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SHK Extension: a new archaeological window in the SHK fluvial landscape of Middle Bed II (Olduvai Gorge, Tanzania)

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In this paper, we present the results of new archaeological and geological research carried out in SHK Extension, a new site excavated within the SHK fluvial complex (Bed II, Olduvai Gorge). The paper describes the stratigraphy of the site and its correlation with our excavation in SHK Main Site, showing that overbank archaeological accumulations in both areas are synchronous and form part of the same fluvial palaeo-landscape. On the basis of the archaeo-stratigraphical analysis performed, mainly geared towards defining high-resolution chrono-stratigraphical frameworks within the deposit, we report the results of a technological study of the lithic collection sorted by archaeo-units, an assessment of the integrity of the main accumulation and an exhaustive lithic refitting programme. The archaeological sequence at SHK Extension, consisting of three archaeo-units, preserves a high-density patch of lithics and fossil bones (Level B2), on an overbank setting, isochronous with the SHK Main site. The high percentage of small lithic remains and bones, large number of fresh archaeological materials, and the identification of several refit sets support the integrity of the anthropogenic accumulation documented in Level B2. The main technological trait of the lithic assemblage from this level is the preservation of a qualitatively significant sample of large flakes and LCTs. The technological behaviours observed in SHKE, in the framework of the SHK complex, confirm that the complex web of inter-assemblage variability during Bed II times operated also in very close fractions of the same palaeo-landscape. This reinforces the idea that subtle functional parameters must be taken into account in our current assessment of the Developed Oldowan/Acheulean interface.

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SHK (Sam Howard Korongo) is located in a lateral gully in the right bank of the Olduvai Side Gorge (Tanzania) and approximately 2 km from its junction with the Main Gorge (Leakey 1971) (Fig. 1). The site was discovered during the Leakeys' 1935 field expedition (Leakey 1971, 1974). Later, three archaeological excavations took place at this site between 1953 and 1957. In the course of fieldwork research, two localities, rich in fossil bones and stone tools, and separated by a distance of about 90 m, were unearthed: SHK Main and SHK Annex. According to Mary Leakey, both sites were ascribed to the Developed Oldowan B and represented pene-contemporaneous windows into hominin activities carried out in a fluvial environment of Middle Bed II (Leakey 1971).

In 2009, our team (The Olduvai Paleoanthropological and Paleoecological Project, TOPPP) resumed archaeological research at SHK (Domínguez-Rodrigo *et al.* 2012a, 2014a; Diez-Martín *et al.* 2014a). Between that year and 2011 a total surface of 40 m^2 was unearthed in the Main site area (hereafter SHKM). In this trench, three archaeological levels were identified, from bottom to top: A, B and C (Diez-Martín *et al.* 2014a). Two of these archaeological horizons were located in the filling (Level A) and the adjacent overbank (Level B) of a medium-size fluvial channel flowing northwards. According to our geological interpretation, both levels represent the remaining palaeolandform of a channel edge and, thus, constitute pene-contemporaneous fractions of the same fluvial palaeosurface. Due to the evident interest of this well-preserved topographical feature, to date our research has been primarily focused on the collections retrieved from these two archaeological units and the spatial links between them (Domínguez-Rodrigo *et al.* 2012a, 2014a; Diez-Martín *et al.* 2014a).

In 2012, a new ~14 m^2 trench was opened 35 m to the south of our excavation in SHKM. We have identified this new area between the Main site and Leakey's Annex (SHKA) as SHK Extension (hereafter SHKE) (Fig. 1). In the course of our research in the SHK archaeological complex, which included the opening of a geotrench connecting both sites, we confirmed that at SHKM and SHKE, two fractions of an isochronous fluvial palaeolandscape had been preserved, as the overbank of Level B recognized in SHKM (Diez-Martín *et al.* 2014a) is also represented in SHKE. Thus, both trenches constitute a remarkable opportunity to gain insights into questions related to archaeological synchronic variability, both

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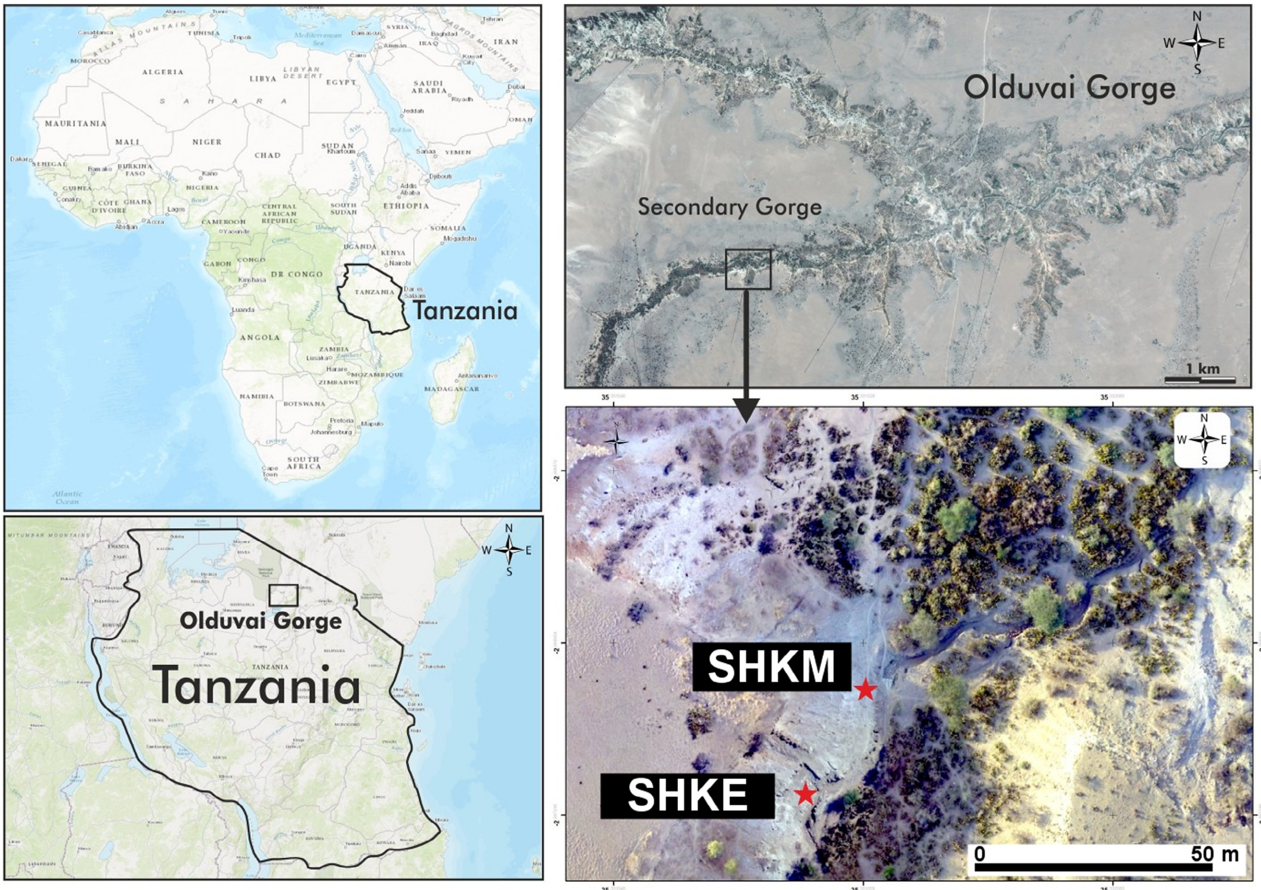

Fig. 1. Site map of Olduvai Gorge and the location of SHK Main and SHK Extension within the Side Gorge. Source: Digital Globe Foundation and orthomosaic using Unmanned Aerial Vehicle and photogrammetric techniques (2016), with 5-cm resolution.

technological and economic, between anthropogenic patches accumulated in the same environmental setting during Bed II times. This work summarizes the results of our research in SHKE, including the local stratigraphical sequence and the geological correlation with SHKM, the archaeo-stratigraphical analysis of the archaeological units identified, as well as taphonomic, micro-spatial and lithic refitting analyses. The technological study of the lithic collections retrieved from this site is also presented here, while the study of faunal remains is currently in progress and will be published independently.

Geology of SHKE and correlation with SHKM

Sites in the SHK complex are bracketed between tuffs IIB and IIC, in Middle Bed II, and are deposited in sediments corresponding to the eastern fluvial-lacustrine facies (Leakey 1971). More specifically, these sites are located in the connection between the alluvial fans descending from the Lemagrut volcano and the edge of the Olduvai palaeo-lake. Limits between these two geological units are vague, as no geomorphological or topographical expression exists marking a clear separation between them. However, as we move away from the lake, towards the south, the fluvial influence upon sedimentation is more evident. Thus, SHKM and SHKE are part of the same landscape, a broad muddy plain, nearly flat (slightly tilting towards the lake), that contains signs of subaerial exposure. Small fluvial channels with coarse bedload and northwards direction formed on this flood-plain. In the Northern Escarpment of the Side Gorge, 300 m away from SHK, similar channels have been identified in the same stratigraphical position. Thus, both SHKM and SHKE are part of this rich network of channels and their banks.

SHKE is located in a well-preserved outcrop, as it is possible to trace a complete cross-section of the channel linked to the site. The channel at SHKE is approximately 6 m wide and 0.8 m deep (Fig. 2A). It is an asymmetrical channel with an irregular base, excavated in a clayish-cohesive substratum, homogeneous and dark olive brown (2.5Y 3/2) in colour. This clayish substratum is made up of a clay unit at least 2 m thick (92% clay, 8% silt and <0.5% sand), made of ~2–5 mm thick sheets with scarce bioturbation (roots and burrows) and abundant nodules of fossilized plant remains (seeds). This unit can

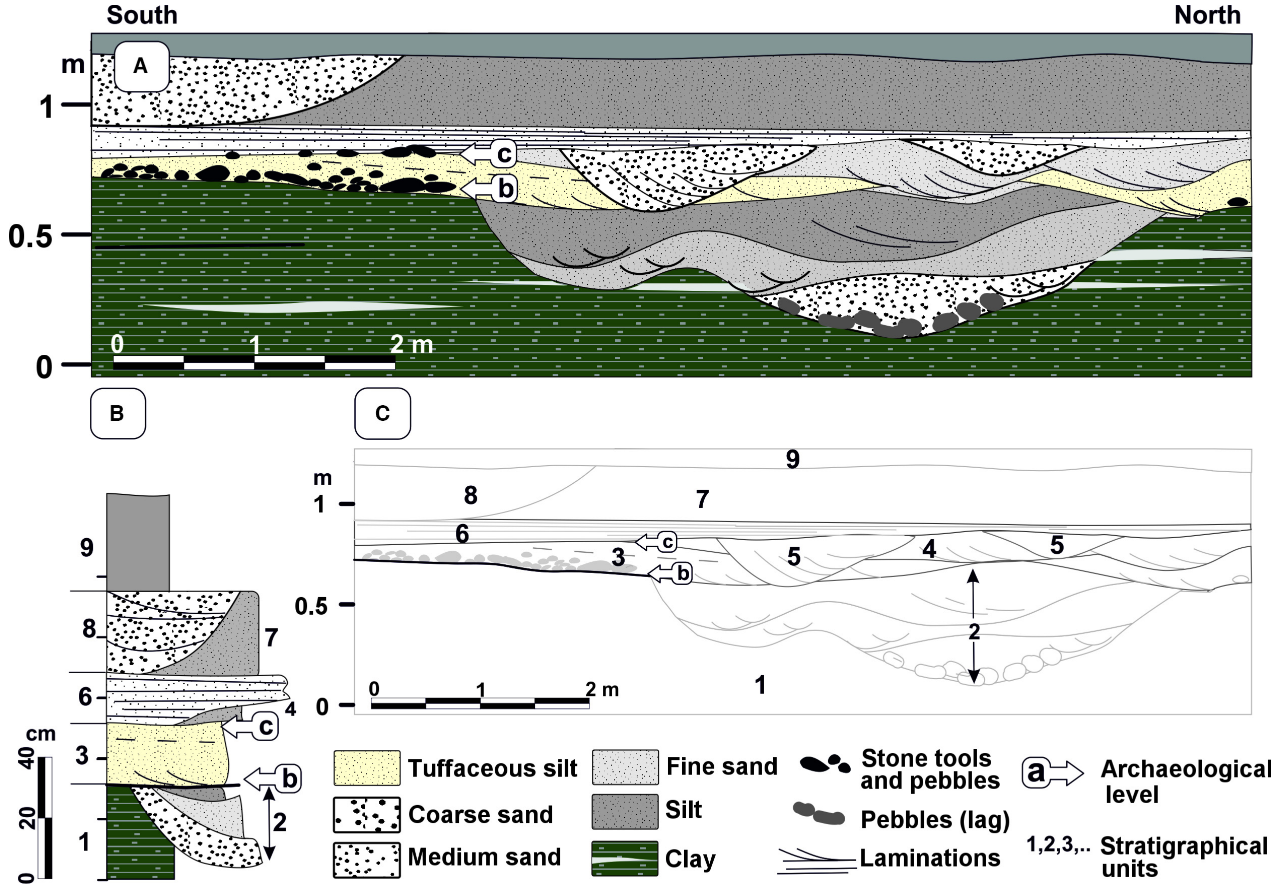

Fig. 2. Stratigraphy and geometry of SHKE. A. Transversal section of the site, with the stratigraphical position of archaeological occurrences within the sequence. B. General stratigraphical column of the site. C. Chrono-stratigraphical sketch (numbers correspond to the geological units, also shown in the stratigraphical column).

be interpreted as a wide mudflat, periodically flooded, where sedimentation was produced by clay decantation.

The channel infilling is complex and heterogeneous, made up of bars and bedload deposits. Erosion and sedimentation processes alternate, forming abundant cut and fill geometries. Taking into account these geometries and their spatial relation, the following sequential interpretation (geological units) of the local stratigraphical column at SHKE (Fig. 2B) can be established (Fig. 2C). (i) Fluvial erosion forms a clay channel with the characteristics mentioned above. On its left bank, a first archaeological aggregate accumulated to the south (Level B, but see archaeo-stratigraphical results). The limit of this patch with respect to the channel is clear and coincides precisely with its edge. This feature makes Level B contemporaneous with the channel. (ii) The channel infilling fines upwards in at least three different episodes. It is not possible to determine if the anthropogenic accumulation B is linked to all the infilling phases or only with some of them. (iii) Once the channel was filled, a tuffaceous silt was deposited on top of Level B. This Unit 3 constitutes a low-energy deposit with great lateral continuity, which can be followed more than 35 m to the north. It reaches SHKM, where it also covers the archaeological Level B, similarly deposited on the clayish bank. This tuffaceous silt is a reworked tuff, containing angular crystals of different size, partially cemented and weathered (presumably Tuff 2C). The base of Unit 3 constitutes the isochronous layer that links Level B in SHKE and SHKM chronologically (Fig. 3). (iv, v) On top of Unit 3, various fluvial units of fine sand were deposited. These are small furrows of <20 cm depth, partially eroding the deposits in Unit 3. Here, a flat palaeo-surface on top of various geological units (iii, iv and v) was formed. On top of this surface, a new archaeological aggregate was deposited (Level C). (vi) Level C is preserved by a level of coarse laminated sands, whose composition includes pellets and carbonate aggregates (lighter than the equivalent in siliciclastic sediment) that suggest a relatively low energy; the sequence continues with 35 cm of (vii) Silt; (viii) Sand and (ix) Clay, in thicker and more laterally continuous deposits that indicate a major change in sedimentation environment. From a lithological perspective, sands are made up of quartz, feldspar, and mafic minerals. Most

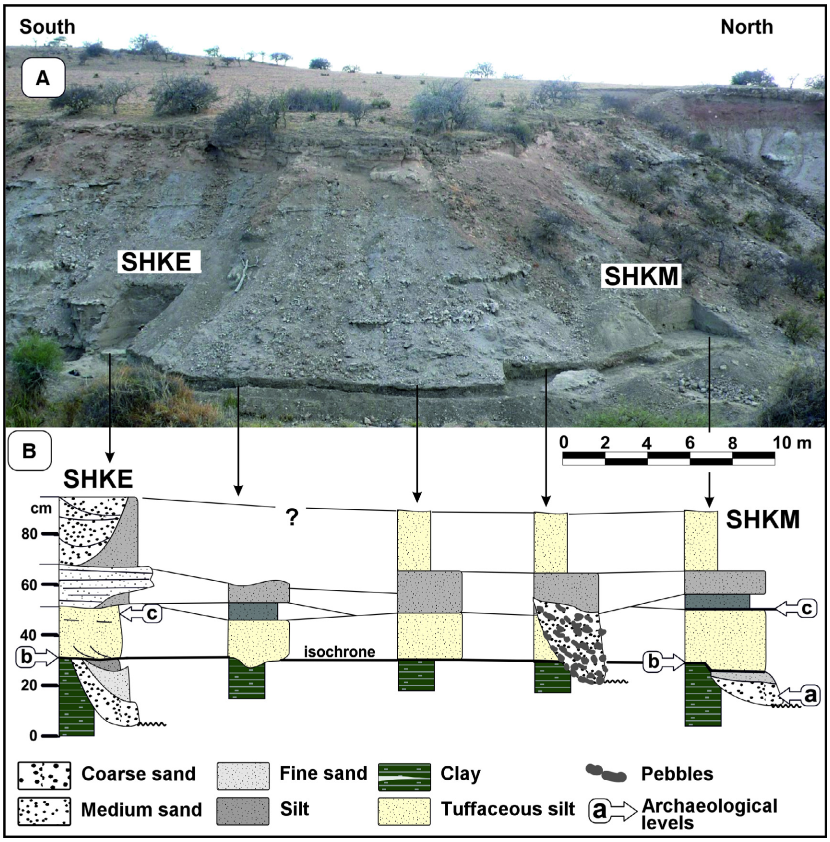

Fig. 3. A. Panoramic view of the geotrench connecting SHKM and SHKE. B. Stratigraphical correlation of geological deposits between SHKM and SHKE, with the description of five columns and the relative location of the archaeological horizons within the sequence in both sites.

of the pebbles are mafic in origin (basalt, andesite) and, to a lesser extent, granitic and metamorphic (granitic gneiss). Basaltic materials correspond to the volcanic lavas originating from the Lemagrut volcano, while the other rocks come from inselbergs such as Kelogi.

Material and methods

At SHKE a total surface of 14.43 m^2 has been excavated. The maximum dimensions of the opened trench are 4.61×3.67 m. Within a thickness of 50 cm, 1654 archae-

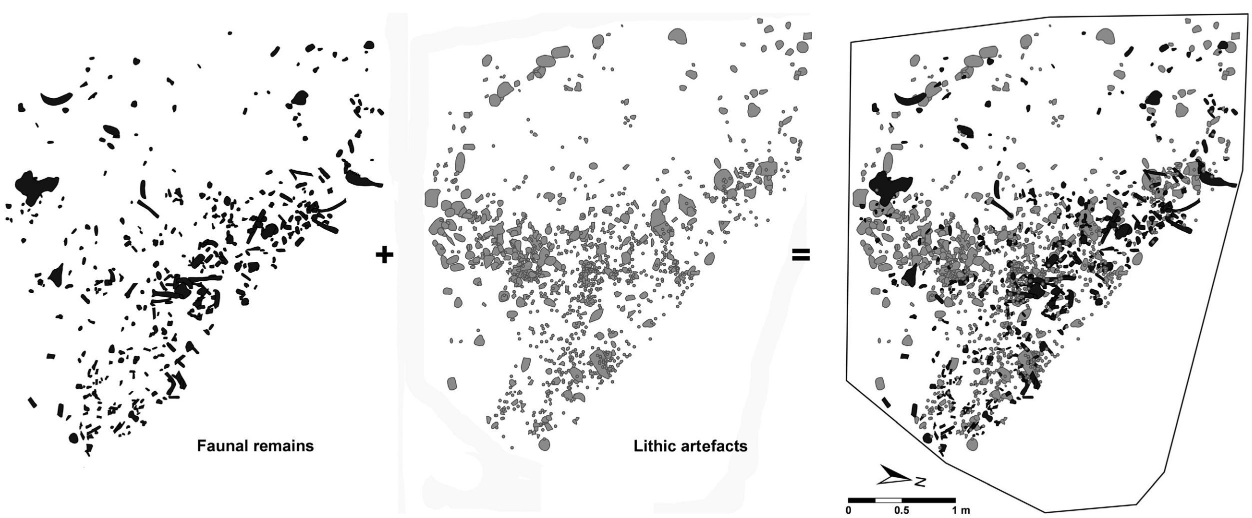

Fig. 4. Horizontal distribution of faunal remains and lithic artefacts at SHKE within the 2012 excavation grid.

Table 1. Number and percentage of lithic artefacts sorted by archaeo-unit, lithic category and raw material type (B = basalt; P = phonolite; Q = quartz; O = other, gneiss and hyaline quartz).

Lithic categories	Raw material								Totals	
	B		P		Q		O		n	%
	n	%	n	%	n	%	n	%		
Level C										
Unmodified									3	10.34
Cobbles	1								1	
Cobble fragments	2								2	
Handheld cores	1				3				3	10.34
Handheld flakes									5	17.24
Whole					3				3	
Broken					1				1	
Retouched	1								1	
Waste									18	62.06
Debris	1				15		1		17	
Undetermined positives					1				1	
Total level C	6	20.68			22	75.86	1	3.44	29	2.50
Level B2										
Unmodified									40	3.95
Cobbles	32		1						33	
Broken cobbles	3								3	
Cobble fragments	4								4	
Percussion									53	5.23
Hammerstones	30				5				35	
Broken hammerstones	4		1						5	
Flakes and fragments	5				1				6	
Modified battered blocks					6				6	
Anvils							1		1	
Cores									36	3.55
Handheld percussion	15		1		16		1			
Bipolar percussion					3					
Flakes									162	16
Whole handheld	17		2		94		2		115	
Broken handheld	2		1		43				46	
Whole bipolar					1				1	
Retouched flakes	1		1		15				17	1.67
Choppers	3				1				4	0.39
Large cutting tools					9				9	0.8
Large flakes					4				4	0.39
Waste									687	67.88
Flake fragments	3		1		63				67	
Core fragments	4		1		31		1		37	
Undetermined positives	5				56		3		64	
Debris	20				498		1		519	
Total level B2	148	14.62	23	2.27	832	82.21	9	0.88	1012	87.31
Level B1										
Unmodified									14	11.86
Cobbles	13								13	
Cobble fragments	1								1	
Percussion									14	11.86
Hammerstones	8				1				9	
Flakes and fragments	1		1						2	
Modified battered blocks					2				2	
Anvils	1								1	
Handheld cores	12				7				19	16.10
Flakes									24	20.33
Whole flakes	4				9				13	
Broken flakes					11				11	
Retouched flakes	2				1				3	2.54
Large flakes					1				1	0.84

(continued)

Table 1. (continued)

Lithic categories	Raw material								Totals	
	B		P		Q		O		n	%
	n	%	n	%	n	%	n	%		
Waste									43	36.44
Flake fragments					6				6	
Core fragments					2				2	
Undetermined positives					10				10	
Debris	1				24				25	
Total level B1	43	36.44	1	0.84	74	62.71			118	10.18
Total	197	16.99	24	2.07	928	80.06	10	0.86	1159	

ological specimens have been retrieved (114.62 items m^{-2}), including 1159 lithic artefacts and 495 fossil bones (Fig. 4). Field methodology has consisted of a recurrent 10-cm arbitrary spit excavation following stratigraphical geometry to ensure correct horizontal exposure of archaeological associations. Once anthropogenic accumulations were unearthed, photogrammetry procedures were applied to obtain georeferenced 3D models (De Reu *et al.* 2014; Duque & de Francisco 2015). With the aid of printed orthophotography copies, the perimeter of each archaeological item was delimited and identified with a correlative numerical code. Finally, the geographical coordinates of the centroid of each item were registered with a TOPCON-GPT3105N total station. Regarding stratigraphical levels and identification/correlation of geological features (such as the topography of the channel adjacent to the site or the geotrench linking SHKE and SHKM), another 600 topographical points were taken. Horizontal and vertical data were reconstructed and managed using ArcGis software (Wheatley & Gillings 2002; Conolly & Lake 2006).

The identification and interpretation of archaeological levels were undertaken with the aid of archaeo-stratigraphy. The main goal of this methodology, devoted to the vertical study of the archaeological distribution, is the identification of sterile strata or sedimentary hiatus within the depositional sequence, allowing the recognition of high-resolution levels beyond geological criteria (Canals *et al.* 2003; Obregón 2012). By doing so, it is possible to individualize groups of items with high synchronicity and to reduce the palimpsest effect, that is to say, the risk of mixing specimens related to different occupational events, as much as possible (Bailey 2007; Vaquero 2008; Malinsky-Buller *et al.* 2011; Henry 2012; Machado *et al.* 2013, 2016). Our analysis consisted of the elaboration of a network of longitudinal (XZ) and transversal (YZ) profiles covering the whole excavated area. All the points representing coordinated archaeological items have been projected within this network. The vertical profiles were then analysed, taking into consideration such criteria as the slope of the geological level, object grouping, and presence of continuous vertical hiatuses. Final archaeo-stratigraphical interpretation was verified through virtual grid rotations or control loops (Canals *et al.* 2003; Obregón 2012; Diez-Martín *et al.* 2014a), confirming that archaeological accumulations and disruptions are coherent within the whole sequence and correctly identified.

The following technological categories were considered for the study of the lithic collection (Table 1). (i) Unmodified material, including complete and broken cobbles, as well as fragments with no sign of anthropogenic use. (ii) Specimens related to percussive processes or actions, that is to say, complete and broken hammerstones, flakes and fragments resulting from percussion, anvils, and – after Leakey 1971 – Modified Battered Blocks (MBB). The MMB category is formed by cuboid or spherical artefacts whose final shape might be the result of the concurrence of percussion tasks. We include here artefacts traditionally defined as spheroids and sub-spheroids (Leakey 1971), as well as other cubic specimens. Recent data provided by experimental work in Olduvai (Sánchez-Yustos *et al.* 2015), as well as by other authors (Willoughby 1987; Jones 1994; Schick & Toth 1994; Mora & de la Torre 2005) coincide in underlining that the variety of rounded shapes included in these classical morpho-types could represent different phases of multiple tasks, amongst which percussive activities could play a prominent role. (iii) Cores. The classification of bipolar cores is based on technical traits and rotation patterns typically related to anvil percussion (Diez-Martín *et al.* 2009a, b, 2010). The identification of reduction patterns in handheld cores is based on such parameters (Diez-Martín *et al.* 2009a, b, 2011) as number of faces knapped (unifacial, bifacial, trifacial, multifacial), striking platforms identified (unipolar, bipolar, multipolar), and the organization of knapping series (lineal, opposed, orthogonal, centripetal). (iv) Detached products include both bipolar and freehand complete and broken flakes (where traits of conchoidal fracture can be recognized and the original size and shape can be reconstructed). Freehand flakes are classified according to the variable presence/absence of cortex on dorsal areas and striking platforms (Toth 1982), type of striking platform and dorsal pattern (Diez-Martín *et al.* 2009a, b, 2010); (v) Retouched flakes are those specimens with natural edges transformed by retouch into a variety of classical types. (vi) Choppers are core-like specimens that can be interpreted as intentionally shaped tools due to the presence of rectilinear and acute distal/side edges and secondary trimming reinforcing edge segments. (vii) Large Cutting Tools (including formal types, such as handaxes, cleavers and picks) and (viii) large flakes (≥100 mm) will be treated cursorily in this study. (ix) Waste, includes all the by-products of the knapping process bearing scarce technological information, such as flake fragments, core fragments, undetermined positives (blocky and angular fragments), and debris (≤25 mm).

Many studies have underlined the need of identifying site integrity as a previous step to horizontal intrasite analysis (Petraglia & Potts 1994; Dibble *et al.* 1997; Malinsky-Buller *et al.* 2011; Giusti & Arzarello 2016; Martinez-Moreno *et al.* 2016). Gathering insights into the formation processes affecting an archaeological assemblage and evaluating to what extent postdepositional dynamics affect artefact associations and patterns produced by anthropogenic activity are key issues in any inference related to the connection time-space. Amongst the different criteria used for this purpose, we studied the archaeological sample according to such parameters as object orientation (Bertran & Lenoble 2002; Boschian & Saccà 2010; García-Moreno *et al.* 2016), distribution by size and mass (Schick 1986; Petraglia & Potts 1994; Kroll 1997; Bertran *et al.* 2012), and degree of roundness/abrasion (Petraglia & Potts 1994; Shea 1999).

Refitting analyses were applied to the lithic collection. Once raw material units (RMU) were established (Conard & Adler 1997; Vaquero 2008; Machado *et al.* 2016) within and between archaeological levels, two groups of associations were identified (Sisk & Shea 2008): (i) refits are those connections of specimens

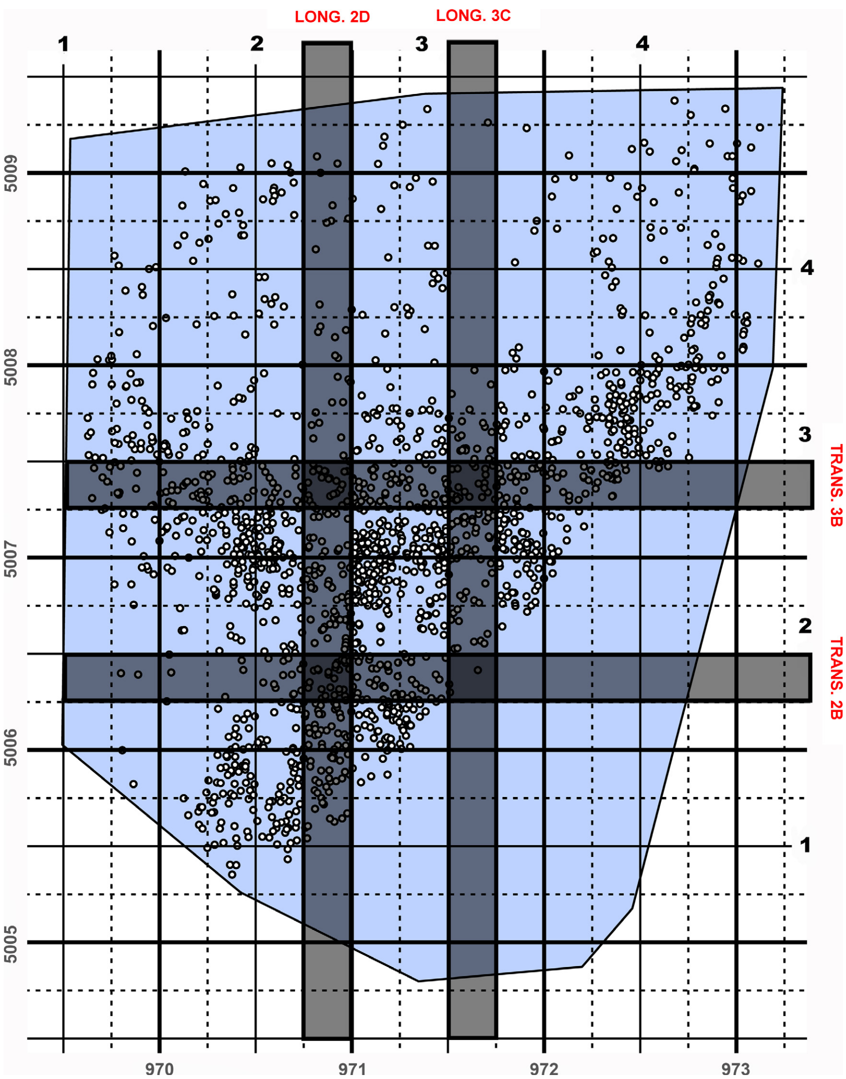

Fig. 5. Grid used for archaeo-stratigraphical analysis and examples of the longitudinal and transversal projection strips.

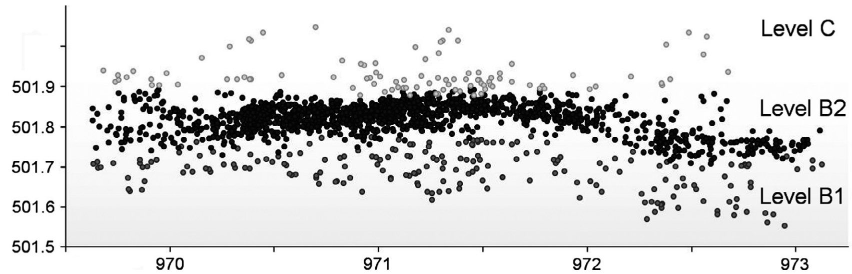

Fig. 6. General XZ projection of the archaeological materials sorted by archaeo-unit.

separated by controlled conchoidal fractures, including refittings of production sequences and modifications (Cziesla 1990); (ii) conjoins identify fractures not related to knapping. Presence of sediment and/or different patina on the articulating surfaces of specimens indicates that they were fractured prior to archaeological fieldwork by cultural processes other than knapping (such as percussion) or postdepositional natural reasons.

Results

Identification of archaeo-units

Considering the general characteristics of the site, 25-cm-wide strips were selected for establishing the study sections (Fig. 5). Using this referential scale, we obtained 32 profiles (15 longitudinal and 17 transversal). However, considering the differential density of archaeological materials within the excavated area, we also produced two more series of projections, enlarging (50 cm) or reducing (10 cm) the interval between sections, as needed. The uppermost level C is easily identifiable in the XZ vertical projection of the archaeological sequence (Fig. 6) and, thus, the stratigraphical disruption that identifies this level was clearly confirmed through the archaeo-stratigraphical method. This archaeological level was deposited in a distinctive depositional context (on a palaeosurface covered by the laminated sands of unit 6) and it consists of a maximum thickness of 20 cm, a scarce collection of archaeological materials (77 items: 29 lithics and 48 fossil bones) and a low density of 11.8 items m^2 (distributed in an area of 6.5 m^2) (Fig. 7A).

The most noteworthy result of the archaeo-stratigraphical analysis was the identification of two different archaeo-levels within the same stratigraphical unit of the overbank (geologically defined as Level B) (Fig. 2). Archaeo-unit B2, deposited on the clays of the channel overbank and directly covered by the tuffaceous silt, is a very dense patch of remains, with a maximum thickness of 10 cm and a density of 153.7 items m^2 (within an area of 9 m^2). It coincides stratigraphically with Level B in SHKM. A total collection of 1384 items belong to this unit (83.6% of all archaeological materials retrieved from SHKE: 1012 lithics and 372 faunal remains; Fig. 7B). Beneath B2 and within the clays, at the base of the sequence, archaeo-unit B1 has a maximum thickness of 20 cm and a density of 22.7 items m^2 (in an area of

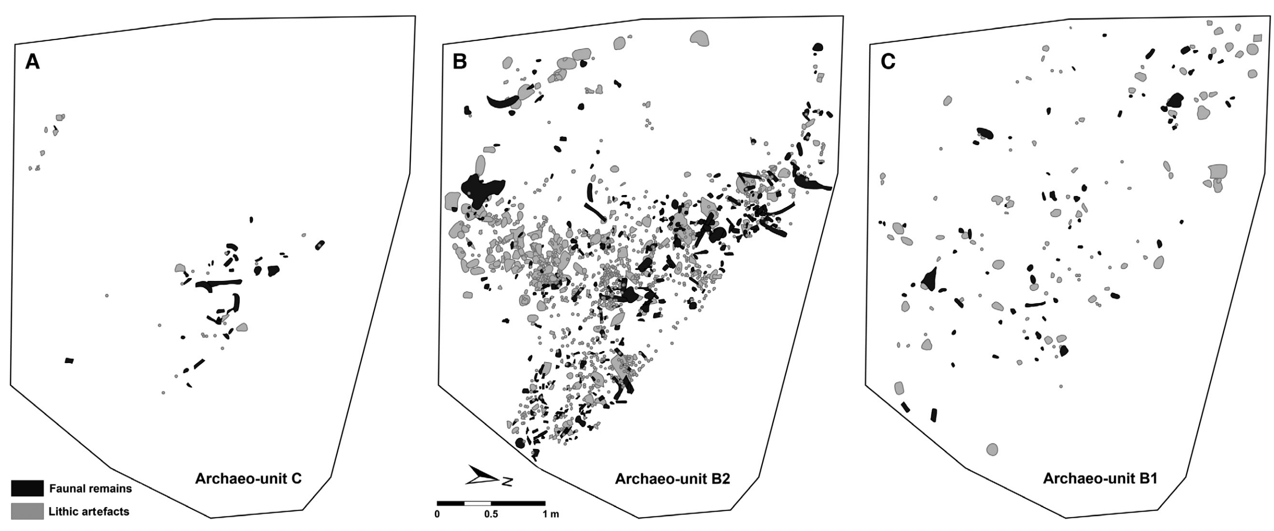

Fig. 7. Horizontal distribution of faunal remains and lithic artefacts at SHKE sorted by archaeo-unit.

8.5 m^2). It has yielded 193 remains: 118 lithics and 75 fossil bones (Fig. 7C). This case constitutes a good example showing the extent to which archaeo-stratigraphy can determine detailed and more accurate archaeological associations within homogeneous lithostratigraphical units (Canals *et al.* 2003; Obregón 2012). As shown in Fig. 8, the two archaeo-levels are clearly separated by a continuous (although variable, between 2 and 10 cm thick) sedimentary hiatus. On a few occasions, as seen in projection Trans 3B, percolated materials were found within the hiatus. This can be related to a variety of postdepositional processes operating in clay sediments (Villa & Courtin 1983; Schiffer 1987; Domínguez-Solera 2010), although the consider-

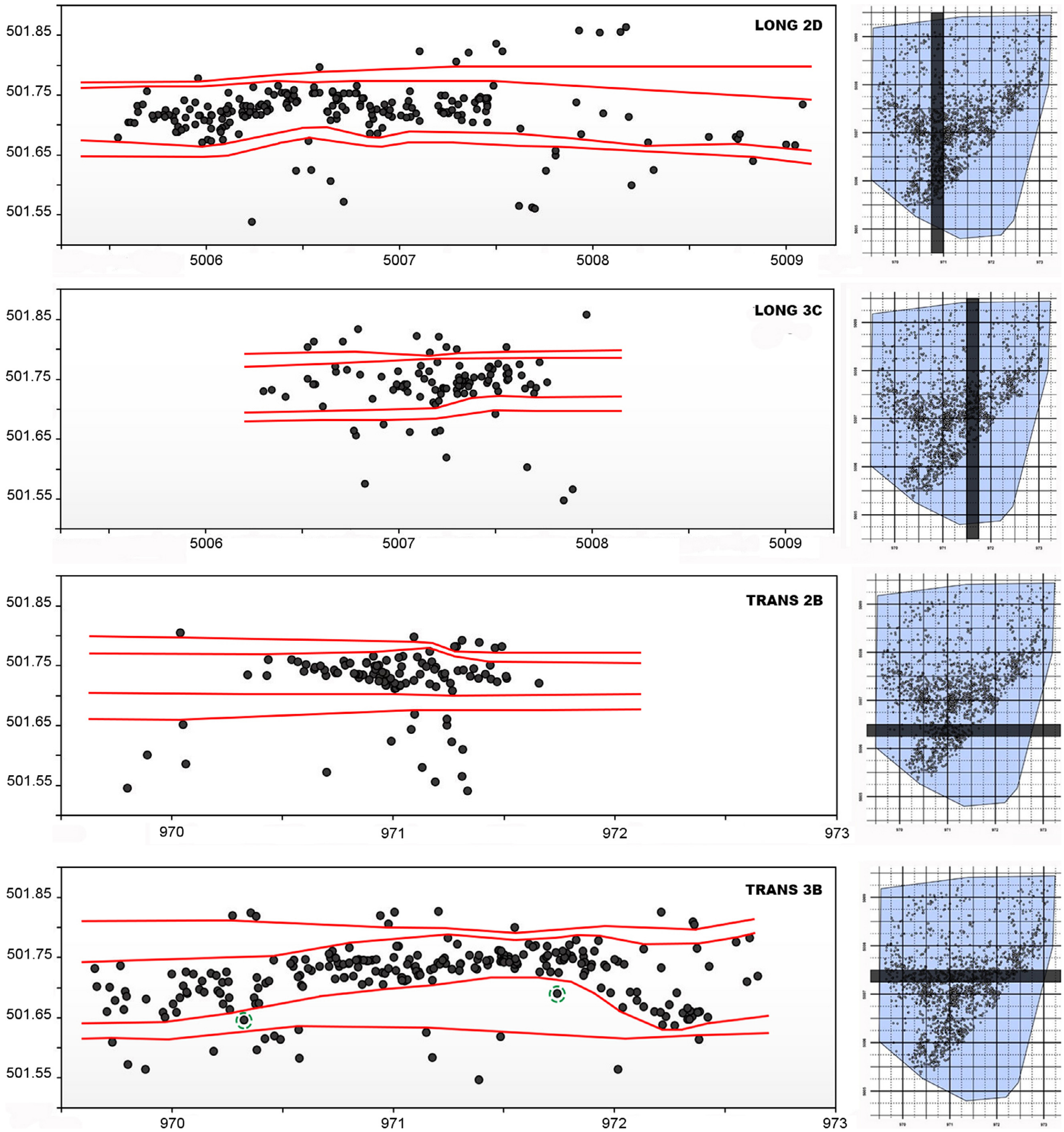

Fig. 8. Examples of longitudinal and transversal projections (scale 25 cm) and their position within the grid. Black dots represent archaeological remains, while red lines delimit archaeo-stratigraphical units and related disruptions. In projection Trans 3B, objects percolated and located in a hiatus are identified with a discontinuous green circle.

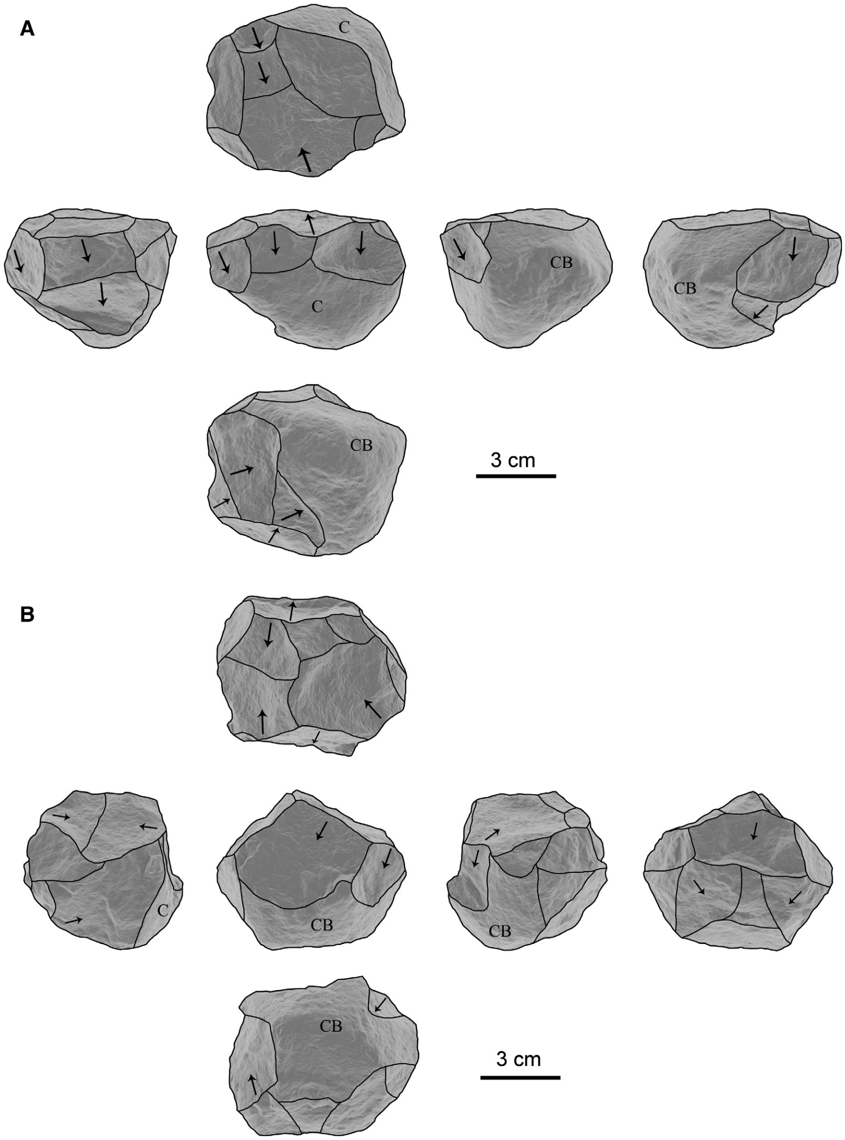

Fig. 9. 3D scans and negative scar organization of quartz cores from SHKE. LB2: A. Bifacial unipolar showing cortex (C) and battering (CB). LB1: B. Multifacial-multipolar with signs of intense battering on cortical areas (CB).

able amount of materials included within this archaeo-unit and, more importantly, the consistency of the vertical disruption documented between B2 and B1, support the idea that the hiatus bears a distinctive depositional meaning (Obregón 2012) and, thus, archaeological implications.

The lithic collections

A collection of 1159 lithic artefacts was studied in this work. Table 1 shows the distribution of lithic materials sorted by categories, raw material and archaeo-unit. The technological study presented here was undertaken based on the units established by the archaeo-stratigraphical analysis.

Level C. – A meagre sample of 29 specimens was retrieved from this unit, representing 2.5% of the total collection. Most pieces are produced in quartz (76%), followed by basalt (21%) and rock crystal (3%). Unmodified materials are represented by a cobble and two fragments. The core category includes three multifacial/multipolar specimens (mean dimensions 76×66×54 mm, and 367 g), intensely reduced (mean number of negative scars per core is 12). One of these polyhedral specimens, with clear and deep negative scars crossing in multiple planes, has been recycled in percussion activities, showing signs of intense crushing on a globular and cortical area (Fig. 9B). Detached objects include three complete non-cortical (32×28×14 mm) and one broken flakes. A Type 2 large flake (74×99×25 mm) has been trans-

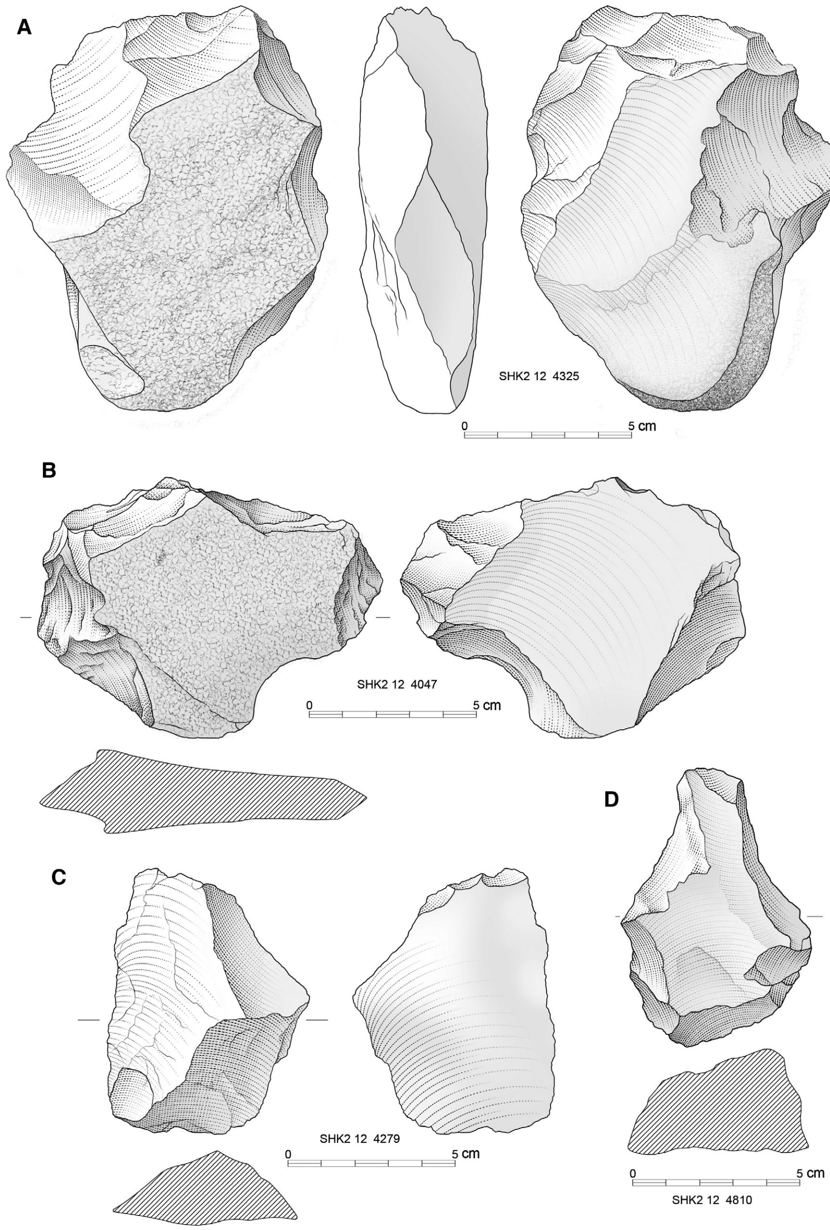

Fig. 10. Lithic artefacts from SHKE. LB2: A. Bifacial chopper on basalt. C. Medium-sized quartz flake (75×58×21 mm and 90 g), Type 6 and orthogonal dorsal pattern. D. Retouched specimen on quartz, lateral concave retouch determines a distal transversal edge. LB1: B. Side-transversal scraper on basalt. Drawings by Francisco Tapias.

formed into a scraper through side and transversal retouch (Fig. 10B). Waste includes 17 debris (most of them ≤20 mm) and an undetermined positive.

Level B2. – The bulk of the lithic materials retrieved from SHKE belong to this archaeo-unit (1012 specimens, 87.3% of the total sample; Table 1). Quartz is the best-represented raw material (82.21%), followed by basalt (14.62%), phonolite (2.27%), gneiss (0.59%) and rock crystal (0.29%). Unmodified items represent 3.95% of the sample and are constituted by volcanic rocks (vesicular basalt, n = 22; basalt, n = 16; and phonolite, n = 2). Most of these specimens are complete cobbles (n = 33) with no percussion marks although it cannot be ruled out that some of them might have been involved in percussion activities (Sánchez-Yustos *et al.* 2015).

Specimens related to percussion tasks represent 5.23% of the sample. Within this group we have included a collection of 35 complete hammerstones, most of which are basaltic (86%) oval cobbles with intense signs of battering and scarring arranged in distal/proximal (n = 7), distal/proximal/lateral (n = 5) orientations, and around the whole perimeter of the piece (n = 14). These pieces tend to be slightly larger and heavier than

Table 2. Mean size (mm) and mass (g) of unmodified cobbles and hammerstones retrieved from SHKE B2.

	Min.	Max.	Mean	SD
Unmodified cobbles (n = 33)				
Length	50	120	80	17.05
Breadth	41	86	64.73	12.95
Thickness	26	74	47.44	11.54
Mass	59	693	282.2	155.8
Hammerstones (n = 35)				
Length	56	142	86.25	19.129
Breadth	47	97	68	13.39
Thickness	28	94	53.84	13.88
Mass	104	1120	433	259.86

natural cobbles (Table 2). Broken hammerstones and flakes of percussion (with cortical areas and signs of percussion) have also been found. A small collection of six quartz MBBs is formed by pieces with multifacial/multipolar planes of fracture and signs of intense battering and frosting on ridges and planes. According to their stage of transformation by percussion, these pieces display shapes that go from cuboid (Fig. 11B) to rounded/spherical. Three specimens are located in an initial stage of transformation, while the other three represent rounded or sub-spheroidal final forms. Interestingly, two of the quadrangular specimens show signs of bipolar percussion, confirming that the bipolar technique might have been efficient to split quartz blocks into smaller cuboid forms that were subsequently used in percussion tasks (Fig. 12B; Sánchez-Yustos *et al.* 2015). Finally, a quadrangular gneiss piece (118×112×96 mm and 1769 g), showing intense pitting on the central area of two adjacent flat surfaces, was classified as an anvil (Fig. 12A).

A collection of 36 cores (3.5% of the total) was retrieved from SHKE. Bipolar cores (8.3% of the core sample), all made of quartz, are tabular specimens showing circular bipolar reduction without rotation (Fig. 11A) (Diez-Martín *et al.* 2009a, b). Freehand knapping is the most abundant reduction technique employed (91.6%) to reduce quartz (n = 16), basalt (n = 15), phonolite (n = 1) and gneiss (n = 1) rocks. Mean dimensions of cores sorted by reduction model are shown in Table 3. Quartz cores were more intensely exploited than volcanic cores. Mean number of identified negative scars per core is eight in quartz and five in basalt. Furthermore, most of the test specimens with casual exploitation are made in basalt. Accordingly, flakes detached from quartz cores tend to be smaller (mean 38×37 mm) than those obtained from volcanic materials (mean 40×48 mm). Quartz and basalt cores in equal numbers (n = 4 per raw material) have been recycled in percussion activities, showing areas with battering. According to the criteria used, the following reduction strategies were identified in handheld cores. (i) Test. Specimens with few, dispersed scars (mean 2.5 per core), not arranged in recurrent series, constitute 24.2% of the freehand core sample (basal = 6, quartz = 1, gneiss = 1). (ii) Unifacial unipolar lineal. Short series of parallel detachments (mean of three) obtained from the same striking platform are represented by four specimens (three basalt, one quartz), equivalent to 12%. Medium-sized, long flakes (mean 60×47 mm) have been detached from lineal cores. (iii) Bifacial unipolar. In six cases (18%), four basalt and two quartz, detachments were obtained from two surfaces, using the same plane (usually a natural ridge of the blank) as the striking platform (Fig. 9A). Mean number of negative scars per core is 5.6. This method has produced wide

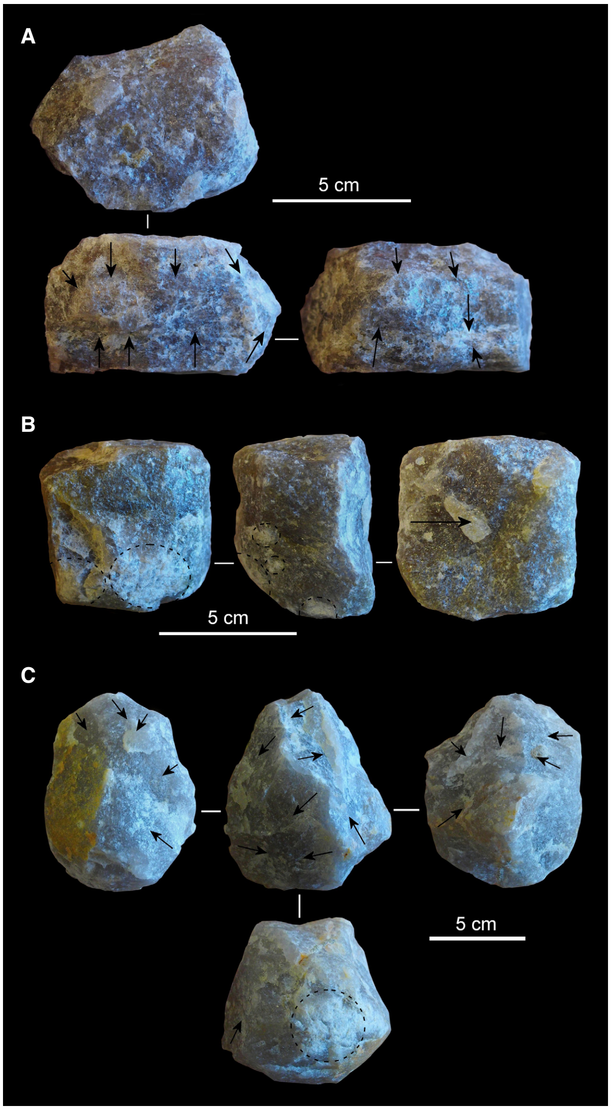

Fig. 11. Lithic artefacts on quartz from SHKE B2: A. Bipolar circular core with no rotation. B. Cuboid fragment with intense frosting concentrated on the proximal area (encircled). C. Multifacial/multipolar core showing frosting concentrated on the proximal area. Arrows indicate direction of detachments.

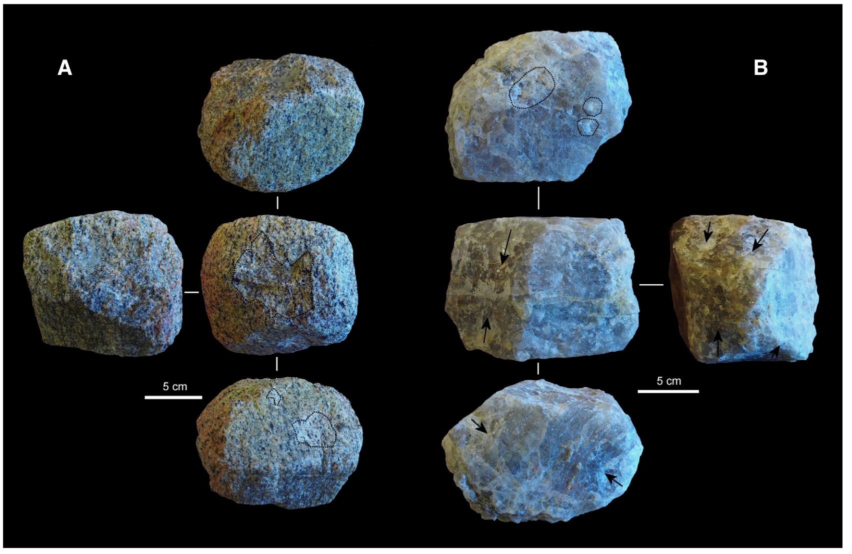

Fig. 12. Lithic artefacts from SHKE B2: A. Anvil on cubic piece of gneiss, showing evident pitting marks (encircled areas). B. Quartz block showing signs of initial bipolar reduction and ridges flattened by battering (arrows indicate direction of detachments).

medium-sized flakes (mean 28.5×50 mm). (iv) Bifacial orthogonal. This method was observed in five cores (15%, quartz = 3, basalt = 1, phonolite = 1). Through bifacial exploitation and core rotation, negative scars show an orthogonal arrangement (Figs 13A, 14A, B). This method is quite productive (9.5 scars per core) and wide medium-sized flakes were obtained (mean 44.5×56.5 mm). (v) Bifacial centripetal. The discoid model is represented at SHKE by two basalt cores (6%; Fig. 13B). This strategy is one of the most intense (9.7), with detachments that tend to be quadrangular (mean 38.5×39 mm). (vi) Multifacial/Multipolar. The polyhedron group is, along with test cores, the most abundant in the collection (n = 8, 24.2%; Fig. 11C). Negative scars, arranged in multiple planes, show the highest productivity per core (10). In all cases, the blank selected for this reduction model is quartz, obtaining quadrangular flakes (mean 38×37.5 mm).

A collection of 162 flakes was unearthed from SHKE (16% of the lithic sample), 138 in quartz (85.20%), 19 in basalt (11.73%), three in phonolite (1.85%), one in rock crystal (0.61%) and one in gneiss (0.61%). Only one quartz specimen was identified as a bipolar flake, showing the characteristic traits of this reduction technique (Diez-Martín *et al.* 2009a, b, 2011). However, due to the characteristics of both Naibor Soit quartz and bipolar knapping, a number of pieces included in the waste category (particularly undetermined blocky positives) could have been the result of the implementation of this method. The bulk of the flake collection was produced via handheld percussion. Broken flakes are quite abundant (28.5% of all freehand flakes), particularly evident in the case of quartz pieces (31% of all quartz flakes are broken, in contrast to 13% of the volcanic flakes). Most of the recognized fractures are longitudinal Siret type (44%), lateral (24%), distal (17%) and proximal (15%). Mean dimensions and mass of complete volcanic (basalt and phonolite) and quartz flakes are shown in Table 4. In both cases, as the mean dimensional values suggest, small flakes (<30–50 mm in maximum length) predominate over medium-sized flakes (51–76 mm) (Fig. 15A), although flakes between 61 and 76 mm in maximum length tend to be slightly more abundant in basalt than in quartz (Fig. 10C). Rejuvenation (two in basalt and one in quartz) and shaping (one in basalt and one in quartz) flakes were recognized in the flake sample.

With regard to their position in the reduction sequence (Toth 1982), pieces retaining cortex on dorsal surfaces and platforms are more abundant amongst volcanic flakes (particularly represented by Types 1 and 2), while Type 6 flakes constitute 35.8% of the sample. In line with this, volcanic rocks tend to show cortical (60%) and plain (40%) butts. In quartz flakes, on the contrary, Type 6 flakes constitute 68% of the sample, followed by Type 5 (20%). Striking platforms in quartz flakes are plain (64%), cortical (11%), broken/removed (8.8%), linear (6.6%), punctiform (5.5%) and bi-faceted (3.3%). Dorsal patterns in flakes tend to be mostly lineal (n = 18) and orthogonal (n = 1) in volcanic rocks. In quartz, lineal patterns predominate (n = 57), followed by unorganized (n = 22), orthogonal (n = 12) and opposed (n = 3).

Retouched flakes represent 1.67% of the collection (n = 17). Most of these artefacts are made in quartz (n = 15), while basalt (n = 1) and phonolite (n = 1) are residually represented in the sample. Retouched flakes are larger than plain flakes (Table 4) and they fit well within medium-sized specimens (51–87 mm) (Fig. 15A). Whereas most pieces (n = 8) do not retain cortex on dorsal areas and butts (Type 6), including the

Table 3. Mean size (mm) and mass (g) of freehand cores retrieved from SHKE B2 and sorted by reduction model.

	Min.	Max.	Mean	SD
Test cores				
Length	64	158	96.28	32.93
Breadth	49	137	74.85	29.49
Thickness	34	82	55	14.84
Mass	161	1886	574	547.74
Unifacial unipolar lineal				
Length	60	106	77.75	21.51
Breadth	43	92	62.25	21.04
Thickness	32	69	51.75	15.71
Mass	120	628	303.25	226.11
Bifacial unipolar				
Length	42	98	76.33	21.05
Breadth	40	83	64.66	14.27
Thickness	22	75	49.33	17.95
Mass	42	607	345.5	191.31
Bifacial orthogonal				
Length	64	94	76	13.19
Breadth	56	77	61	9.02
Thickness	37	57	43.4	8.01
Mass	164	419	244.4	104.78
Bifacial centripetal				
Length	81	93	87	8.48
Breadth	73	88	80.5	10.6
Thickness	42	64	53	15.55
Mass	320	618	469	210.71
Multifacial/multipolar				
Length	49	113	69.7	21.88
Breadth	46	97	59.75	16.55
Thickness	37	63	46.75	10.19
Mass	93	626	254.37	186.93

phonolite and basalt specimens, five retain cortical areas on the dorsal surface (Type 5); one is Type 2 and one is completely cortical (Type 1). Regarding striking platforms, 12 are plain, three removed and two cortical. Dorsal patterns tend to be preferentially lineal (n = 10), followed by unorganized (n = 5) and opposed (n = 2). Retouch is mostly casual, with the presence of non-continuous direct/inverse and small retouched areas in a single natural edge, lateral or distal (n = 6) (Fig. 16F). Another specimen shows bifacial and discontinuous retouch performed bifacially (Fig. 16G). Another piece shows abrupt retouch on the proximal area associated with a side and continuous retouch (Fig. 16E). Casual retouch on a further two pieces serves to enhance a natural edge (Fig. 10D) or a point (Fig. 16D). The remaining artefacts can be included in more conventional types, such as two quartz notches, two borers on quartz (Fig. 16C) and three scrapers (one in phonolite and two in quartz), showing continuous, direct, transversal (n = 1) or transversal/side retouch (Fig. 16A).

Large configuration tools have been included in three different categories here. We defined core-like specimens as choppers when a clear and rectilinear edge was produced by knapping in discrete areas of the cobble. A sample of four choppers (0.39% of the collection), three in basalt and one in quartz, was retrieved. In two cases, the edge was produced by unifacial knapping (Fig. 16B), while in the remaining two detachments are arranged bifacially (Fig. 10A). Two of these pieces display battering as well, although the edges produced were not caused by percussion. Regarding large cutting tool production, we took into consideration both large flakes and LCTs as part of the same sequence that includes both initial blanks or preforms and final forms. We retrieved from this level a collection of four large flakes and nine LCTs (1.28% of the total sample), all produced in quartz. Large flakes (mean size 104×108×43 mm and 495 g) belong to Toth's Types 3 (n = 3) and 5 (n = 1) and show casual retouched areas to different degrees. The nine tools considered as LCTs were produced on large flake (n = 6) or tabular (n = 3) blanks. They were identified as handaxes (n = 1, 144×68×47 mm and 421 g), cleavers (n = 2, mean 164×90×37 mm and 512 g), knives (n = 4, mean 178×84×48 mm and 724 g) and pointed forms (n = 2, mean 135×65×59 mm and 599 g).

The waste category is, by far, the best represented in this collection (67.8%). We included here clear flake fragments produced through handheld percussion but with no identifiable technical attributes (9.75% of the waste category), core fragments with recognizable traces of negative scars (5.38%), undetermined and blocky positives, mostly related to the unpredictable process of quartz breakage (9.31%), and ≤25 mm debris (75.5%). Amongst the flake fragments, we included one piece (84 × 88 mm) that corresponds to a non-identifiable fragment of a large flake. The distribution of detached waste (debris, flake fragments and undetermined positives) grouped by maximum length is shown in Fig. 15B. The bulk of waste specimens are made in quartz (94.32%), followed at a distance by basalt (4.65%), gneiss (0.43%), phonolite (0.29%) and rock crystal (0.29%).

Level B1. – A collection of 118 lithic implements was retrieved from the lowermost B1 level, constituting 10.18% of the total sample (Table 1). As in the rest of the sequence, quartz is the most abundant raw material (62.71%), followed by volcanic rocks, basalt (36.44%) and phonolite (0.84%). Unmodified materials, all in basalt (one is a vesicular basalt), sum 11.86% of the sample, and we included here 13 oval and amorphous cobbles with no sign of anthropogenic use (mean size and mass is 74×59.6×40.7 mm, and 226.6 g), and one cobble fragment. Specimens related to percussion activities represent another 11.86% of the collection, and we count here nine hammerstones (eight in basalt and one in quartz) that tend to be larger and heavier than unmodified cobbles (mean 83.87×67.75×49.25 mm and 411.62 g). All these pieces show signs of both battering and scarring to different degrees, particularly concen-

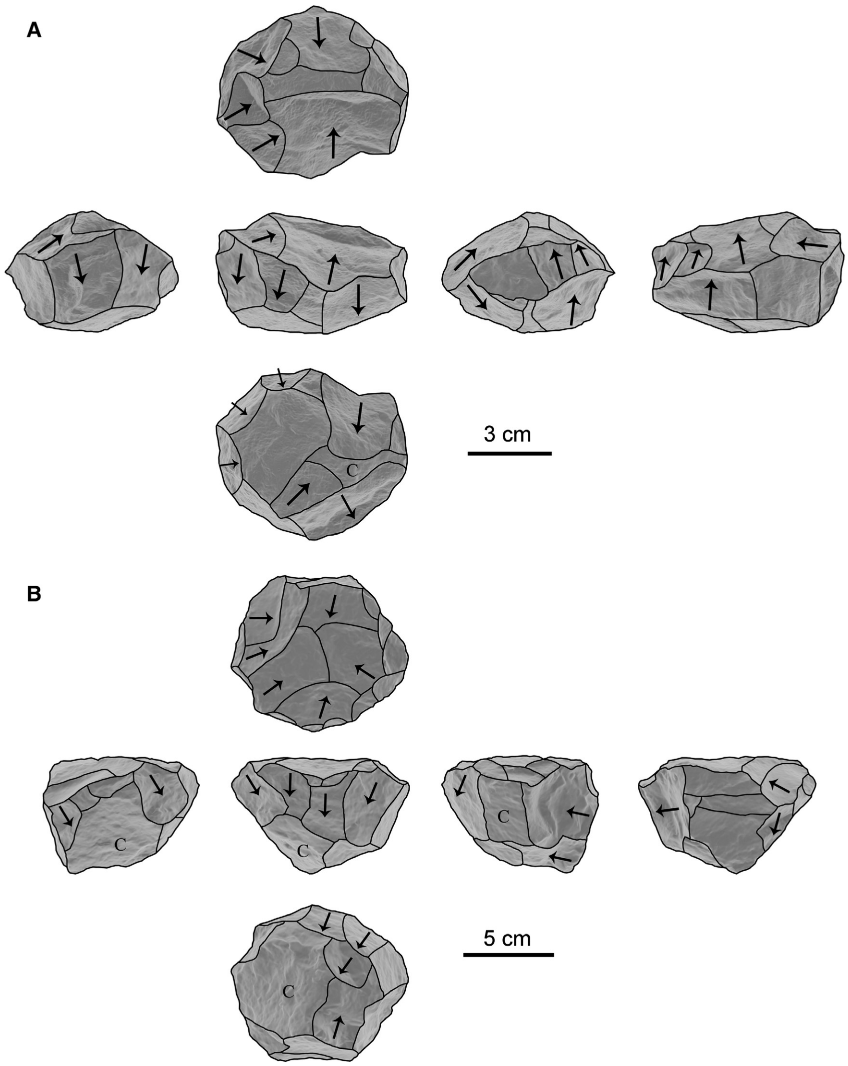

Fig. 13. 3D scans and negative scar organization of cores from SHKE LB2: A. Bifacial multipolar orthogonal on quartz. B. Bifacial multipolar centripetal on basalt. C = cortical area.

trated in proximal and distal areas, but usually connecting with marks around the perimeter of the piece. Percussion flakes with battering on dorsal areas were also found (two flakes in volcanic rocks). We also include in this group one quartz MBB in an advanced stage of transformation that can be described as a subspheroid. Finally, one quadrangular basalt anvil, with concentrated pitting on the central area of the upper surface, was recognized.

Handheld percussion is represented in the collection by 19 cores (16.10%). Most cores are in basalt (n = 12, including three vesicular basalt specimens), while the others were made in quartz (n = 7). Basalt cores tend to be larger than quartz cores (mean dimensions and mass in basalt are 90.6×76.6×60.3 mm and 516.16 g; in quartz 74.4×65.4×54 mm and 409.4 g). The following reduction strategies were identified. (i) Test cores (n = 5, 26.3%), all of them in basalt, including two vesicular basalt specimens, show a low number of unorganized and small-sized flakes produced per core (mean 2, mean size of 22×37 mm). (ii) Unifacial patterns (n = 3, 15.78%) include two basalt cores showing short lineal series of detachments and a quartz specimen in which negative scars are arranged in a semi-circular manner. Mean number of flakes per core is 4.3 and mean dimensions of flakes obtained is 39.4×44.2 mm. (iii) Bifacial unipolar strategies, by which the same striking platform is used to detach flakes from two faces (mean productivity is 5.8 flakes per core), were identified in five cases (26.31%: four basalt and one quartz also showing signs of percussion). This method produced relatively large flakes, with mean values of 50.75×42.3 mm. (iv) Bifacial orthogonal cores (n = 2, one quartz and one basalt that represent 10.5% of the core collection) show a high productivity (9.6) of short and wide flakes (mean 27×35 mm). (v) Multifacial/multipolar cores (n = 3, 15.7%) were produced in quartz

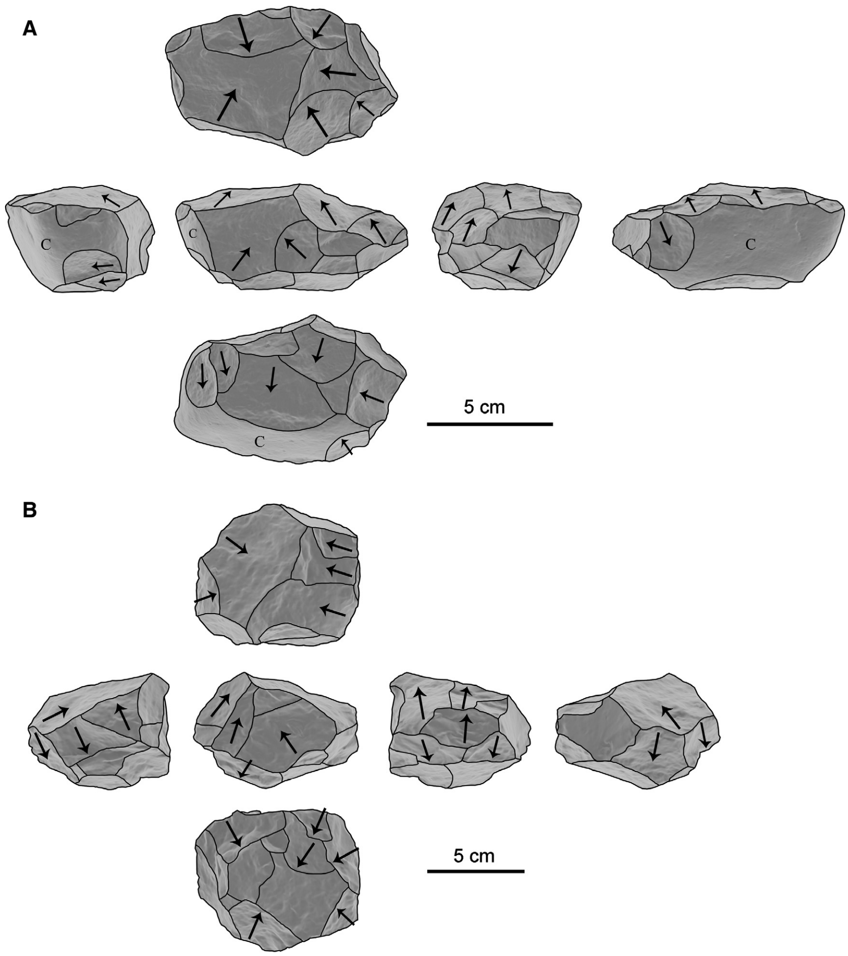

Fig. 14. 3D scans and negative scar organization of volcanic cores from SHKE LB2: A. Bifacial multipolar orthogonal on basalt. B. Bifacial multipolar orthogonal on phonolite. C = cortical area.

and show the highest number of negative scars per core (9.8) organized in multiple planes. This method produced quadrangular flakes (mean 39×38 mm). Two pieces included in this method display frosted areas, evidencing that they were also used in percussion tasks. (vi) The core sample is completed with an exhausted quartz core, with negative scars in at least three planes and with evidence of frosting.

Table 4. Mean size (mm) and mass (g) of complete plain and retouched flakes from SHKE B2.

	Min.	Max.	Mean	SD
Plain flakes (quartz, n = 38)				
Length	16	75	36.93	11.52
Breadth	14	75	35.21	12.23
Thickness	6	28	14.03	5.39
Mass	3	99	24.23	23.73
Plain flakes (volcanic, n = 22)				
Length	18	70	30.23	13.88
Breadth	15	76	38.47	18.82
Thickness	7	31	14.47	6.68
Mass	4	137	32.94	39.41
Retouched flakes				
Length	31	87	54.17	16.7
Breadth	26	67	46.7	11.56
Thickness	11	41	23.52	8.02
Mass	17	243	69.94	56.34

Freehand flakes (n = 24), represent 20.3% of the collection. We include here 11 broken quartz flakes, mostly with longitudinal (n = 6) and proximal (n = 3) fractures, and 13 whole flakes (nine in quartz and four in basalt). Two rejuvenation flakes (one in basalt and another one in quartz) were identified within the flake group. In level B1, flakes accord with the small-size interval (mean 46×42×14 mm). Most flakes show no cortex on dorsal areas or striking platforms (n = 9), while two specimens are Type 5 flakes and a further two are Type 2 flakes. Consequently, butts are plain (n = 11), cortical (n = 1) and lineal (n = 1). We identified a meagre collection of three retouched flakes (2.54% of the total). We include here a basalt denticulate, a quartz pointed piece obtained through deep and continuous bilateral retouch, and a basalt specimen showing abrupt retouch on both sides. A large Type 3 quartz flake

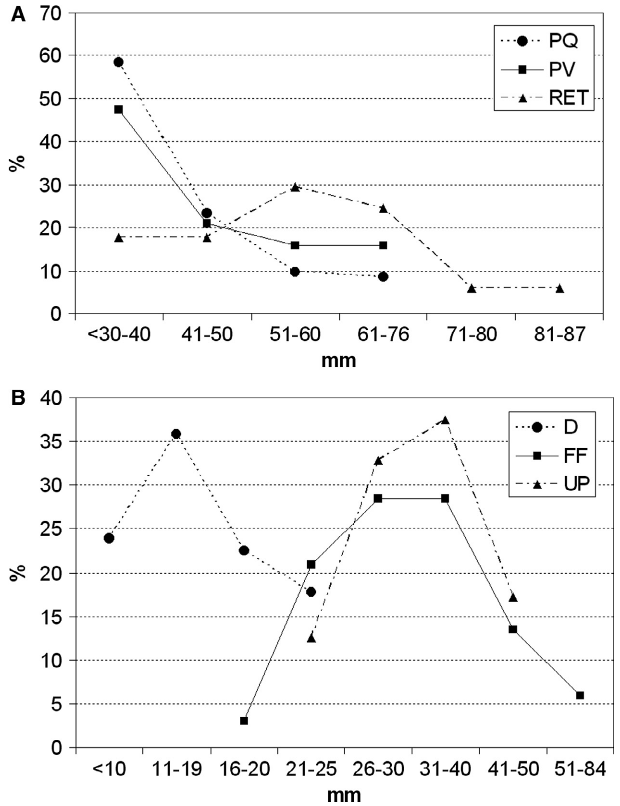

Fig. 15. A. Percentage contribution of detached specimens from SHKE B2 sorted by maximum length classes (PQ = plain quartz flakes; PV = plain volcanic flakes; RET = retouched flakes). B. Percentage contribution of detached waste from SHKE B2 sorted by maximum length classes (D = debris; FF = flake fragments; UP = undetermined positives).

(102×138×40 mm and 605 g) was also retrieved from this level.

Waste represents 36.4% of the studied sample. Excepting a piece of basalt debris, all the pieces included in this category were produced in quartz. This group consists of six flake fragments, two core fragments, 10 undetermined blocky positives and 25 pieces of debris (<25 mm).

Taphonomic observations on the B2 aggregate

Level B2 constitutes the most remarkable patch of archaeological materials in SHKE and is geologically isochronous with the overbank level B in SHKM (Diez-Martín *et al.* 2014a). For these reasons, which may have important implications for the study of local technological and economical variability in the palaeolandscape of the SHK complex in further investigations, we include here a taphonomic analysis devoted to assessing the integrity of the palimpsest unearthed in SHKE B2.

In fluvial contexts, such as the one identified in SHK, most postdepositional disturbance processes are linked to the effect of water action upon anthropogenic accumulations (Schick 1986, 1987; Petraglia & Nash 1987; Petraglia & Potts 1994). In the particular case of clay plains as at SHK, two external processes related to water flux operate, diffuse and concentrated runoff. Concentrated runoff applies in cases when water is restricted to the riverbed or when it is located in small depressions in the plain (in this situation, it may be able to erode the clay substratum and generate new channels). In this case, flux concentration tends to make channel energy much higher, which explains the presence of coarse-grained sands, gravels and pebble lags within the channel matrix. In this case, surface runoff is enhanced by an impermeable clay substratum. Although the dense archaeological accumulation of Level A in SHKM was deposited in a river channel, a number of taphonomic signals (Diez-Martín *et al.* 2014a) suggest that the effects of water action were less severe than expected.

On the plain and the overbanks, diffuse runoff takes place during rain events or when the flooding volume overflows the channels. In this case, flux is relatively slow and water will dam for a period of time, fostering the formation of low-energy deposits via decantation. This is the case for Unit 3, which preserves Level B in both SHKE and SHKM. Sedimentary and taphonomic data retrieved from SHKE confirm a low-energy context for the preservation of the archaeological palimpsest, although the effects of water action cannot be ruled out. First of all, an orientation analysis of the archaeological material was undertaken using the Minimum Bounding Geometry tool of the ArcGis Data Management toolkit. This method calculates the orientation angle of the main axis of each archaeological specimen (Boschian & Saccà 2010; de la Torre & Benito-Calvo 2013; García-Moreno *et al.* 2016; Sánchez-Romero *et al.* 2016). The analysis was carried out using remains ≥20 mm showing an elongation index ≥1.6 (Bertran & Lenoble 2002). Out of a total collection of 1384 specimens retrieved from archaeo-unit B2, only 464 (33.5%) fulfil these two premises (223 lithics and 241 fossil bones). Specimen vectors were calculated (μ = mean vector, and r = length of mean vector) with the aid of Oriana 4 software. Figure 17 shows the general rose diagram of orientations within the sampled population in SHKE B2, indicating a low diversity of specimen orientation. In order to improve the results shown by the histogram, a Rayleigh Uniformity test (p = 5.41 E06) and a Kuiper's test (p = <0.01) were performed, confirming that the analysed sample is anisotropic. This orientation pattern accords with a situation in which water forces in a fluvial environment, although most likely related to diffuse runoff (as discussed in previous paragraphs), have played a role in reorientating the archaeological items within the patch unearthed in Level B2. Even low-energy hydraulic forces can produce reorientation patterns of archaeological materials, but orientation per se cannot determine the degree of integrity of archaeological sites

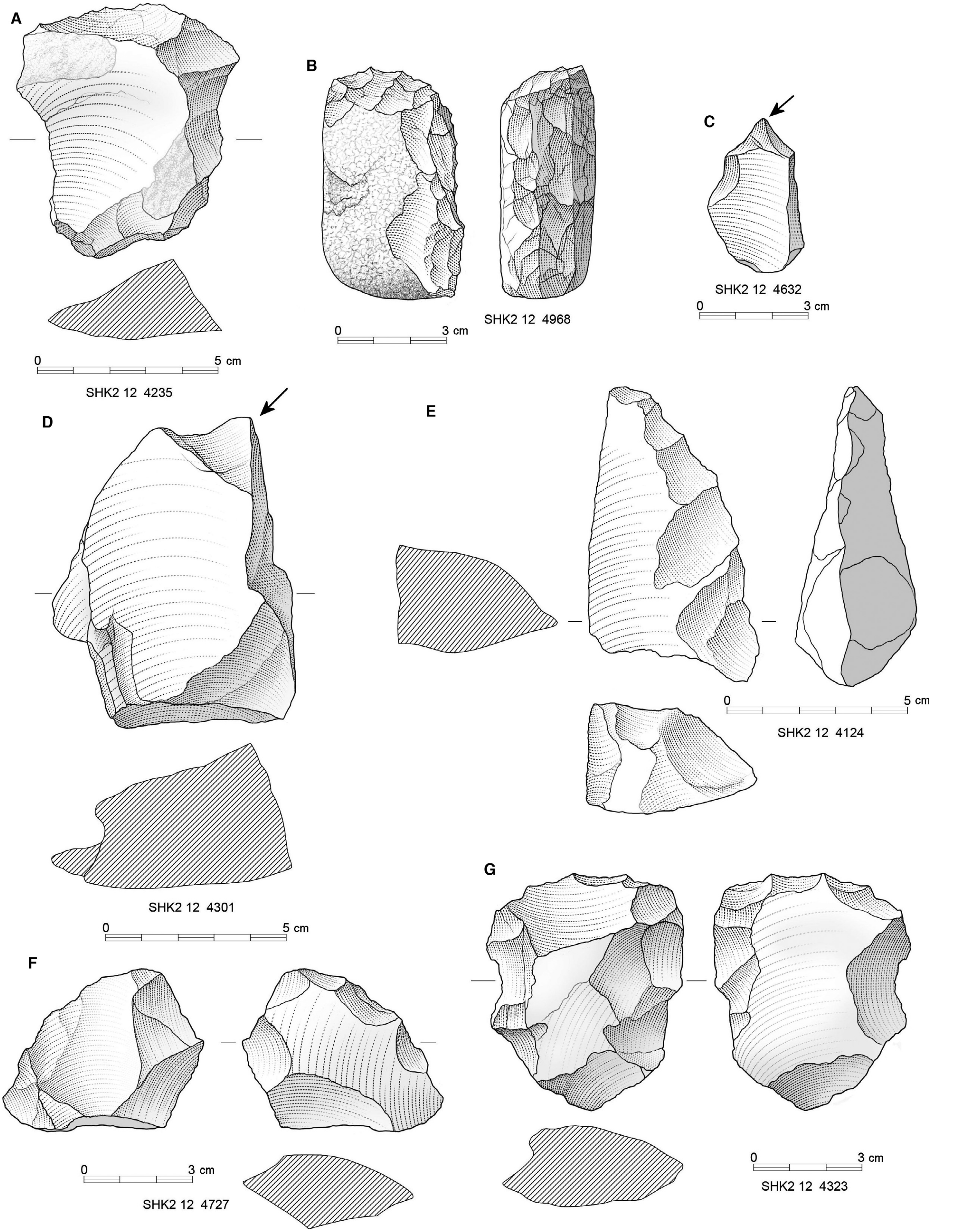

Fig. 16. Lithic artefacts from SHK E. LB2: A. Quartz flake showing side and distal retouch. B. Unifacial chopper. Small quartz pebble showing side and transversal abrupt retouch. C. Borer on a broken quartz flake (the arrow indicates the position of the trihedral point). D. Quartz flake showing removals that determine a pointed edge (the arrow indicates the position of the trihedral point). E. Lateral scraper with continuous simple retouch and proximal area reduced with abrupt retouch. F. Quartz flake with lateral inverse and continuous retouch. G. Basalt flake with circular bifacial retouch. Drawings by Francisco Tapias.

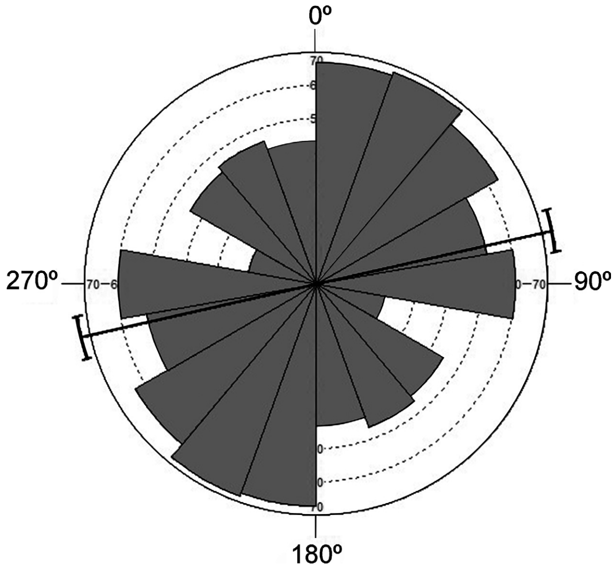

Fig. 17. Rose diagram showing the orientation of the archaeological specimens analysed using MBG.

(see Domínguez-Rodrigo *et al.* 2012b, 2014b). On the contrary, taphonomic signals other than the low-energy depositional context described in previous sections (i.e. high contribution of the small/light lithic and faunal fraction to the archaeological sample, scant presence of polished specimens, very low percentage of unmodified material, and identification of lithic refittings) strongly suggest that the patch preserved in SHKE Level B2 can be interpreted as an autochthonous collection, although reorientated by low-energy water action.

First of all, there is a high correlation between the small fraction of the archaeological sample and the action of water fluxes (Binford 1978; Schick 1986, 1987; Petraglia & Nash 1987; Bertran *et al.* 2012; Domínguez-Rodrigo & García-Pérez 2013). In SHKE B2, a remarkable feature of the lithic and bone collections is the high percentage of small items. Particularly, in the case of lithic materials, the abundant presence of ≤25 mm debris is a sufficiently explicit trait (Delagnes & Roche 2005; Delagnes *et al.* 2006). As we have seen in previous sections, debris make up 51.28% of the collection retrieved from level B2 and, if we add to this percentage other flake fragments and undetermined positives located in the same dimensional range, a total of 54.24% of the whole lithic sample is made up of small specimens. Furthermore, when all specimens are included within the dimensional classes established by Kroll (1997), we see that 44.4% of the sample is constituted by remains ≤19 mm (Fig. 18). The density distribution of these objects within the excavation grid is shown in Fig. 19.

The relevance of the small fraction in the B2 collection, significantly higher than in Level B at SHKM (Diez-Martín *et al.* 2014a), accords with a situation in which on-site lithic activities must have been relatively well preserved (Schick 1986; Marder *et al.* 2011). When faunal remains are sorted by maximum dimension, a similar pattern arises (Fig. 20), as the small fraction of bones and splinters (<30 mm) constitutes 18% of the sample, while the most abundant bone size-class is represented by the interval 30–39 mm.

When mass is taken into consideration, it appears that 53.58% of the lithic sample is made up of specimens ≤5 g (Fig. 21). The spatial distribution of lithic artefacts sorted by mass class (Fig. 22) does not show a prominent spatial bias, as specimens of different mass classes are homogeneously distributed within the area (Kroll 1997). However, it is important to note a significant cluster of heavy items (≥150 g), including most of the unmodified pebbles, towards the south of the trench, precisely an area in which ≤10 g pieces are scarce (Fig. 19) and most of the abraded pieces are located. This cluster needs to be taken into consideration when the SHKE trench is enlarged to the south in order to unveil whether these traits can be related to taphonomic or anthropogenic factors.

The lithic archaeological sample was also analysed with regard to polishing (Petraglia & Potts 1994; Shea 1999). Both lithic and faunal remains were divided into three categories according to the degree of polishing/abrasion: R1, mint fresh/fresh specimens, showing no signs of alterations on surfaces, edges and ridges; R2, specimens showing slight/moderate polishing; R3, artefacts with heavily rounded edges and/or flattened dorsal ridges. Table 5 shows the distribution of lithic artefacts sorted by polishing category and archaeo-unit. Overall, the levels taken together show a mean percentage of 95.68% of fresh specimens, while pieces showing some sort of abrasion constitute a mean of 4.31%. Specimens affected by intense polishing/abrasion are more abundant in unit B1, where they represent 7.62% of the sample. Regarding unit B2, numbers and percentage are significant. While 96.2% of the collection was classified within the group of mint-fresh specimens, only 0.79% of items were considered to show an intense alteration. These data

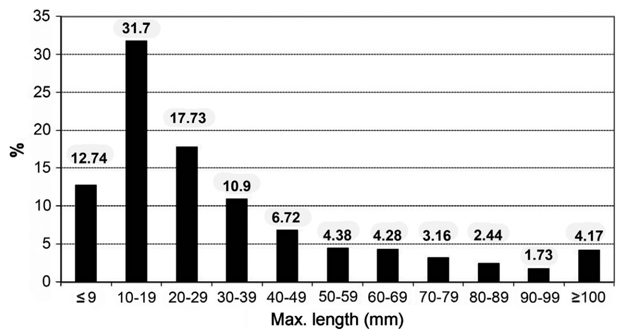

Fig. 18. Percentage contribution of the lithic collection retrieved from SHKE B2, distributed by the maximum length classes established by Kroll (1997).

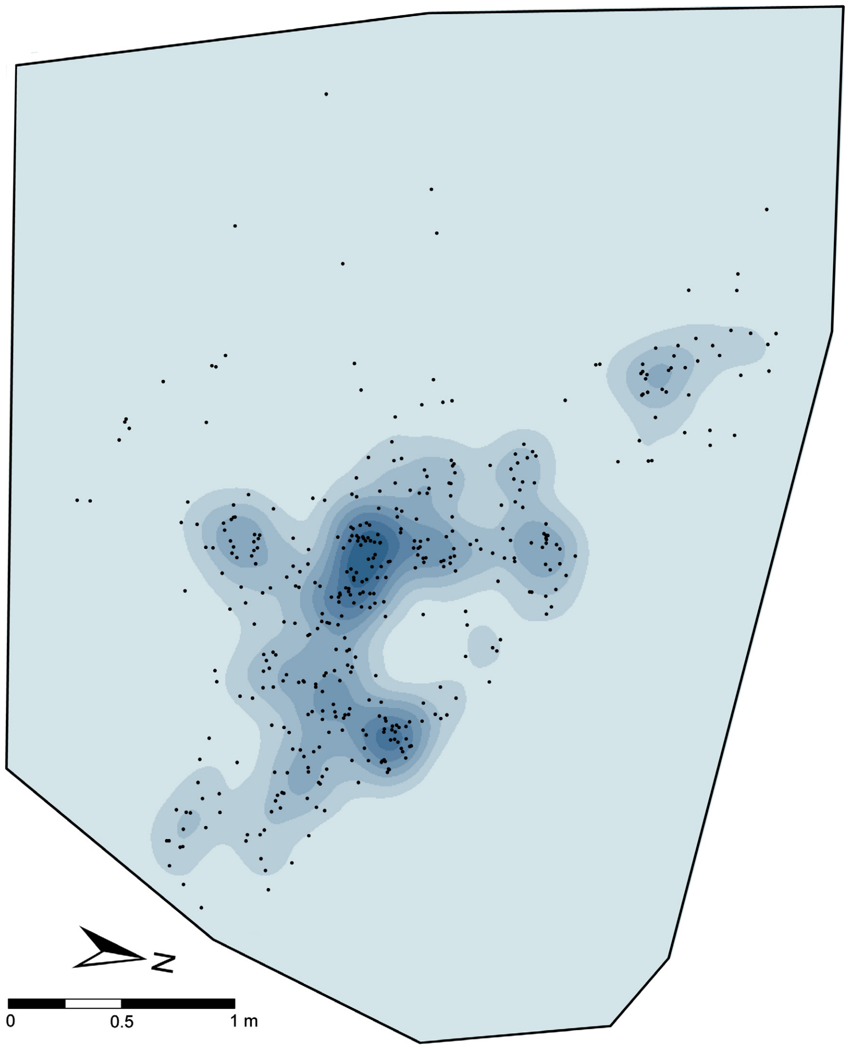

Fig. 19. Horizontal distribution and density of ≤20 mm lithic specimens in SHKE B2.

are well in agreement with those observed in the bone sample. Although faunal remains tend to be more sensitive to water forces (Schick 1986, 1987) and tend to show higher numbers of polished specimens in fluvial contexts (Diez-Martín *et al.* 2014a; Domínguez-Rodrigo *et al.* 2014b), the bone collection retrieved from level B2 shows that water action has been moderate. While fresh (R1) specimens constitute 73.11% of the sample (n = 272), fossil bones showing polishing (R2) represent 15.86% (n = 59) and intense abrasion (R3) sums 41 specimens (11.02%).

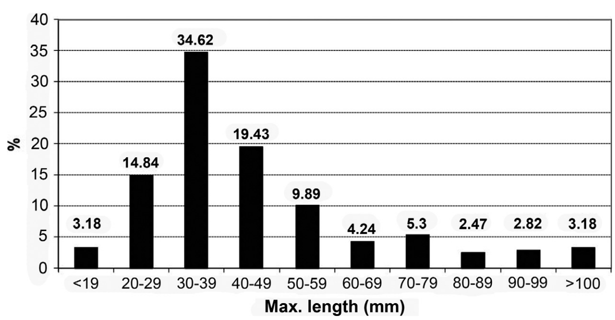

Fig. 20. Percentage contribution of the faunal collection retrieved from SHKE B2, distributed by the maximum length classes established by Kroll (1997).

Lithic refitting

Preferential use of Naibor Soit quartz, a friable raw material with a high degree of homogeneity at the macroscopic level (Diez-Martín *et al.* 2011), has hampered the implementation of a lithic refitting program in SHKE (Cahen *et al.* 1979; Cattin 2002; Proffitt & de la Torre 2014). For these reasons, and regarding the RMU approach, we were able to identify few raw material sub-groups, none of them represented by more than three items. As almost 45% (n = 521) of the lithic sample is made up of specimens ≤2 cm, a size range that makes the identification of morphological traits extremely difficult

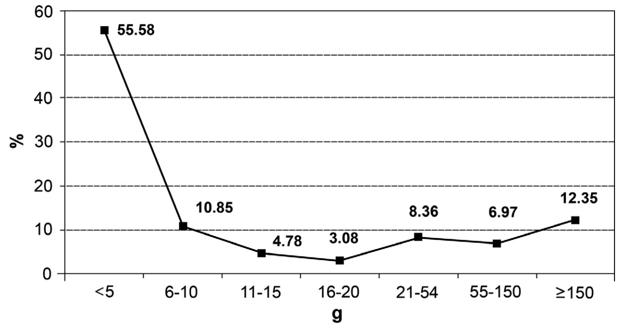

Fig. 21. Percentage contribution of the lithic collection retrieved from SHKE B2, distributed by mass classes.

(Schick 1986; de la Torre *et al.* 2004; López-Ortega *et al.* 2011, 2015), the search for refittings was restricted to a population of 759 artefacts (65.48% of the total collection retrieved from SHKE). Out of this sample, 22 lithic objects (1.98% of the sample) were satisfactorily refitted in seven different sets. Their main characteristics are shown in Table 6. Four refits are constituted by pairs of conjoining elements, while the rest involve more than two articulating artefacts. Of particular interest is Set D, formed by seven elements, revealing actions related to the knapping process of a basalt nodule (Fig. 23). As regards raw material, four refits are in basalt and three in quartz. In the studied sample, conjoins predominate (n = 5), while two sets (B and D) can be strictly defined as refits (i.e. the reconstruction of actions linked to a test core and a shaped chopper). Refitting yielded valuable spatial data (Table 6). When considering the horizontal distributions of the articulating pieces in each set (Fig. 24), most of them (n = 4) are constituted by pieces separated by short distances (<50 cm), while two are made up of pieces separated by medium distances (50 cm–1 m). Only Set E shows a long horizontal pattern, reaching almost 2 m in distance between individual pieces. Regarding vertical distance, matched pieces tend preferentially (n = 5) to be separated by <5 cm. Correspondence between refittings and archaeo-units is excellent. Most refits correspond to specimens in Level B2 (Fig. 25). Only one specimen in Set A, identified as a percolated object, was retrieved within the disruption between levels B2 and B1.

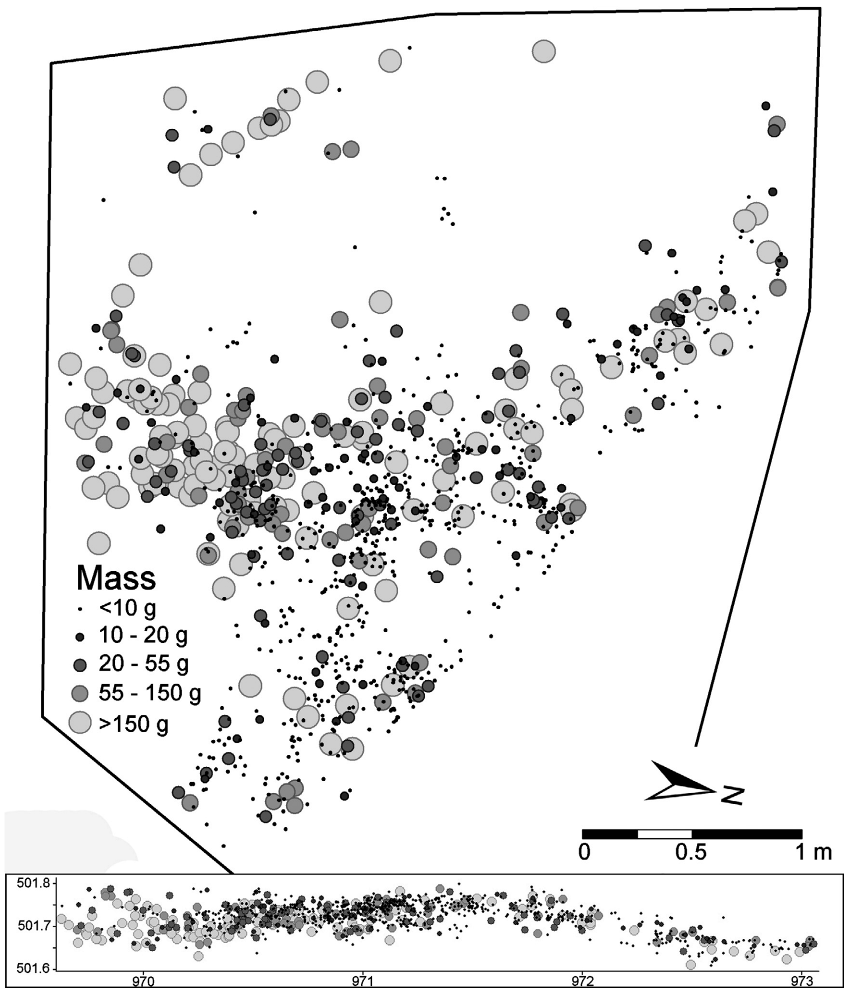

Fig. 22. Horizontal distribution of artefact mass classes in SHK B2.

Table 5. Number and percentage distribution of lithic specimens from SHKE B2, sorted by archaeo-unit and abrasion category.

Abrasion category	Level C		Level B2		Level B1		Total	
	n	%	n	%	n	%	n	%
R1	27	93.1	974	96.24	108	91.52	1109	95.68
R2	1	3.44	30	2.96	1	0.84	32	2.76
R3	1	3.44	8	0.79	9	7.62	18	1.55
Total	29		1012		118		1159	

Discussion

Interpreting lithic inter-assemblage variability constitutes a recurrent concern for archaeologists interested in the study of human evolution (Isaac 1981; Blumenschine & Masao 1991; Rogers 1997; Blumenschine & Peters 1998; Domínguez-Rodrigo *et al.* 2005; Tactikos 2005; Diez-Martín *et al.* 2012; de la Torre & Mora 2013). Synchronic and/or diachronic changing patterns in the composition of lithic assemblages can be influenced by a number of key factors relevant for our understanding of the adaptive patterns and behavioural processes operating in hominin evolution: landscape use and mobility strategies, techno-economic and environmental strategies, inter-related diversification of site functionality, or socio-cultural developments (Sullivan 1987).

In order to minimize as much as possible limitations that can blur the array of interpretative inferences linked to inter-assemblage variability, particularly those imposed by time-averaging (Stern 1993, 1994; Holdaway & Wandsnider 2008; Fluck 2011) or postdepositional biases in ESA contexts (Shott 2008), researchers have paid attention to the identification and analysis of minimum archaeo-stratigraphical units through the excavation of isochronous archaeological horizons over broad lateral exposures (Blumenschine & Masao 1991; Blumenschine & Peters 1998; Potts *et al.* 1999). Despite its remarkable significance for interpretative purposes (Isaac 1981), this precise landscape approach to the study of the ESA archaeological record is not a particularly common procedure. Furthermore, it has rarely been accompanied by an in-depth time-resolution evaluation of the spatial component of archaeological aggregates.

The quality of the archaeological record unearthed in the SHK fluvial landscape constitutes a remarkably valuable data set to refine our current understanding and interpretation of the long-running debate of inter-assemblage variability during Bed II times in Olduvai

Table 6. Summary of main information related to the connection sets identified in the lithic assemblage from SHKE: set code, number of pieces involved per set, catalogue numbers, archaeo-stratigraphical units involved in the connection, raw material, type of connection (1 = refit; 2 = conjoin), maximum horizontal and vertical distances (in cm) between pieces involved in each connection, and descriptive observations.

Set	No. of pieces	Catalogue numbers	Archaeo-units involved	Raw material	Connection type	Distance (cm)		Description
						Horizontal	Vertical	
A	2	3758, 3764	B1, B2	Basalt	2	58	7.0	An undetermined positive that conjoins to a hammerstone showing intense scarring and battering.
B	2	4128, 4298	B2	Quartz	1	15	4.4	A poor-quality quartz core that refits to an undetermined fragment. Test core.
C	4	4133, 4153, 4167, 4168	B2	Quartz	2	42	7.2	Conjoin between an almost complete large flake and three lateral flake fragments. This refit group shows the greatest vertical distance amongst matched elements.
D	7	4143, 4619, 4620, 4621, 4622, 4623, 4749	B2	Basalt	1, 2	40	2.6	Refit between an oval cobble, shaped by few shallow removals in order to obtain a lateral working edge, and several detached products: three whole flakes, one debris, and two conjoining broken fragments of a split flake.
E	3	4543, 4566, 4589	B2	Basalt	2	185	1.8	Three conjoining fragments of an incomplete oval cobble. No percussion marks can be observed, so breakage might be due to reasons other than pounding.
F	2	4741, 5145	B2	Quartz	2	62	2.3	Two conjoining indeterminate broken fragments.
G	2	5041, 5139	B2	Basalt	2	11	1.8	Conjoin between a battered pebble and a percussion flake.

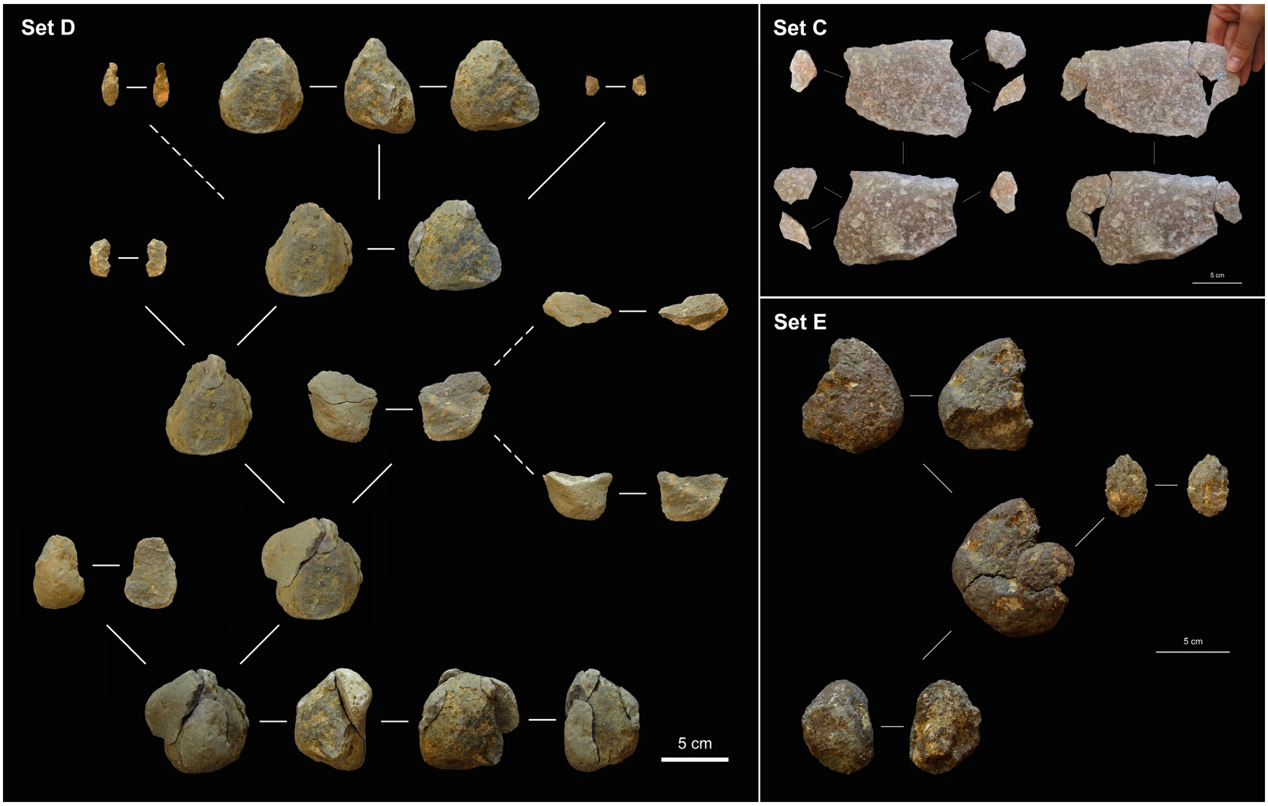

Fig. 23. Reconstruction of various refitting sets identified in SHKE.

Gorge (Semaw *et al.* 2009; Diez-Martín & Eren 2012; de la Torre & Mora 2013). The discovery of a precise stratigraphical interval, laterally continuous over a broad area, and preserving fractions of anthropogenic activity at different points of the same fluvial network makes it feasible to identify the variable techno-economic ways in which hominins responded to the local palaeo-landscape that operated in this area of the Gorge at *c.* 1.5 Ma. It thus represents a robust tool of inference for exploring the Developed Oldowan/Acheulean interface (hereafter DO/A) from a more landscape-orientated perspective. With this goal in mind, a substantial part of the present study was devoted to the assessment of the spatial and temporal integrity of the new window opened in SHKE, refining the analytical tools already explored for the study of SHKM (Diez-Martín *et al.* 2014a).

Nowadays, and particularly in the framework of micro-spatial analyses, it is assumed that most, if not all, archaeological aggregates must be understood as palimpsests formed by the succession of an undetermined number of accumulation events (caused independently by human and/or non-human agents) over an undetermined period of time (Bailey 2007). The palimpsest character determines, inevitably, our analysis and interpretation of past human behaviours. The very process of archaeological material superposition can alter, move and even destroy anthropogenic remains accumulated through time, covering up spatial patterns. Furthermore, palimpsests tend to mask and/or reduce variability of past human behaviours.

In the present study, much effort was made to refine time resolution in SHKE. The most significant challenge we faced is the correct definition of minimum units of analysis susceptible to interpretation in terms of both spatial organization and behavioural attribution. Using currently available analytical methods (Vaquero 2008; Chacón *et al.* 2015; Bargalló *et al.* 2016; Machado & López 2016), such as archaeo-stratigraphy, taphonomic evaluation and identification of refitting sets, the most temporally bounded basic units of behavioural analysis were established, particularly in the case of archaeo-unit B2. As explained at length in previous sections, this unit is geologically contemporary with the accumulation deposited in the channel and bank at SHKM and, thus, both data sets are enormously relevant to tackling synchronic technological variability in the framework of the DO debate from an alternative (let us say, fine-grained or horizontal approach) landscape perspective. In line with this, it is very important to note that to date the evaluation of the meaning of inter-assemblage variability during the DO/A interface has mainly been undertaken from a coarse-grained

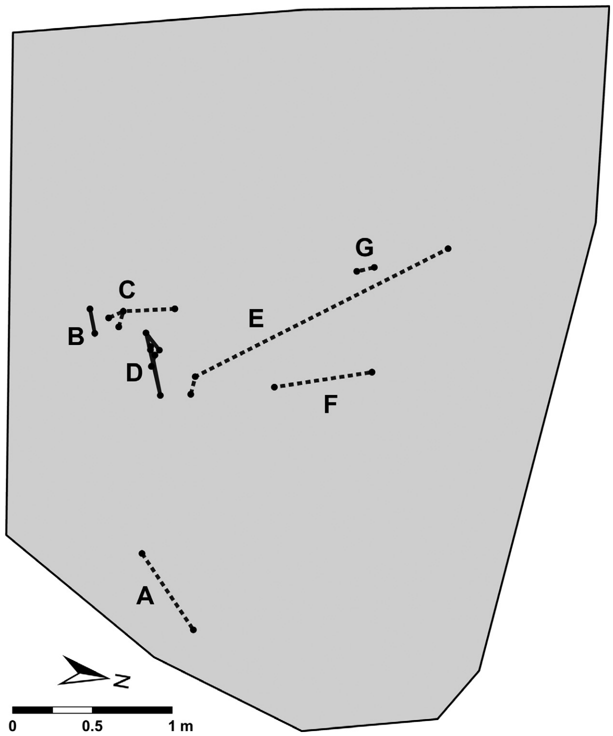

Fig. 24. Horizontal distribution of the articulating pieces in each refitting set.

(vertical and over time) temporal perspective, covering the whole archaeological sequence of Bed II in Olduvai Gorge, as originally studied by Leakey (1971, 1976).

The term DO was coined by Mary Leakey as a result of her description of the cultural sequence observed in Olduvai Gorge (Leakey 1967, 1971, 1976). Leakey noted that in Middle and Upper Bed II, a shift towards larger proportions of percussion artefacts and a small percentage of crude small handaxes could be identified and differentiated from classical Oldowan assemblages (Leakey 1967). The cultural entity of the DO was subsequently refined in a tripartite sequence (DOA, DOB and DOC) grounded on the stratigraphical position of the archaeological assemblages and variations in their artefact composition (Leakey 1971, 1976). As assemblages identified as DOB and Acheulean (the referential site for the latter being EF-HR, where handaxes occurred in a noticeably higher proportion and were accompanied by large flakes) were stratigraphically pene-contemporaneous in Middle and Upper Bed II (i.e. both entities were found above Tuff IIB at *c.* 1.6 Ma), Leakey's interpretation of the inter-assemblage variability in Middle and Upper Bed II was mainly supported by quantitative, typological and stylistic criteria (form, frequency and refinement of handaxes). These bore cultural consequences: the co-occurrence of two distinctive cultural traditions, produced by different hominin species with heterogeneous technological backgrounds (Leakey 1971, 1976).

Subsequently, Leakey's interpretative framework triggered a very intense and long-lasting debate on the meaning of the DO/A dichotomy. Researchers have suggested that, rather than in cultural patterns, differences and variations between lithic assemblages in Bed II could be more accurately explained through variations in the properties of raw materials used (Stiles 1979, 1981, 1991), mobility patterns and differences in the phases of the reduction sequence preserved in different places (Jones 1994) or functional parameters (Gowlett 1986). Recent reappraisals of the DO/A phenomenon (de la Torre & Mora 2005, 2013; Semaw *et al.* 2009; Diez-Martín & Eren 2012), supported by the recent discovery of Early Acheulean sites in Olduvai and in other East African regions pre-dating DO assemblages (Lepre *et al.* 2011; Beyene *et al.* 2013; Diez-Martín *et al.* 2015), coincide in attributing previously labelled DO sites to the Acheulean technological concept (de la Torre 2011; Gallotti 2013). Thus, most researchers currently favour the idea that the highly diverse technological variability that seems to have flourished after the onset of the Acheulean at around 1.7 Ma is better explained by a number of functional, ecological and/or locational parameters (de la Torre 2016).

The archaeological record recently unearthed in SHKE and SHKM adds valuable information to understand the nature of inter-assemblage variability in Bed II regarding the DO/A debate and complements recent revisions of the classical collections excavated in SHK by Mary Leakey (de la Torre & Mora 2013). The lithic collection retrieved from SHK was originally labelled within the DOB complex, including high proportions of percussive artefacts (mostly spheroids, sub-spheroids and MBB), choppers

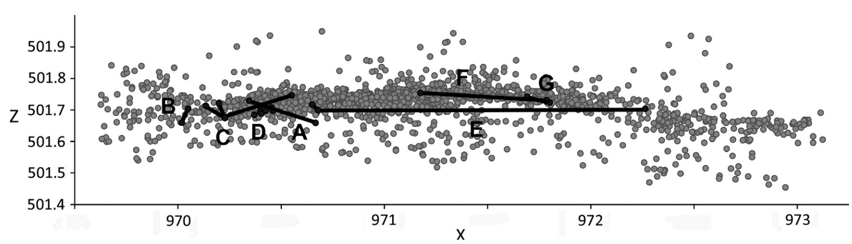

Fig. 25. Vertical distribution of the articulating pieces in each refitting set.

and light-duty tools along with a non-negligible collection of bifaces (Leakey 1971, 1976). A recent reappraisal of Leakey's SHKM and SHKA collections led to a remarkably different and extremely interesting interpretation of the technological behaviours observed in SHK (de la Torre & Mora 2013), including traits representative of the Acheulean (de la Torre 2016). In SHKA, for instance, these authors recognized three LCTs (0.7% of the total sample studied) and five ≥10 cm large flakes (1.2%). Furthermore, the contribution of specimens related to percussion (spheroids, sub-spheroids, anvils and hammerstones) to the general counts constitutes 6.1%. In SHKM, LCTs are more abundant (n = 18), including seven specimens that were produced on large flake blanks. Some of the SHKM LCTs were reported to be the result of intense bifacial and invasive reduction (de la Torre & Mora 2013).

Amongst the SHKE lithic collection, there are a number of traits that are in agreement with de la Torre and Mora's interpretation of the old lithic samples and consistently support the current vision of the DO/A gradient. The contribution of MBBs to the percussion group is moderate and does not fully accord with the parameters established by Leakey for the DOB complex (Leakey 1971, 1976). Most of the percussion elements are basaltic rounded cobbles with traces of intense battering activity, while clearly identified spheroids or sub-spheroids are scarce. However, there are significant examples suggesting the continuum represented by polyhedral forms and spheroidal forms, as a number of quartz cores exploited on multiple planes display initial phases of shape transformation via intense battering and frosted surfaces (Sánchez-Yustos *et al.* 2015). Although the core sample retrieved does not display complex operational exploitation strategies of small- and medium-sized flakes (through the implementation of more organized platform preparation and flake predetermination), a technological trait that is currently claimed to represent a complementary marker of the Acheulean innovations (de la Torre 2009, 2011), large flake production, is proven by a far from negligible collection of ≥100 mm flake preforms and a large flake core.

It is widely acknowledged that Glynn Isaac (1969, 1977, 1984, 1986) claimed that one of the relevant technological traits that identified the Acheulean techno-complex was the ability to produce large flakes, that is to say, the recurrent detachment of flakes with a maximum dimension ≥100 mm (*sensu* Kleindienst 1962). The exploitation of large cores for the production of large flakes (Toth 2001; Madsen & Goren-Inbar 2004) and the subsequent use of these flakes as blanks for LCT shaping have been considered to require more progressive technical and cognitive skills than those observed during the previous Oldowan techno-complex (Isaac 1986; Wynn 1989; de la Torre 2011, 2016). There is a common consensus amongst researchers interested in the study of the Early Acheulean to consider flakes ≥100 mm as an indicator of the large flake production ability of Early Acheulean knappers (Sharon 2007; de la Torre *et al.* 2008; Semaw *et al.* 2009; de la Torre 2011; Chevrier 2012; Diez-Martín & Eren 2012; Beyene *et al.* 2013; Diez-Martín *et al.* 2014b,c, 2015). This ability accords with the diverse collection of LCTs retrieved from SHKE that includes a variety of formal types, some of them showing a high degree of tool configuration through invasive series of volumetric treatment (handaxes) and some others exhibiting more casual shaping strategies (knives and pointed forms), all of them produced preferentially in quartz on large flake blanks.

Although a more in-depth analysis is needed, when we compare these technological data with those observed in the lithic collections retrieved from the isochronous A (channel) and B (overbank) levels of SHKM, an interesting pattern arises: while LCTs are remarkably poorly represented and large flakes are absent in SHKM, these tools constitute a qualitatively important category in SHKE. By contrast, the rather simple exploitation strategies preferentially implemented in SHKE contrast with the identification of core preparation patterns in SHKM (Sánchez-Yustos *et al.* 2017). It is relevant to note that presence of LCTs and production of large flakes, on the one hand, and predetermined cores, on the other, have both been considered key traits with which to define the Acheulean techno-complex technologically (de la Torre & Mora 2005; de la Torre 2011; Gallotti 2013).

Certainly, the flourishing and diversification of technological behaviours seems to be a remarkable attribute in the framework of the Acheulean emergence (i.e. *c.* 1.7–1.4 Ma): an early shift towards consistent LCT and/or large flake preform production at Kokiselei 4 (Kenya), Konso (Ethiopia) and FLK West (Olduvai Gorge, Tanzania) (Lepre *et al.* 2011; Beyene *et al.* 2013; Diez-Martín *et al.* 2015), the preferential production of large flakes and a variety of LCT forms at EF-HR (Olduvai) and Lepolosi and Noolchalai (Peninj) (de la Torre & Mora 2005; Diez-Martín *et al.* 2014b, c), the presence of low percentages of LCTs and large flake blanks (SHKE, this paper) combined or not with prepared medium-sized cores at SHKM, BK (Olduvai), Garba IV and Gadeb 2E (Ethiopia) (de la Torre 2011; Gallotti 2013; Sánchez-Yustos *et al.* 2016) and the exclusive presence of prepared cores at Nyabusosi (Uganda) (Texier 1995).

The extremely diverse picture that emerges in the East African archaeological record in this period of time can be well epitomized by the case of the lithic collections retrieved from the Type Section of Peninj at *c.* 1.5–1.4 Ma (Diez-Martín *et al.* 2012). Stratigraphically bracketed between sites classified as Early Acheulean (Domínguez-Rodrigo *et al.* 2009), including the classical sites of ES2-Lepolosi and EN1-Noolchalai, where abundant accumulations of LCTs and large flake preforms have been excavated (Diez-Martín *et al.* 2014b, c), the Type Section lithic collections proximal to the lake largely consist of small- and medium-sized cores and flakes with no sign of preparation or predetermination, and a remarkably residual presence of LCTs, large flakes and LCT resharpening flakes (Diez-Martín *et al.* 2012). The Type Section industry has been claimed to be part of the regional Acheulean of Peninj (de la Torre *et al.* 2008; Diez-Martín *et al.* 2012). Inter-assemblage variability in Peninj (focus on LCTs and large flake blanks on the one hand and prevalence of small flake production on the other) has been interpreted in terms of environmental, territorial, functional and/or economic interests or constraints and may be the result of different procurement, accumulation and discard patterns operating on a regionally inter-related landscape (Diez-Martín *et al.* 2012). In Peninj, highly fragmented *chaînes opératoires* could be responsible for the formal differences observed between the lithic collections from the Escarpment sites and the Type Section sites. This fragmentation might have been driven by different functional tasks and constraints operating at a regional scale.

Different technological traits currently considered to be representative of the Acheulean clearly co-occur at SHK but, importantly, they do not seem to be coincident in very close fractions of the same palaeo-landscape. The fine-grained technological diversity observed in these two spatial windows of a synchronous landscape at SHK is extremely significant. It reveals, for instance, that interpretations of inter-assemblage variability at much more coarse-grained scales and their contribution to the DO/A debate in terms of cultural or functional perspectives (de la Torre & Mora 2013) still have a long way to go to provide a more detailed picture of the constellation of behavioural patterns operating within the current interpretative paradigm. SHK demonstrates that, even within a very restrictive spatio-temporal interval, a complex and subtle array of factors might be operating at a local scale in order to create a remarkably diverse and variable mosaic of technological behaviours amongst hominins in the Olduvai basin during Bed II times.

Conclusions

Through fieldwork carried out in SHKE it has been possible to enlarge our understanding of hominin presence in the SHK area. Relevant conclusions are the following:

- The trench opened in SHKE represents a supplementary window in the SHK palaeo-landscape, constituted by a network of small channels formed in a muddy plain and draining northwards to the palaeo-lake. Intense hominin activities took place in different portions of this fluvial network, where SHKM and SHKA are two examples of the complex spatial distribution of the anthropogenic presence in the area.
- Archaeo-stratigraphical analysis undertaken in SHKE allowed the identification of three archaeological levels. Levels B1 and B2 were deposited on the left bank of the channel, constituted by a geologically homogeneous clay unit. Both levels are separated by a continuous hiatus. Level B2, resting on top of the bank, represents a significant high-density accumulation of archaeological materials.
- Level B2 in SHKE is isochronous with Level B in SHKM. Both levels are located in the same stratigraphical position: on the bank of two channels with similar dimensions and flowing in the same direction.
- The most representative lithic sample retrieved from SHKE was unearthed from Level B2. The traits that technologically define this level are the following: (i) overall predominance of quartz, but preference for basaltic cobbles for percussion activities; (ii) high proportion of waste; (iii) preference of volcanic hammerstones over quartz MBB; (iv) preferential production of small- and medium-sized flakes; (v) low percentage of retouched flakes in non-standardized forms; (vi) predominance of casual and polyhedral cores, scarce contribution of bipolar knapping and absence of core preparation; and (vii) qualitative significance of a diverse group of LCTs and large flakes.
- A number of traits bearing taphonomic implications favour a scenario in which low-energy processes prevailed over fluvial forces leading to natural transport and severe re-accumulation: (i) the good preservation of the small fraction amongst fossil bones and lithic implements; (ii) the predominance of fresh specimens with no signs of roundness or abrasion; and (iii) the low frequency of unmodified material in the collection.
- The identification of seven different sets of refits (involving 22 volcanic and quartz specimens) reinforces the idea of stratigraphical integrity and low taphonomic bias in archaeo-unit B2.
- The technological behaviours observed in SHKE, in the framework of the SHK complex, confirm that inter-assemblage variability during Bed II times operated in very close fractions of synchronic palaeo-landscapes.

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