 6C).

Handaxe preforms. – We identified five handaxes that were being made on NQ blanks when the process stopped. Some of them had broken during shaping and were thrown out. Four have silhouettes similar to those of pointed handaxes, one is similar to oval handaxes.

One of the pointed preforms was being made from a large flake (Fig. 7C); its point is broken, probably because of use. Another specimen, on an NQ slab (Fig. 7A), is broken in the proximal area. It underwent bilateral reduction – bifacial on the left side, unifacial on the right – extending all the way to the apical end. One of the two smaller pointed specimens displays bifacial bilateral shaping, including on the point, and a large removal in its ventral face (Fig. 7B). The other one (128×71×43 mm, 448 g) is on a flake, and its bifacial bilateral reduction focused on fashioning a point by means of lateral removals; its thick base bears percussion marks.

The oval preform (128×78×58 mm, 680 g) is broken on one side and exhibits partial bifacial reduction.

Handaxe fragments. – We identified three NQ handaxe points that had probably broken off accidentally during use. Two of them display bifacial reduction and apical removals in the axial direction (Fig. 7D, E). The third one is a fragment of the apical third of a handaxe shaped by bilateral bifacial knapping and by lateral removals on the point.

Trihedral picks

Eight specimens exhibit a basic trihedral *façonnage* method (Inizan *et al.* 1992: p. 44). They are slightly smaller than the NQ handaxes (Tables S13, S14). They were made on NQ slabs, thick in three specimens and slightly flattened in the other five; in some cases knapping was marginal and not very invasive.

In one specimen the shaping extends all around its contour; this pick also has a narrow tranchet on its apical end (Fig. 8A). In two specimens the contours are almost entirely shaped. The reduction applied to four other picks was mainly unifacial; three of them have thick bases, one has a base with a cutting edge. In one case volumetric reduction was achieved by extensive removals followed by regularization of the silhouette and of the point. The last specimen was shaped by bifacial freehand knapping on one side and bipolar knapping on the other (Fig. 8B).

Cleavers

The assemblage includes three cleavers on flake that closely fit Tixier's (1956) definition of hacheraux. Their measurements fall within the same range as those of the bifaces (Table S15). The largest one corresponds to Tixier's type 0; it has an oblique natural edge, extensive bifacial removals on both sides and a thinned base, and other removals that have eliminated the butt of the flake blank (Fig. 8E). The second specimen corresponds to Type I and was shaped bilaterally by mostly unifacial

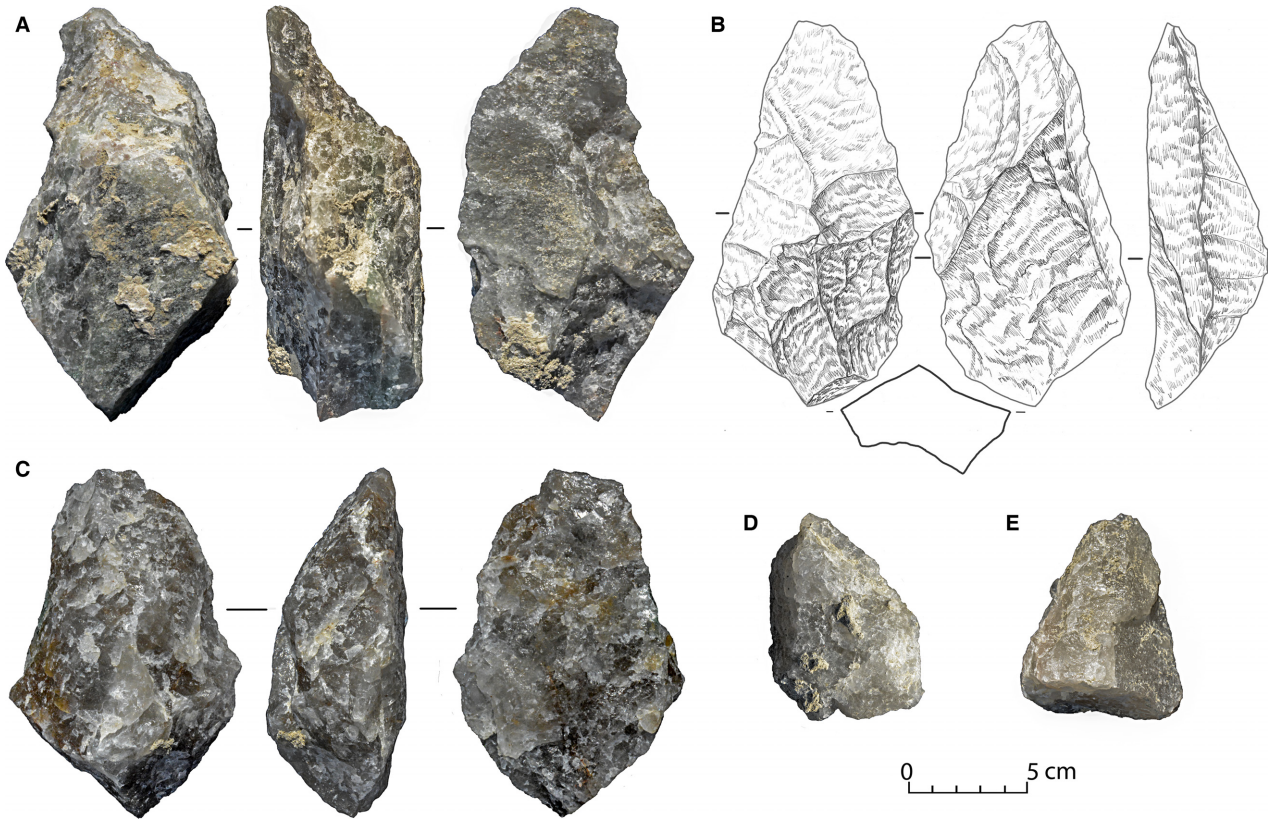

Fig. 7. Façonnage: handaxe preforms and handaxe fragments. A, B, C. NQ pointed handaxe preforms. D, E. Apical fragments of NQ handaxes.

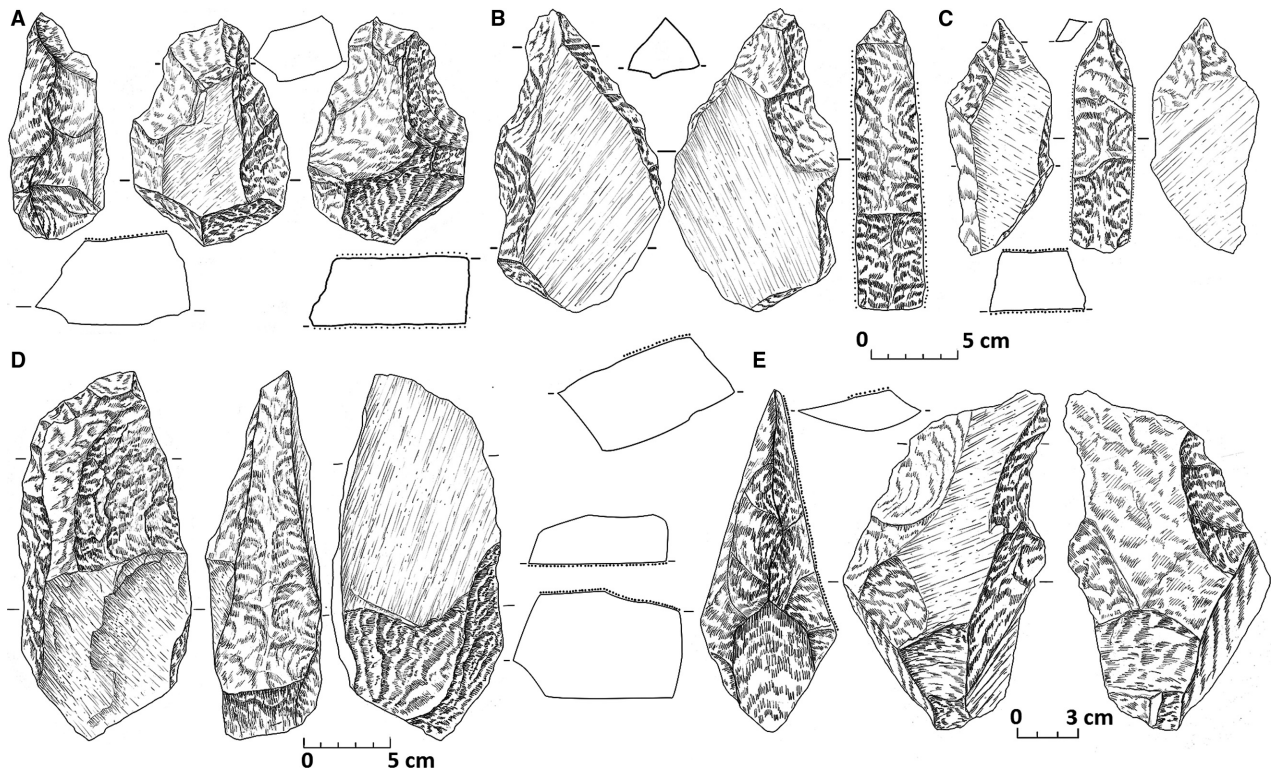

Fig. 8. Façonnage. A, B. Trihedral picks. C. Shaped NQ slab with pointed end and lateral backs. D. Cleaver on NQ slab. E. Cleaver on NQ flake, Type 0 (according to Tixier 1956).

knapping. The third cleaver, which corresponds to Type II (Tixier 1956), underwent invasive unifacial knapping on both lateral areas; it has a natural oblique cutting edge and its base is partly broken.

To this group we have added a specimen shaped on a NQ slab that is comparable to cleavers from the formal standpoint. Similar items have been described at European Acheulean sites (i.e. Terra Amata, in France, and El Sartalejo, in Spain; Villa 1983; Santonja & Villa 2006: p. 440, 465). Starting with a slab fragment, it was shaped by invasive knapping on the distal third of the main face and on the base of the other face, while the left side underwent bipolar knapping. The cutting edge is oblique and was prepared by means of three large removals (Fig. 8D).

Large scrapers and shaped slabs

We have documented four large items that were shaped by knapping. One is a large scraper made on a non-cortical flake (138×92×52 mm, 692 g) that exhibits large removals on the ventral face, the right side and the apical area; these removals were made with the intent of fashioning a pointed tip. The other three items were made on slabs. Two of them (88×63×32 mm, 250 g; 190×68×51 mm, 324 g) have cutting edges opposite natural backs; the third also has a pointed end with lateral backs that form a techno-functional unit suitable for gripping (Fig. 8C).

Shatter

The 611 items included in this category weigh a total of 49.5 kg and account for a fifth of the total weight of the TKSF industry (Table S16). These fragments could have originated mainly during all the phases of knapping on NQ slabs and in some types of percussion activities that involved NQ anvils or hammerstones. There is no criterion by which we could ascribe them to a particular phase; hence we consider them undifferentiated products (u.p.). We distinguish three variants: NQ slab fragments, chunks (items with cortical surfaces or with portions of removal scars, but do not exhibit any technical feature that would enable a specific technological definition) and splinters, i.e. small pieces (<15 mm) with no defined bulb or butt, that could have originated in any stage in the production or shaping chains.

Slab fragments account for 95.6% of the u.p.; they are all made of NQ except for two VR ones. Their dimensions vary, with lengths ranging between 9 and 181 mm (Table S17); 15.7% are <20 mm, 66.1% are between 20 and 60 mm, and 18.2% are >60 mm long. These sizes suggest that these are knapping by-products, and were

partly produced during the initial process of preparing blanks suitable for shaping handaxes. Another possible origin could be that they broke off from anvils during percussion activities correlated either with knapping or with use (de la Torre *et al.* 2013).

Chunks probably derive from fragmentation of cores, and amount to only 3.4% of the u.p. They are made of NQ, VR and gneiss. NQ chunks are the most numerous (18) and are larger (11.6×10.8×9.2 mm and 17.5 g; Table S18) than NQ fragments. All of the VR chunks except one are larger than the VR fragments. The largest of all the undifferentiated products is a gneiss chunk (98×67×55, 553 g).

We found very few splinters: five of NQ and one of VR. Their average dimensions and weight are 13.7/13.8/6.2 mm and 3.2 g.

Discussion

The identification at TK of two Acheulean floors that pertain to the Earlier Acheulean phase, stratigraphically very close to each other, with no significant temporal diachrony and that have both been excavated recently with the same methodology, makes it possible to study their technical and typological differences in the context of the synchronic variability that can be recorded in Acheulean assemblages. In the following discussion we present a comparison that will make it possible to define the similarities and differences –which may be further defined when the excavation area is enlarged – between the technological strategies adopted at the TKSF (45.3 m^2 excavated, and 1161 items found), which we have just described, and those employed at the TKLF (51.9 m^2 excavated and 5805 items found; Santonja *et al.* 2014, in press). To try to identify the kinds of activity that were carried out at these levels and the relationships between their respective industrial assemblages, we are performing – amongst other things – traceological, phytolite, biomarker and starch grain analyses (Bello-Alonso *et al.* 2016; Mercader-Florin *et al.* 2016).

Just as happened in the TKLF (Santonja *et al.* 2014), level TKSF was deposited in a sedimentary environment whose energy was too low to transport centimetric-sized clasts. However, overland flow and the presence of a channel in erosive contact, which partly affected the area occupied by the TKLF, could have caused minor displacements of the items; this would explain the scarcity of sub-centimetric lithic items present there. Likewise, the white-pale yellow sandy clay (4) (Fig. 1F) on the TKSF may have undergone some erosion and could have caused displacements of sub-centimetric lithic items; this would explain the scarcity of these items in this level. Nonetheless, the taphonomic analyses carried out at the TKLF (Yravedra *et al.* 2016) and at the TKSF (work in progress) reveal important differences between the burial processes that occurred in these two levels. The bones found in the TKLF had been exposed for a long period of time, as indicated by the presence of microabrasion, trampling, biochemical alterations and dry fractures. Moreover, in this unit faunal remains <40 mm long bear rounding marks (Yravedra *et al.* 2016), which were probably caused by the activity of small ephemeral streams that may have carried these remains into the site (Santonja *et al.* 2014). At the TKSF, by contrast, the low incidence of weathering on the well-preserved part of the bone assemblage, including whole long bones of large mammals, suggests that rapid sedimentation buried these remains quickly, thus protecting them from prolonged exposure to atmospheric agents (23.3% of the identified specimens show weathering stage 1; 3.3% stage 2 and 0% stage 3, as per Behrensmeyer 1978).

The 51.9 m^2 excavated in 2010–2012 contains an average of 4.4 items per m^2 more than the 45.3 m^2 excavated at the TKSF; this proportion decreases to 3.2 items per m^2 if we exclude shatter, and to 1.8 kg per m^2 if we consider only weight (Table S19). These results may be correlated to the fact that the TKLF was exposed to atmospheric agents for a longer period, and to the fact that the lithic items knapped at this level are more fragmented. Another explanation could be that the activities carried on at each level may have not been the same, or may have been similar in kind but conducted at different intensities.

Lithic raw materials were employed at the TKLF and the TKSF in very similar ways. In both levels, NQ is the one most used, followed by volcanic rocks. These two are the only raw materials for which we observe all the chaîne opératoire phases in both floors. Volcanic rocks are slightly better represented in the TKLF than in the TKSF, especially in terms of weight (Fig. 9A). The presence of other kinds of rocks, such as nNQ, gneiss and flint, is minimal (Fig. 9B).

NQ was brought mostly unworked to both levels, whereas at least some of the VR items, especially shaped tools, may have reached both the TKLF and the TKSF already worked, as can be inferred from the fact that in the TKSF there were nine cores and seven bifaces, but only 20 VR flakes. Unmodified VR cobbles were also brought here to be used directly as hammerstones, but the presence of some cores and flakes shows that this raw material was also knapped at the site. The source of the NQ recorded throughout all the TK levels has been identified as the Naibor Soit inselbergs ridge (Hay 1976; Kyara 1999; de la Torre 2004: p. 348–349; Blumenschine *et al.* 2008). However, the quartzite that outcrops at Naibor Soit is not uniform. The hill where we found that the quartzite's macroscopic features were similar to those of the rocks used at TK was the one closest to TK, i.e. the Naibor Soit Southern Outlier (Fig. 1A–D). At the time when the TK site was formed, this hill would have been about 750 m away (cf. Santonja *et al.* 2014: fig. 27), but there may also be some small outcrops closer to TK that are now hidden by Pleistocene deposits. If so, NQ would have been readily available.

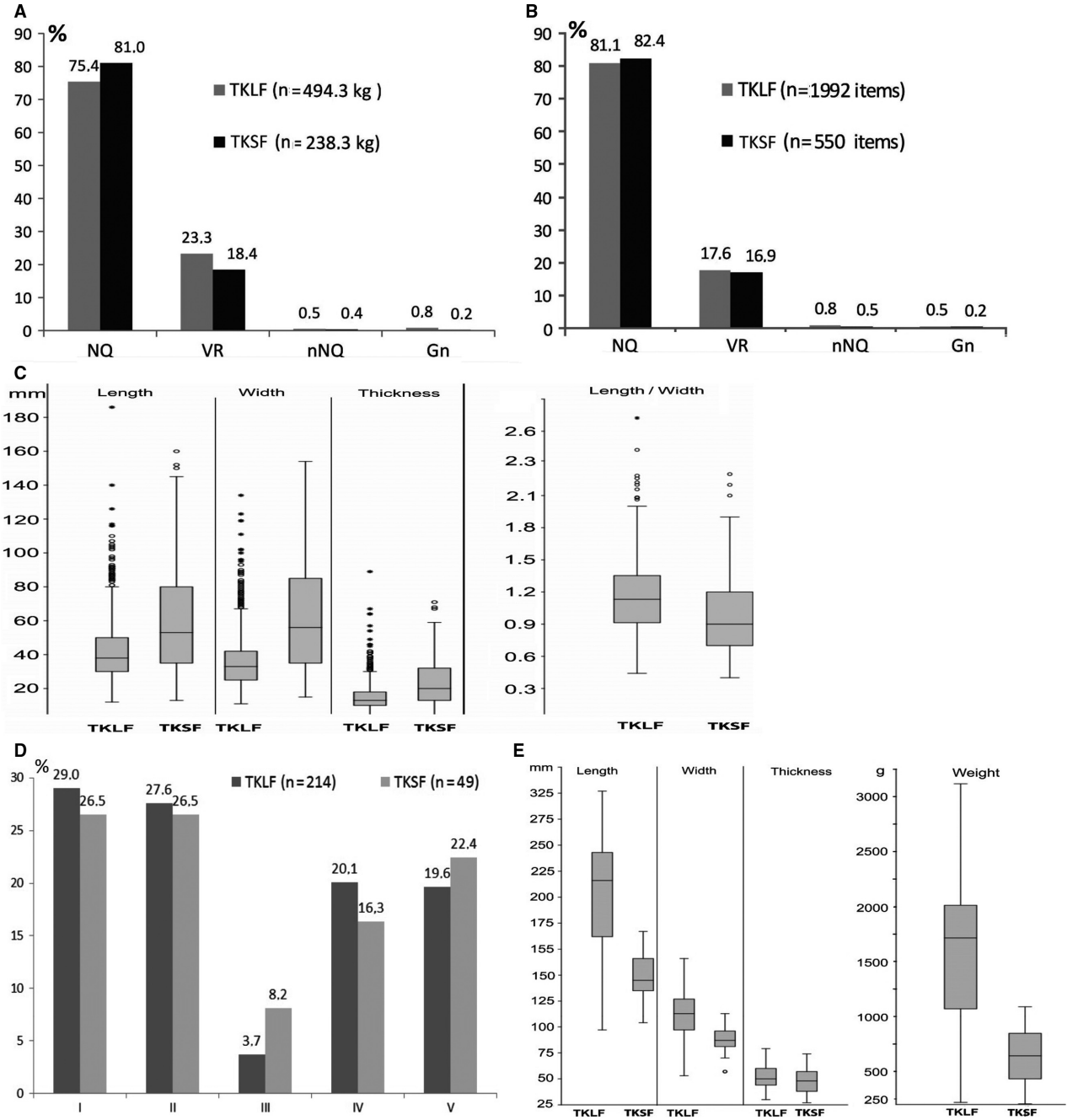

Fig. 9. A. Distribution of raw materials by weight (shatter included) in levels TKLF and TKSF. B. Distribution of raw materials by number of items (shatter excluded) in levels TKLF and TKSF. C. Boxplot of typometric values of flakes. D. Distribution of the core groups. Group I: cores displaying opportunistic exploitation (occasional, unipolar and bipolar). Group II: multipolar cores (elementary, polyhedral and facetted subspheroid). Group III: bifacial cores. Group IV: peripheral unipolar cores (with a natural initial surface or one produced by debitage). Group V: discoid and centripetal bifacial cores. E. Boxplot of typometric values of the handaxes.

The main sources of the volcanic rocks found at the TKLF and TKSF were the formations originated by the Olmoti, Ngorongoro, Sadiman and Lemagrut volcanoes (Hay 1976; Jones 1994; Kyara 1999: p. 114), whence streams and rivers would have carried these rocks to the centre of the basin, bringing them close to TK and to other Olduvai sites in the form of rounded cobbles (Hay 1976: p. 344; Feblot-Augustins 1990; Kyara 1999). Judging by the total weight of VR items in both levels (115 kg in TKLF and 38 kg in TKSF), these rocks may have come from streambeds that were not far away. As suggested by the almost identical length and weight values, the same streambeds may have supplied the VR cobbles brought to both the TKLF and the TKSF (Table S20).

The scarcity of nNQ items seems to be due to the fact that its source is farther away, in the western part of the

Olduvai Gorge. The same applies to gneiss, whose known outcrops are located at Kelogi Hill, about 11 km west of TK (Hay 1976; Kyara 1999).

The presence of cores, flakes and hammerstones bearing percussion marks, and the high percentage of undifferentiated products, clearly prove that knapping activities were carried out at the TKSF just as they were at the TKLF (Santonja *et al.* 2014). These activities focused mainly on producing flakes from cores, sometimes applying retouch, and on the shaping of bifaces from slabs, cobbles and large flakes.

The percentage of anvils we identified in TKLF is higher than in TKSF (2.5 and 0.6%, respectively, shatter excluded). In both levels they may have been used for both bipolar percussion and pounding of organic material (Diez-Martín *et al.* 2011; de la Torre *et al.* 2013). Therefore, some of the 3237 NQ slab fragments recorded in TKLF and of the 587 found in TKSF may be anvil fragments. The dimensions of some of the TKSF fragments coincide with values found experimentally (de la Torre *et al.* 2013). Only 21.1% of the sizes of the TKLF slab fragments coincide with the results of one of these experiments (Table S21), whereas in TKSF they amount to 87.5%. Based on these indicators, the most common activities performed at the TKLF could have been bone breaking and plant processing, while those at the TKSF could have been bone-marrow extraction and plant processing, although other activities related to bone breaking might have been conducted there too.

Flake presence (shatter excluded) is high in both the TKLF and TKSF (71.3 and 62%, respectively). However, it is significant that 61.6% of the TKLF flakes are broken, whereas only 8.2% of the TKSF ones are. Taking into account the recorded fragments (cf. Jayez & Nasab 2016: p. 445), the number of whole flakes that could have been included in the TKLF assemblage would be 938 instead of 1259 (607 whole flakes and 652 flake fragments), which would account for 54.8% of the total (shatter excluded). If we apply the same calculation to the TKSF, there would be 180 flakes instead of 204 (176 whole flakes and 28 fragments), which means 58.7% of all the technological categories taken together. Hence, the difference between the two levels is only 4%.

The TKSF flakes are slightly larger than the TKLF ones, and especially wider, as appears from their L/W ratios, and their values are more dispersed (Fig. 9C). The percentages of flakes with backs are similar in both levels (5.7% in TKLF, 6.5% in TKSF), but some dimensions of the TKSF ones are larger than the overall average for flakes (32/29.4/14.6 mm, 242.8 g). In both levels we can recognize in the flakes the successive stages of the reduction processes, from specimens that are entirely cortical to those whose dorsal face is totally occupied by removal scars. Cores that have been worked more are slightly better represented in TKSF, except those displaying unipolar peripheral knapping, which are more frequent in TKLF (Fig. 9D). Flakes exploited as cores are few both in TKLF (2.2%) and in TKSF (5.4%). The low percentage of cortical flakes indicates that core exploitation was intense in both levels.

Freehand percussion is always the dominant knapping technique, although bipolar percussion gains prominence in the TKSF (83.6% FHP and 16.4% BP in TKLF, vs. 60.4% FHP and 39.6% BP in the TKSF). Some authors believe that the peripheral removals often observed on the NQ slabs are generally due to percussion activities unrelated to knapping (Mora & de la Torre 2005; de la Torre *et al.* 2013). However, in both the TKLF and TKSF the parameters of such peripheral removals on the NQ slabs coincide with those observed in BP (Diez-Martín *et al.* 2011). Both levels contain examples of transfers of percussion methods. In the TKLF, 48% of cores exploited by BP also display FHP removals, and 7% of cores exploited by FHP show BP as well. In the TKSF, 41.7% of the cores exploited by BP display FHP, and 9.1% of the ones exploited by FHP display BP. This flexibility in switching between techniques is confirmed by the fact that some cores made on slabs by FHP were also used as anvils.

As regards the degree of completeness of the debitage chaînes opératoires, we note several differences. In the TKLF, the presence of NQ and VR cores displaying similar exploitation schemes and of products corresponding to all the stages of production show that, contrary to previous conclusions (Leakey 1971: p. 264; de la Torre 2004: p. 275, 386, 391; Mora & de la Torre 2005: p. 143), debitage was performed at the site (Santonja *et al.* 2014). However, the fact that in the TKSF we found only two VR flakes with extensive cortex (corresponding to the first reduction phase), combined with the presence of 2.2 flakes per core and of only five undifferentiated products, suggests that exploitation of the VR cores began outside the site, or in a different sector not yet excavated. As regards NQ, however, the proportions of flakes, cores and shatter are more consistent. We recognized approximately 5.1 flakes per core and a large amount of undifferentiated products (about 9.6 per core, although not all of them originated from the preliminary flaking of these items). Hence, unless further excavations of larger areas lead to different conclusions, in the TKSF we identify an economy of production that differs for VR and NQ. VR cores were brought to the site after having been subjected to preliminary flaking, or were exploited in an area of the site that has not been excavated, whereas exploitation of the NQ blanks would have been carried out at the site.

Modification by retouch of the flakes' cutting edge was not common. Only 3.2% of the TKLF flakes and 2.6% of the TKSF ones were retouched. In TKSF we recorded scrapers, denticulates and one notch; to these types we have to add awls and becs found in the TKLF. Moreover, the presence in both levels of knives with debitage or natural backs supports the idea that these products – being of a type that enabled immediate use of their natural edges – were produced intentionally.

Biface shaping has been one of the main arguments used in differentiating phases in the Acheulean techno-complex in Africa (Clark 1994). This differentiation was made according to the gradually increasing symmetry of handaxes, and it rested on an evolutionary concept based on stylistic perception (Schick & Toth 2000; Bar-Yosef 2006: p. 480; Diez-Martín & Eren 2012). Today this view is considered to be an outdated phase of investigation (fossil approach, Vega 2001; Monnier 2006), as has been recently highlighted at the FLK West Acheulean site. This site's chronology is close to 1.69 Ma, which would make it one of the earliest manifestations of this techno-complex, where simple bifaces coexist with an extremely sophisticated handaxe type, symmetrical and bifacially flaked (Diez-Martín *et al.* 2015). From the standpoint of typological-stylistic perception, this handaxe would belong to a later Acheulean assemblage.

The most significant differences between the TKLF and the TKSF are seen on bifaces. In the TKSF they account for 9.6% (shatter excluded) of the series studied (53 items), whereas in the TKLF there are 85 specimens (2.2%, shatter excluded). The technical characteristics of the TKLF bifaces led M. Leakey to ascribe this level to the Acheulean (Leakey 1975), changing its earlier attribution to the Developed Oldowan B (Leakey 1971: p. 262 ff.). Years later, de la Torre & Mora (2005, 2013) still interpreted the TKLF as Acheulean, even though they warned that it contains hardly any true handaxes, as, according to these authors, most of them would have been shaped by a special method that they call 'the rhomboidal reduction method'. As a matter of fact, only a limited number of TKLF handaxes were made with this method, which actually corresponds to a bilateral shaping phase specially adapted to the type of blank (NQ slabs) most commonly used for these specimens, and to the creation of techno-functional units suitable for gripping (Santonja *et al.* 2014; cf. Boëda 2001).

The dimensions and weights of the NQ and VR handaxes are homogeneous in both levels, but differ sharply from one level to the other. The TKLF handaxes are longer and heavier than the TKSF ones (Fig. 9E), and have markedly higher average lengths and weights (NQ handaxes: 84.4 mm, 1050.3 g; VR handaxes: 40.8 mm, 481.7 g). Thirty-nine of the 49 TKLF handaxes are over 19 cm long, whereas only one of the TKSF specimens is that long. Weights too differ significantly: 44 of the TKLF NQ handaxes (89.7%) weigh more than 1 kg, and four of them weigh more than 3 kg. Conversely, only two of the 20 TKSF specimens weigh more than 1 kg (Fig. 9E).

The differences are not only volumetric; they are also observed in the shaping processes. The TKLF handaxes are adapted closely to the nature of the blank, especially in the case of NQ slabs. The most intense bifacial shaping focuses on creating a functional area in the distal third. On the rest of the blanks, knapping defines backs and bases that make the tools easier to handle, which in a good number of cases (as noted above) are large and heavy (Santonja *et al.* 2014, in press). This is not so for the TKSF handaxes: of the 28 specimens, we have identified only three backed handaxes; the ones that dominate the set are those whose cutting edge covers the tool's whole perimeter up to the tip, shaping edges that are potentially sharp and active all around the tool.

The fragility of the NQ flakes is a factor that could explain why in the TKSF we have not identified any flakes resulting from the shaping or maintenance phases of bifaces. In any case, the presence of NQ handaxe preforms and points proves that such tools were shaped and used on this level, without ruling out the possibility that some of them were brought here after having been partly shaped at the source of the raw material, an outcrop that was located very close to the site. We need to consider that in this level we found three NQ cores that have removal scars 80 to 110 mm long and 60 to 156 mm wide: these dimensions resemble those of the macrotools shaped on flakes, which confirms the possibility of obtaining at the site itself blanks suitable for shaping large tools. We have not found any cores with removal scars that big in the TKLF. As regards the VR specimens, the small number of flakes and undifferentiated products made of this raw material suggests more strongly that the VR specimens were brought already shaped to the site.

The presence in the TKSF of many handaxes that are smaller and lighter than the TKLF ones and whose ends were rejuvenated by lateral and distal sharpening removals (Fig. 5D, F, G) suggests prolonged use of these tools. At the TKLF, however, the choice seems to have been to discard these tools after a very specific and immediate use that would have also caused occasional fractures on the points, albeit rejuvenating would have required less effort.

Conclusions

The TKLF and TKSF are two archaeological units that are chronologically close to each other and have well-defined positions in TK's stratigraphical sequence (Fig. 1F). Between 21 and 42 cm they are separated vertically by a sandy loam tuff and a loamy sand channel facies. Taphonomic analysis tells us that the bones found in the TKLF had been exposed for a long period of time and had been affected by overland flow and other erosive agents before being buried by tuff and a channel loamy sand. This facies was deposited by an ephemeral and seasonal channel with low transport capacity that may have been active for dozens or perhaps a few hundred years. The TKSF archaeopalaeontological record, by contrast, was quickly buried by a sandy clay tuff and was not exposed for long to atmospheric agents, as indicated by the good condition of the bone assemblage. The TKSF occupation floor may have undergone some erosive process caused by the sandy clay tuff, but

the stratigraphical contact between this deposit and the channel loamy sand is very flat (Fig. 1F) and does not show erosion scars.

The presence of handaxes, cleavers and picks makes it possible to identify the TKSF industrial series as being Acheulean without any doubt (Diez-Martín & Eren 2012; Gowlett 1996; Lycett & Gowlett 2008; Roche *et al.* 2003; Sahnouni *et al.* 2013; Semaw *et al.* 2009). Particularly significant is the presence of cleavers, implements that seem to belong exclusively to the Acheulean technocomplex (Mourre 2003a) and are also present in the TKLF.

The longer exposure of the palaeosurface on which the TKLF rests is a key factor for explaining the greater density of industry remains per m^2 in this unit compared to the TKSF (38.4 and 12.1 items, respectively, shatter excluded, and 9.5 and 5.3 kg, respectively, shatter included). The dominant raw materials are NQ and VR, which are present in similar proportions in both levels, especially if we do not consider small fragments (shatter), which are affected by different erosive processes. The NQ outcrop would have been no farther than 750 m from TK, and the areas where VR would have been gathered a little farther away, but not too far. While most of the NQ was brought to the site unworked, at least part of the VR may have reached the site partly worked. As regards gneiss and nNQ, marginally represented in the TKSF, their sources would have been located several km away from the site.

The percentage of cobbles with percussion marks is larger in the TKSF than in the TKLF, but the percentage of anvils is smaller. These hammerstones were certainly used in knapping activities that focused mainly on the production of flakes (barely modified by retouch) and on the shaping of bifaces from slabs, cobbles and large flakes.

Only in the TKSF do we identify an economy of tool manufacturing that was different for VR and NQ. At the TKLF, debitage of NQ and VR was performed at the site, but at the TKSF only the NQ cores were knapped, while VR cores were flaked, at least in part, outside the site. If we look at the percentage of flakes found in the TKLF, more knapping took place there than at the TKSF, unless some of the TKSF flakes were transferred outside the site. In the TKSF we observed a clear intent to manufacture implements with rectangular formats, larger than the TKLF ones; the same is true for cores, which in this level are likewise larger and heavier.

Bipolar percussion and switching between FHP and BP are more represented in the TKSF than in the TKLF. The higher average dimensions of the NQ cores exploited by FHP vs. those exploited by BP, combined with the limited use of these blanks, shows that the knappers did not care much about using this raw material economically (Tables S10, S11). Cores that were exploited opportunistically are more frequent in the TKLF. Cores are larger and heavier in the TKSF, and more of them belong to the more elaborate categories, such as the bifacial, discoid and bifacial discoid; except for the peripheral unipolar cores, which are more frequent in the TKLF.

The biggest differences between these two levels are observed in the bifaces. Handaxes, trihedral picks and cleavers are much better represented in the TKSF. In both levels handaxes were worked and used at the site, although some may have been brought there partly or wholly worked, especially the VR specimens in the TKSF. The type of raw material significantly influenced the manufacturing process used for the TKLF handaxes; this influence is much less visible in the TKSF. In the TKLF we observe a large percentage of long and heavy NQ handaxes whose functional area is concentrated on the apical third and that have backs on the rest of the tool to make them easier to handle. In the TKSF handaxes, the cutting edge occupies the perimeter up to the tip, perhaps in order to shape an active edge. Moreover, the presence in the TKSF of biface points that were rejuvenated by means of lateral and distal sharpening removals indicates that TKSF knappers chose to prolong the tools' useful lives more than TKLF knappers did.

The main quantitative differences we recorded between the TKLF and the TKSF –which we expect to be able to further define when we enlarge the excavation area – can be explained by the different lengths of time that the floors were exposed to atmospheric agents; the TKLF was certainly exposed for a longer time. However, the differences we highlighted as regards the industrial assemblages of each of the two levels are due to different production methods, and were not influenced by sedimentary or erosive processes that could have affected the archaeological record. The lapse of time between the two industrial assemblages is small, hence these differences cannot be explained by evolutionary dynamics; they may be more plausibly correlated with different behaviours and practices. This is what has been observed at sites like Gesher Benot Ya'aqov, where 14 occupation levels deposited over 50 ka show that the marked variability of the lithic chaînes opératoires was correlated to distinct activities (Goren-Inbar *et al.* 1994; Goren-Inbar & Saragusti 1996; Rabinovich *et al.* 2008; Sharon *et al.* 2011). The TK site would thus have been more complex than has been thought until now (Leakey 1971; de la Torre 2004; de la Torre & Mora 2005).

Once again, the technological changes that occurred at TK over a short span of time encourage us to examine the technological variability identified in the Acheulean technocomplex in close correlation with patterns of behaviour (Soressi & Dibble 2003). The situation observed in the TKLF and TKSF levels underlines the importance of understanding sites as functional areas and suggests, as does the ecological hypothesis (Hay 1976: p. 181; Domínguez-Rodrigo *et al.* 2005), that there is a close connection between tools – especially LCTs in the case of the Acheulean technocomplex (Sharon 2007) – and activities

dependent on the landscape. To this end, we are carrying out taphonomic, traceological, biomarker and microresidue analyses (Bello-Alonso *et al.* 2016; Mercader-Florin *et al.* 2016; Yravedra *et al.* 2016) that will enable us to gain a better understanding of the activities performed at TK.

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References

Bar-Yosef, O. 2006: The known and the unknown about the Acheulean. *In* Goren-Inbar, N. & Sharon, G. (eds.): *Axe Age. Acheulean Toolmaking from Quarry to Discard*, 479–494. Equinox, London.

Behrensmeyer, A. K. 1978: Taphonomic and ecologic information from bone weathering. *Paleobiology 4*, 150–162.

Bello-Alonso, P., Ríos-Garaizar, J., Santonja, M. & Panera, J. 2016: Approach to economic activities developed in the African Acheulean. Use-wear analysis from Thiongo Korongo site (Olduvai Gorge, Tanzania). Poster, 23rd Biennal meeting of the Society of Africanist Archaeologists, Toulouse, France.

Blumenschine, R. J., Masao, F. T., Tactikos, J. C. & Ebert, J. I. 2008: Effects of distance from stone source on landscape-scale variation in Oldowan artifact assemblages in the Paleo-Olduvai Basin, Tanzania. *Journal of Archaeological Science 35*, 76–86.

Boëda, E. 2001: Détermination des unités techno-fonctionnelles de pièces bifaciales provenant de la couche acheuléenne C3 base du site de Barbas I. *In* Cliquet, D. (ed.): *Les Industries à Outils Bifaciaux du Paléolithique Moyen d'Europe Occidentale ERAUL 98*, 51–75. Université de Liége

Böeda, E., Geneste, J. M. & Meignen, L. 1990: Identification de chaînes opératories lithiques du Paléolithique ancien et moyen. *Paléo 2*, 43–80.

Bordes, F. 1961: *Typologie du Paléolithique Ancien et Moyen*. 101 pp. Imprimeries Delmas, Bordeaux.

Bower, J. R. F. 1977: Attributes of Oldowan and Lower Acheulean tools: "tradition" and design in the early Lower Palaeolithic. *The South African Archaeological Bulletin 32*, 113–126.

Brézillon, M. N. 1971: *La Dénomination des objets de Pierre Taillée*. 416 pp. IVe supplément à Gallia Préhistoire. C.N.R.S., Paris.

Cahen, L. & Snelling, N. J. 1966: *The Geochronology of Equatorial Africa*. 205 pp. North Holland Pub. Co., Amsterdam.

Chavaillon, J. 1979: Essai pour une typologie du matériel de percussion. *Bulletin de la Société Préhistorique Française 76*, 230–233.

Clark, J. D. 1994: The Acheulean industrial complex in Africa and elsewhere. *In* Corruccini, R. & Ciochon, R. (eds.): *Integrative Paths to the Past*, 451–469. Prentice Hall, New Jersey.

Clarke, D. L. 1968. *Analytical Archaeology*. 526 pp. Methuen & Co. Ltd., London.

Diez-Martín, F. & Eren, M. I. 2012: The Early Acheulean in Africa: past paradigms, current ideas, and future directions. *In* Domínguez-Rodrigo, M. (ed.): *Stone Tools and Fossil Bones. Current Debates in the Archaeology of Human Origins*, 310–357. Cambridge University Press, Cambridge.

Diez-Martín, F., Sánchez Yustos, P., Domínguez-Rodrigo, M., Mabulla, A. Z. P. & Barba, R. 2009: Were Olduvai Hominins making butchering tools or battering tools? Analysis of a recently excavated lithic assemblage from BK (Bed II, Olduvai Gorge, Tanzania). *Journal of Anthropological Archaeology 28*, 274–289.

Diez-Martín, F., Sánchez Yustos, P., Domínguez-Rodrigo, M., Mabulla, A. Z. P., Bunn, H. T., Ashley, G. M., Barba, R. & Baquedano, E. 2010: New insights into hominin lithic activities at FLK North Bed I, Olduvai Gorge, Tanzania. *Quaternary Research 74*, 376–387.

Diez-Martín, F., Sánchez Yustos, P., Domínguez-Rodrigo, M. & Prendergast, M. E. 2011: An experimental study of bipolar and freehand knapping of Naibor Soit quartz from Olduvai Gorge (Tanzania). *American Antiquity 76*, 690–708.

Diez-Martín, F., Sánchez Yustos, P., Uribelarrea, D., Baquedano, E., Mark, D. F., Mabulla, A. Z. P., Fraile, C., Duque, J., Díaz, I., Pérez-González, A., Yravedra, J., Egeland, C. P., Organista, E. & Domínguez-Rodrigo, M. 2015: The origin of the Acheulean: the 1.7 million-year-old site of FLK West, Olduvai Gorge (Tanzania). *Scientific Reports 5*, 17839, https://doi.org/10.1038/srep17839.

Domínguez-Rodrigo, M., Alcalá, L., Luque, L. & Serrallonga, J. 2005: Quelques aperçus sur les significations paléoécologique et comportementale des sites oldowayens anciens et acheuléens du Peninj (Upper Humbu Formation, Ouest du Lac Natron, Tanzanie). *In* Sahnouni, M. (ed.): *Le Paléolithique en Afrique. L'Histoire la Plus Longue*, 129–156. Editions Artcom, Paris.

Domínguez-Rodrigo, M., Pickering, T. R., Baquedano, E., Mabulla, A., Mark, D. F., Musiba, C., Bunn, H. T., Uribelarrea, D., Smith, V., Diez-Martin, F., Pérez-González, A., Sánchez, P., Santonja, M., Barboni, D., Gidna, A., Ashley, G., Yravedra, J., Heaton, J. L. & Arriaza, M. C. 2013: First partial skeleton of a 1.34-million-year-old *Paranthropus boisei* from Bed II, Olduvai Gorge, Tanzania. *PLoS ONE 8*, e80347, https://doi.org/10.1371/journal.pone.0080347.

Feblot-Augustins, J. 1990: Exploitation des matières premières dans l'Acheuléen de l'Áfrique: perspectives comportamentales. *Paléo 2*, 27–42.

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

Goren-Inbar, N. & Saragusti, I. 1996: An Acheulian biface assemblage from the Site of Gesher Benot Ya'aqov, Israel: Indications of African affinities. *Journal of Field Archaeology 23*, 15–30.

Goren-Inbar, N., Lister, A., Werker, E. & Chech, M. 1994: A butchered elephant skull and associated artifacts from the Acheulian site of Gesher Benot Ya'aqov, Israel. *Paléorient 20*, 99–112.

Goren-Inbar, N., Sharon, G., Alperson-Afil, N. & Laschiver, I. 2008: The Acheulean massive scrapers of Gesher Benot Ya'aqov: a product of the biface chaîne opératoire. *Journal of Human Evolution 55*, 702–712.

Goren-Inbar, N., Sharon, G., Melamed, Y. & Kislev, M. 2002: Nuts, nut cracking, and pitted stones at Gesher Benot Ya'aqov, Israel. *Proceedings of the National Academy of Sciences of the United States of America 99*, 2455–2460.

Gowlett, J. A. 1996: The frameworks of early hominid social systems. *In* Steele, J. & Shennan, S. (eds.): *The Archaeology of Human Ancestry*, 135–183. Routledge, London.

Gowlett, J. A. 2005: Seeking the Palaeolithic individual in East Africa and Europe during the lower-middle Pleistocene. *In* Gamble, C. & Porr, M. (eds.): *The Hominid Individual in Context: Archaeological Investigations of Lower and Middle Palaeolithic Landscapes, Locales and Artefacts*, 50–67. Routledge, Abington and New York.

Hay, R. L. 1976: *Geology of the Olduvai Gorge*. 203 pp. University of California Press, Berkeley.

Howell, F. C. & Clark, J. D. 1963: Acheulian hunter-gatherers of Sub-Saharan Africa. *In* Howell, F. C. & Bourliere, F. (eds.): *African Ecology and Human Evolution*, 458–533. Aldine Publishing Company, Chicago.

Inizan, M. L., Reduron, M., Roche, H. & Tixier, J. 1995: *Préhistoire de la Pierre Taillée 4. Technologie de la Pierre Taillée*. 199 pp. CREP, Meudon.

Inizan, M. L., Roche, H. & Tixier, J. 1992: *Technology of Knapped Stone*. 127 pp. CREP, C.N.R.S., Meudon.

Isaac, G. L. 1977: *Olorgesailie. Archaeological Studies of a Middle Pleistocene Lake Basin in Kenya*. 272 pp. The University of Chicago Press, Chicago.

Jayez, M. & Nasab, H. V. 2016: An experimental study on the methods of quantifying fragmented flake. *Journal of Archaeological Science: Reports 6*, 442–450.

Jones, P. R. 1981: Experimental implement manufacture and use: a case study from Olduvai Gorge, Tanzania. *Philosophical Transactions of the Royal Society, London B 292*, 189–195.

Jones, P. R. 1994: Results of experimental work in relation to the stone industries of Olduvai Gorge. *In* Leakey, M. (ed.): *Olduvai Gorge. 5.*

Excavations in Beds III, IV and the Masek Beds, 1968–1979, 254–298. Cambridge University Press, Cambridge.

Kimura, Y. 2002: Examining time trends in the Oldowan technology at Beds I and II, Olduvai Gorge. *Journal of Human Evolution 43*, 291–321.

Kyara, O. A. 1999: *Lithic Raw Materials and their Implications on Assemblage Variation and Hominid Behavior during Bed II, Olduvai Gorge, Tanzania*. 876 pp. University of Rutgers, New Brunswick.

Leakey, M. D. 1971: *Olduvai Gorge, Volume 3. Excavations in Beds I and II, 1960–1963*. 306 pp. Cambridge University Press, Cambridge.

Leakey, M. D. 1975: Cultural patterns in the Olduvai sequence. *In* Butzer, K. W. & Isaac, G. L. (eds.): *After the Australopithecines. Stratigraphy, Ecology, and Cultural Change in the Middle Pleistocene*, 477–493. Mouton, Chicago.

Leakey, M. D. 1976: The early stone industries of Olduvai Gorge, Tanzania. *In* Clark, D. & Isaac, G. L. (eds.): *Les Plus Anciennes Industries en Afrique. Union Internationales des Sciences Préhistoriques et Protohistoriques*, 24–41. IXe Congrés, UISPP, Nice.

Leakey, M. D. 1978: Olduvai Gorge 1911–75: a history of the investigations. *In* Bishop, W. W. (ed.): *Geological Background to Fossil Man: Recent Research in the Gregory Rift Valley, East Africa*, 151–155. Scottish Academic Press, Edinburgh.

Lepre, C. J., Roche, L., Kent, D. V., Harmand, S., Quinn, R. L., Brugal, J.-P., Texier, P.-J., Lenoble, A. & Feibel, C. S. 2011: An earlier origin for the Acheulian. *Nature 477*, 82–85.

Ludwig, B. V. & Harris, J. W. K. 1998: Towards a technological reassessment of East African Plio-Pleistocene lithic assemblages. *In* Petraglia, M. D. & Korisettar R. (eds.): *Early Human Behaviour in Global Context. Rise and Diversity of the Lower Paleolithic Record*, 84–107. Routledge, London.

Lycett, S. J. & Gowlett, J. A. J. 2008: On questions surrounding the Acheulean tradition. *World Archaeology 40*, 295–315.

Mercader-Florin, J. M., Diez-Martín, F., Domínguez-Rodrigo, M., Favreau, J., Itambu, M., Lee, P., Mabulla, A., Panera, J., Patalano, R., Pérez-González, A., Rojas, R., Rubio-Jara, S., Santonja, M. & Tucker, L. 2016: Acheulean ecology, diet, and technological behavior: plant residues from Olduvai Gorge. *Proceedings of the European Society for the Study of Human Evolution 5*, p. 171.

Monnier, G. 2006: The Lower/Middle Paleolithic periodization in Western Europe. An evaluation. *Current Anthropology 47*, 709–744.

Mora, R. & de la Torre, I. 2005: Percussion tools in Olduvai Bed I and II (Tanzania): implications for early human activities. *Journal of Anthropological Archaeology 24*, 179–192.

Mourre, V. 1997: Industries en quartz: Précisions terminologiques dans les domaines de la pétrographie et de la technologie, Préhistoire Anthropologie Méditerranéennes, t. 6. *Première Table Ronde sur l'exploitation du Quartz au Paléolithique 6*, 201–210.

Mourre, V. 2003a: *Implications culturelles de la technologie des hachereaux*. Ph. D. thesis, University of Paris X, 883 pp.

Mourre, V. 2003b: Discoïde ou pas discoïde? Reflexions sur la pertinence des critères techniques définissant le débitage Discoïde. *In* Peresani, M. (ed.): *Discoid Lithic Technology. Advances and Implications*, 1–17. *BAR International Series 112*.

Perlès, C. 1991: Économie des matières premières et économie du débitage: deux conceptions opposées? *In 25 Ans d'Études technologiques en Prèhistoire XIe Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*, 35-45. Éditions APDCA, Juan-les-Pins.

Rabinovich, R., Gaudzinski, S. & Goren-Inbar, N. 2008: Systematic butchering of fallow deer (Dama) at the early Middle Pleistocene Acheulian site of Gesher Benot Ya'aqov, (Israel). *Journal of Human Evolution 54*, 134–149.

Roche, H. & Texier, P. J. 1995: *Evaluation of technical competece of Homo erectus in East Africa during the Middle Pleistocene. Evolution and Ecology of Homo erectus*. 153–167. Royal Netherlands Academy of Arts and Sciences Pithecanthropus Centennial Foundation, Leiden.

Roche, H., Brugal, J.-P., Delagnes, A., Feibel, C., Harmand, S., Kibunjia, M., Prat, S. & Texier, P.-J. 2003: Les sites archéologiques plio-pléistocènes de la Formation de Nachukui, Ouest-Turkana, Kenya: Bilan synthétique 1997–2001. *Comptes Rendus Palevol 2*, 663–673.

Sahnouni, M. 1991: Étude comparative des galets taillés polyédriques, subsphériques et sphériques des gisements d'Ain Hanech (Algérie Orientale) et d'Olduvai (Tanzanie). *L'Anthropologie 97*, 51–68.

Sahnouni, M., Schick, K. & Toth, N. 1997: An experimental investigation into the nature of faceted limestone "spheroids" in the early palaeolithic. *Journal of Archaeological Science 24*, 701–713.

Sahnouni, M., Semaw, S. & Rogers, M. 2013: The African Acheulean. An archaeological summary. *In* Mitchell, P. & Lane, P. (eds.): *The Oxford Handbook of African Archaeology*, 307–323. Oxford University Press, Oxford.

Sánchez-Yustos, P., Diez-Martín, F., Domínguez-Rodrigo, M. & Tarriño Vinagre, A. 2012: Discriminación experimental de los rasgos técnicos en la talla bipolar y a mano alzada en lascas a través de los cuarzos de Naibor Soit (Garganta de Olduvai, Tanzania). *Munibe. Sociedad de Ciencias Naturales Aranzadi (San Sebastian) 63*, 5–26.

Santonja, M. & Villa, P. 2006: The Acheulian of Western Europe. *In* Goren-Inbar, N. & Sharon, G. (eds.): *Axe Age. Acheulian Tool-Making from Quarry to Discard*, 429–478. Equinox Publishing, London.

Santonja, M., Panera, J., Rubio-Jara, S., Pérez-González, A., Uribelarrea, D., Domínguez-Rodrigo, M., Mabulla, A. Z. P., Bunn, H. T. & Baquedano, E. 2014: Technological strategies and the economy of raw materials in the TK (Thiongo Korongo) lower occupation, Bed II, Olduvai Gorge, Tanzania. *Quaternary International 322–323*, 181–208.

Santonja, M., Rubio-Jara, S., Panera, J., Pérez-González, A., Rojas-Mendoza, R., Domínguez-Rodrigo, M., Mabulla, A. Z. P. & Baquedano, E. in press: The Bifacial shaping in the TK Acheulean site (Bed II, Olduvai Gorge, Tanzania): new excavations 50 years after Mary Leakey. *In* Galloti, R. & Mussi, M. (eds.): *International Workshop. The Emergence of the Acheulean in East Africa. In honor of the 50th Anniversary of the Discovery of Melka Kulture (1963–2013). Rome, September 2013*. Springer, New York.

Schick, K. & Toth, N. 2000: Paleoanthropology at the millennium. *In* Feinman, G. & Price, T. (eds.): *Archaeology at the Millennium. A Sourcebook*, 39–108. Kluwer/Plenum, New York.

Semaw, S., Rogers, M. & Stout, D. 2009: The Oldowan-Acheulean transition: is there a "Developed Oldowan" tradition? *In* Camps, M. & Chauhan, P. (eds.): *Sourcebook of Palaeolithic Transitions*, 173–193. Springer, New York.

Sharon, G. 2007: *Acheulean Large Flake Industries: Technology, Chronology, and Significance*. 236 pp. Hadrian Books, Oxford.

Sharon, G., Alperson-Afil, N. & Goren-Inbar, N. 2011: Cultural conservatism and variability in the Acheulian sequence of Gesher Benot Ya 'aqov. *Journal of Human Evolution 60*, 387–397.

Soressi, M. & Dibble, H. L. (eds.) 2003: *Multiple Approaches to the Study of Bifacial Technologies*. 290 pp. University of Pennsylvania Museum, Philadelphia.

Soressi, M. & Geneste, J.-M. 2011: The history and efficacy of the *Chaîne Opératoire* approach to lithic analysis: studying techniques to reveal past societies in an evolutionary perspective. *PaleoAnthropology 2011*, 334–350.

Stiles, D. 1977: Acheulian and Developed Oldowan: the meaning of variability in the Early Stone Age. *Mila 6*, 1–35.

Stiles, D. 1979: Early Acheulean and Developed Oldowan. *Current Anthropology 20*, 126–129.

Tixier, J. 1956: Le hachereau dans l'Acheuléen Nord-Africain. Notes typologiques. *Congrès Préhistorique de France, XVème session (Poitiers)*, 914–923.

de la Torre, I. 2004: *Estrategias tecnológicas en el Pleistoceno inferior de África oriental (Olduvai y Peninj, norte de Tanzania)*. Ph. D. thesis. Universidad Complutense: Madrid, 618 pp.

de la Torre, I. & Mora, R. 2005: *Technological Strategies in the Lower Pleistocene at Olduvai Beds I and II*. 255 pp. *ERAUL 112*. University of Liège Press, Liège.

de la Torre, I. & Mora, R. 2013: The Transition to the Acheulean in East Africa: an assessment of paradigms and evidence from Olduvai Gorge (Tanzania). *Journal of Archaeological Method and Theory 21*, 781, https://doi.org/10.1007/s10816-013-9176-5.

de la Torre, I., Benito-Calvo, A., Arroyo, A., Zupancich, A. & Proffitt, A. 2013: Experimental protocols for the study of battered stone anvils

from Olduvai Gorge (Tanzania). *Journal of Archaeological Science 40*, 313–332.
Turq, A. 2000: *Paléolithique inférieur et moyen entre Dordogne et Lot. Paléo, Supplement 2*. 454 pp. Société des Amis du Musée National de Préhistoire et de la techerche archéologique, Aquitaine.
Vega, L. G. 2001: Aplicación de la metodología de los programas de investigación al análisis historiográfico del Paleolítico. *Complutum 12*, 185–215.
Villa, P. 1983: *Terra Amata and the Middle Pleistocene Archaeological Record of Southern France*. 304 pp. University of California Publications in Anthropology, Oakland.
Willoughby, P. R. 1987: *Spheroids and Battered Stones in the African Early Stone Age*. 253 pp. *BAR International Series 321*. Hadrian Books, Oxford.
Yravedra, J., Domínguez-Rodrigo, M., Santonja, M., Rubio-Jara, S., Panera, J., Pérez-González, A., Uribelarrea, D., Egeland, C., Mabulla, A. Z. P. & Baquedano, E. 2016: The larger mammal palimpsest from TK (Thiongo Korongo), Bed II, Olduvai Gorge, Tanzania. *Quaternary International 417*, 3–15.

Supporting Information

Additional Supporting Information may be found in the online version of this article at http://www.boreas.dk.

Table S1. Flakes and flake fragments by raw material.

Table S2. Whole flakes (NQ n = 165; VR n = 11): dimensions (mm, measured with reference to the flake's technological axis), weights (g) and L/W ratios.

Table S3. Cores classified by raw material and blank type.

Table S4. FHP cores found in TKSF, classified by debitage method. Raw materials: NQ = Naibor quartzite; VR = volcanic rock. Blank types: 1: slab; 2: cobble; 3: flake; 4: undetermined. Intensity of reduction: A: low; B: medium; C: high; D: exhausted.

Table S5. FHP cores: raw material, lengths and weights.

Table S6. NQ cores exploited by FHP, classified by debitage method: lengths and weights.

Table S7. BP cores: lengths and weights.

Table S8. BP cores with limited FHP.

Table S9. Lengths and weights of cores that have percussion marks and may have been used as hammerstones or anvils.

Table S10. Types of retouched tools, based on Bordes (1961).

Table S11. Handaxes classified by raw material and blank type.

Table S12. Extent of cortex on whole bifaces. a: intensively knapped surface; b, less intensively knapped or unknapped surface.

Table S13. Average dimensions (mm) and weights (g) of handaxes (NQ n =20; VR n = 6). Two bifaces (one NQ, one VR) have not been included because each one has a small distal fracture that prevents their dimensions from being determined precisely.

Table S14. Trihedral picks (NQ, n = 8): average dimensions (mm) and weights (g).

Table S15. Cleavers: dimensions (mm) and weights (g).

Table S16. Total weight (kg) of items found in level TKSF, by raw material and chaîne opératoire phase.

Table S17. NQ slab fragments (n = 581): average dimensions (mm) and weights (g).

Table S18. NQ chunks (n = 18): average dimensions (mm) and weights (g).

Table S19. Density and weight density of lithic items found in levels TKLF and TKSF.

Table S20. Average length (mm) and weight (g) of VR cobbles and hammerstones found in levels TKLF and TKSF.

Table S21. Percentages of NQ slab fragments that can be attributed to a specific activity, based on experiments carried out by de la Torre *et al.* (2013).