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Acheulean without handaxes? Assemblage variability at FLK West (Lowermost Bed II, Olduvai, Tanzania)

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Summary - *The FLK West sequence is divided into six fluvial stratigraphic levels, each of which provided archaeological materials. In the present paper we outline the major similarities and differences displayed by the lithic assemblages in FLK W, particularly the lower assemblages, which have yielded more objects than the upper ones. The differences noted in the absence/presence and frequency of LCTs may be explained in occupational terms, while the similarities in raw material selection, core reduction and flake retouching patterns indicate homogeneous cultural decisions and cognitive skills. We conclude that these assemblages were likely formed by the same hominin group or taxon and, therefore, the assemblage variability registered would correspond to different expressions of the same economic structure.*

Keywords - *Oldowan, Developed Oldowan, Early Acheulean, Handaxe, Olduvai.*

Introduction

The Acheulean appeared *ca* 1.7 Ma in the East African Rift Valley. The earliest evidence comes from Kokiselei 4 (KS4, West Turkana, Kenya) and KGA6-A1 (Konso, Ethiopia) and dates back to 1.76-1.74 Ma (Lepre *et al.*, 2011; Beyene *et al.*, 2013). However, the dating procedure employed in both sites, largely based on inter-basin correlations, may suggest an open margin for chronological variation (Diez-Martín *et al.*, 2015). The radiometric dates for the tuffaceous sediments underlying and overlying the stratified archaeological sequence registered in FLK West (FLK W, Olduvai, Tanzania) have constrained the Acheulean materials documented within them to between 1.69 and 1.66 Ma (Diez-Martín *et al.*, 2015). These materials are stratigraphically situated much closer to the lower tuff (Fig. 1). Notwithstanding the uncertain chronological differences that might exist among the three mentioned sites, their techno-typological affinities seem to suggest the homogeneity and rapid dispersal across East Africa of the new technology (Sánchez-Yustos *et al.*, 2017a).

It has been noted that both handaxe-bearing assemblages and non-handaxe-bearing ones co-occurred in the same palaeolandscape in KS4, KGA6-A1 and FLK W (Lepre *et al.*, 2011; Beyene *et al.*, 2013; Uribelarrea *et al.*, 2017). Actually, these sites represent the beginning of the patchy nature that characterised the archaeological record of the Oldowan-Acheulean gradient (OAG, *ca* 1.8-1.3 Ma). The Bed II archaeological record represents the quintessence of this phenomenon (Leakey, 1971). The inter-assemblage variability documented during this period has been ordered according to the absence/presence/frequency of handaxes, interpreted in terms

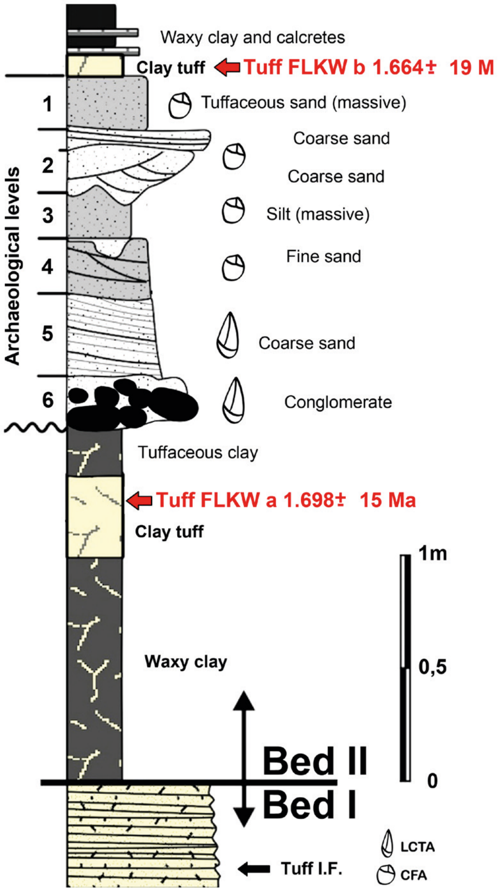

Fig. 1 - Stratigraphic section at FLK West. Large cutting tool assemblage (LCTA) and core-and-flake assemblage (CFA) (Modified from Diez-Martín* et al.*, 2015, Fig. 1). The colour version of this figure is available at the JASs website.

of cultural progression (see review in de la Torre & Mora, 2014).

FLK W is the only site on the OAG where different types of assemblages according to the absence/presence/frequency of handaxes and other Large Cutting Tools (LCTs) are interstratified in the same sequence (Diez-Martín *et al.*, 2015). The objectives of this paper are: (1) to present a detailed technological description of the six archaeological levels at FLK W; (2) to conduct an inter-assemblage comparison (3) and, on this basis, to discuss the behavioural and palaeoanthropological implications of the assemblage variability registered in Bed II at Olduvai.

Materials and Methods

FLK W is located in a fluvial palaeo-channel that flowed from the Lemagrut volcano slopes to the central Olduvai palaeo-lake. The FLK W channel (about 40 m wide with a maximum depth of 1.2 m) is infilled with a sequence of six stratigraphic levels that correspond to different flood events and all of them have provided archaeological remains (Fig. 1). Stratigraphically, FLK W is situated in the lowermost Bed II, between Tuff II-A and Tuff II-B (see Uribelarrea *et al.*, 2017, Fig. 4). Since its discovery in 2012 due to an intensive survey focused on the lowermost Bed II (the publication of the new date of KS4 the year before encouraged us to carry out the survey), FLK W has been the object of an extensive excavation and multidisciplinary research (Diez-Martín *et al.*, 2015; Sánchez-Yustos *et al.*, 2017a; Uribelarrea *et al.*, 2017; Yravedra *et al.*, 2017; this work).

The chronology and geology of FLK W was presented in an earlier publication, together with a preliminary technological and taphonomic description of the lithic and faunal assemblages recovered in the Acheulean levels (levels 5-6) (Diez-Martín *et al.*, 2015). More recently, we have presented a techno-functional analysis of the large and heavy tools documented in the lower levels (Sánchez-Yustos *et al.*, 2017a). This paper presents, for the first time, a detailed technological analysis of all lithic materials (n=2790) documented in the six levels up to the 2015-field season. The studied artefacts have been included in the following artefact categories: cobbles (unmodified elements), hammerstones, modified battered blocks (MBB), chopper cores, large cutting tools (LCTs), flaked cores, bipolar cores, flakes, retouched flakes and waste.

The main difference between hammerstones and MBB is based on the blank: cobbles made from volcanic rocks were used for the former, while the latter are usually quartz blocks although exceptionally other rocks were also used (e.g. basalt or gneiss). It was experimentally proved that quartz blocks employed in battering tasks suffer progressive shape transformation that goes from cubic to spherical morphologies (Sánchez-Yustos *et al.*, 2015). Accordingly, we included within this category those blocks/slabs that show different degrees of modification through percussion, but not by knapping (e.g. flaked cores with percussion marks).

The distinction between chopper cores and flaked cores has traditionally proved problematic (e.g. Toth, 1982; Isaac, 1986). The ascription of artefacts to the former category should be cautious and restrictive, paying special attention to specific attributes. We employed the following criteria developed by Leakey (1971) and Chavaillon & Chavaillon (1973) to characterise these tools, namely: acute angle (<75º), overlapping series for secondary trimming, and edge-damage (i.e. battered or micro-scars). Within the category of LCTs (>10 cm) we included formally classified specimens (specifically, handaxes and picks) and large shaped tools that are difficult to define typologically due to lack of standardisation of shape or plan form. We distinguished here between the LCTs made from blocks/slabs and those made from flakes.

Our main concern in the analysis of the flaked cores was to recognise the production process. The variables employed to characterise these cores in such terms are scar faciality (unifacial, bifacial and multifacial) and scar organisation (linear, opposed, orthogonal and centripetal). Flakes are classified according to the six flake categories proposed by Toth (1982) on the basis of the occurrence of cortex on the platforms and dorsal surfaces and used as evidence of reduction stages. Other variables considered in flake analysis were size (small: 20-<50mm; medium: ≥50 – <100mm; large: ≥100mm), type of butt (cortical, plain and faceted), dorsal scar pattern (linear, opposed, orthogonal, centripetal and unorganised), presence of retouch and type of retouch (i.e. morphotype). The parameters followed to identify the presence of the bipolar technique were opposite platforms with shallow pits, opposite notches, crushing ridges and plunging and irregular fracture planes tending toward 90º (Diez-Martín *et al.*, 2011; Sánchez-Yustos *et al.*, 2015). Finally, we included different types of residues within the category of waste: hammer detachments, hammer fragments, MBB fragments, bipolar fragments, LCT fragments, indeterminate positives and debris (<20 mm items).

Results

Level 1 assemblage (L1)

This level at the top of the sedimentation sequence is formed by fine-grained sand and silt. It contained the smallest number of objects (n=26). There are two items with fluvial abrasion. According to the artefact categories documented (Tab. 1), isolated and fragmentary flaking sequences and percussion tasks were performed in L1.

Level 2 assemblage (L2)

The L2 lithic assemblage consists of 89 objects, where six show fluvial abrasion. Quartz is the best-represented raw material (80.8%), followed at a great distance by chert and basalt (10.1% and 6.7% respectively) and other marginal materials. Most of the objects are residues (64.4%) and the rest of categories are represented by a few objects or are not present (Tab. 1). Many of the quartz objects are waste (n=53), the rest are flaked cores (n=3), small-sized flakes (n=13) and retouched flakes (n=3). The flaked cores show unifacial reduction schemes (Tab. 2), but nearly all flakes belong to Toth's type 6 and correspond to advanced flaking reduction phases (Tab. 3). It is thus evident that the production of quartz flakes is spatially and temporally fragmented and formed by different and disconnected knapping events. Chert is represented by a bifacial linear flaked core and a few small-sized flakes (n=3), retouched flakes (n=2) and residues (n=2). The few hammerstones (n=2) and the unifacial shaped core documented are made from volcanic rocks (basalt and phonolite). The other basalt items are a bifacial orthogonal flaked core and a hammerstone detachment.

Tab. 1 - Counts of the lithic materials, sorted by artefact categories and raw materials. Numbers in parenthesis refers to abraded fluvial artefacts. Core (C.). Flake (F.). Large cutting tool (LCT).

LEVEL 1	BASALT	QUARTZ	CHERT	OTHER	TOTAL
Cobbles	2				2
Hammers	1				1
MBBs		1			1
Chopper					
Flaked Cores		1			1
Bipolar C.					
Flakes		5	1		6 (1)
Retouched F.		2			2 (1)
Bipolar F.					
Waste		13			13
Total	3	22	1		26 (2)

LEVEL 2	BASALT	QUARTZ	CHERT	OTHER	TOTAL
Cobbles	1			1	2
Hammers	2			1	3
MBBs					
Chopper	1				1
Flaked Cores	1	3	1		5 (1)
Bipolar C.					
Flakes		13	3		16 (4)
Retouched F.		3	2		5 (1)
Bipolar F.					
Waste	1	53	3		57
Total	6	72	9	2	89 (6)

LEVEL 3	BASALT	QUARTZ	CHERT	OTHER	TOTAL
Cobbles	12			4	16
Hammers	15	1		1	17
MBBs		4			4 (1)
Chopper				1	1
Flaked Cores		8	1	1	10 (1)
Bipolar C.		1			1
Flakes		11	1		12 (1)
Retouched F.		3	2		5 (2)
Bipolar F.					
Waste	4	24	2	1	31
Total	31	52	6	8	97 (5)

LEVEL 4	BASALT	QUARTZ	CHERT	OTHER	TOTAL
Cobbles	11				11
Hammers	8			1	9
MBBs		3			3
Chopper		1			1
Flaked Cores	3	8	1		12 (2)
Bipolar C.		2			2
Flakes	3	41	6	1	51 (2)
Retouched F.		3	2		5 (1)
Bipolar F.					
Waste	6	166	19	1	192
Total	31	224	28	3	286 (5)

LEVEL 5	BASALT	QUARTZ	CHERT	OTHER	TOTAL
Cobbles	60			4	64
Hammers	41			1	42
MBBs		10			10 (5)
Chopper	4			1	5 (4)
LCTs (Blocks)		3			3 (1)
LCTs (Flakes)		1			1
Flaked Cores	26	40	8	2	76 (31)
Bipolar C.		8			8 (2)
Flakes	10	122	21	7	160 (34)
Retouched F.	1	16	11	1	29 (12)
Bipolar F.		2			2
Waste	32	680	34	8	754
Total	174	882	74	24	1.154 (89)

LEVEL 6	BASALT	QUARTZ	CHERT	OTHER	TOTAL
Cobbles	79			7	86
Hammers	52			18	70
MBBs	1	33			34 (16)
Chopper	2				2 (2)
LCTs (Blocks)	1	35			36 (2)
LCTs (Flakes)	2	21			23 (2)
Flaked Cores	23	71	9	7	110 (40)
Bipolar C.		18			18 (1)
Flakes	15	163	18	9	205 (32)
Retouched F.	1	8	8	1	18 (4)
Bipolar F.		6			6
Waste	18	469	32	11	530
Total	194	824	67	53	1.138 (99)

Level 3 assemblage (L3)

A total of 97 objects were unearthed in L3. According to Table 1, quartz is associated with percussion (hammers and MBBs) and flaking (cores and flakes), basalt with percussion (hammers) and chert with flaking (cores and flakes). Quartz is the best represented raw material in L3, but compared with the other levels, it is least frequent here (n=52 or 53.6%). This is because basalt (n=31 or 31.9%) and other volcanic rocks (phonolite, n=6 or 6.1%) are best represented here (see Tab. 1). The quantitative importance of volcanic rocks runs in parallel with the quantitative importance that cobbles (n=16) and hammers (n=17) have in L3 (46.2% of the assemblage). The type of sediment in L3 (clayish silt without flow structures) seems to exclude the possibility that these cobbles were deposited by the flow channel. Actually, only five artefacts display fluvial abrasion. This assemblage contains the lowest percentage of waste (31.9%) and the highest percentage of cores (10.3%). Nearly all quartz cores show bifacial (n=4) or multifacial (n=3) reduction schemes (Tab. 2). In accordance with the flaked cores, the quartz flakes correspond to advanced flaking reduction phases according to the Toth's flake types represented (Toth types 6 and 5, see Tab. 3), and their scar patterns are equally linear or orthogonal. 63.6 % (n=7) of the quartz flakes are fractured. Regardless of their raw material, all flakes (retouched or not) are small-sized, with the exception of a large-sized quartz flake and a medium-sized quartz retouched flake. Evidence of bipolar knapping is only detected in two objects.

Level 4 assemblage (L4)

This assemblage is formed by 286 objects, many of them residues (67.1% or n=191). Fluvial abrasion is documented in five objects. Quartz is the most-used raw material (78.3% or n=224), mainly in flaking (cores and flakes), but also in battering (MBBs), shaping (chopper cores) and bipolar knapping (Tab. 1). All flaked cores made from quartz (n=8) were aimed at producing small-sized flakes and rarely medium-sized flakes. Nearly all quartz flaked cores show bifacial (n=4)

Tab. 2 - Counts of flaked-cores, sorted by reduction models [Unifacial (Uf.), Bifacial (Bf.), Multifacial (Mf.), Linear (Lin.), Orthogonal (Ort.)], sorted by levels (L) and raw materials.

QUARTZ	L 2	L 3	L 4	L 5	L 6
Uf. Lin.	2			10	8
Uf. Ort			1		3
Uf. Cent.	1				3
Bf. Lin.		1	2	10	16
Bf. Ort.		1	2	5	6
Bf. Cent.		2		1	2
Mf		3	2	10	19
Test		1	1	2	5

BASALT	L 2	L3	L 4	L 5	L 6
Uf. Lin.				4	3
Uf. Ort				1	
Bf. Lin.			1	10	7
Bf. Ort.	1			1	2
Mf			1	2	6
Test			1	6	3

CHERT	L 2	L 3	L 4	L 5	L 6
Uf. Lin.				2	
Bf. Lin.	1	1	1	4	1
Bf. Ort.					1
Mf				2	5
Test					1

OTHERS	L 2	L 3	L 4	L 5	L 6
Uf. Lin.					2
Bf. Lin.				1	1
Tf/Mf		1		1	4

Tab. 3 - Counts of Toth's flake types (Tp.), sorted by levels (L) and raw materials.

QUARTZ	L 1	L 2	L 3	L 4	L 5	L 6
Tp. 1	1				3	1
Tp. 2					8	21
Tp. 3	1	1		1	12	10
Tp. 4					1	1
Tp. 5	1		1	3	16	37
Tp. 6	3	10	7	23	65	62

BASALT	L 1	L 2	L 3	L 4	L 5	L 6
Tp. 1					1	3
Tp. 2					2	1
Tp. 5				1	2	5
Tp. 6				1	3	3

CHERT	L 1	L 2	L 3	L 4	L 5	L 6
Tp. 1					1	
Tp. 2						1
Tp. 3				2		1
Tp. 5	1	2		2	8	10
Tp. 6		2		1	7	5

OTHERS	L 1	L 2	L 3	L 4	L 5	L 6
Tp. 3				2		1
Tp. 5				2	2	1
Tp. 6			1	1	3	4

or multifacial (n=2) reduction schemes (Tab. 2). Almost all the quartz plain flakes are small-sized, while just a few are medium-sized (n=2) or large-sized (n=1). According to the Toth's flake types, almost all quartz flakes belong to advanced stages of bifacial production (Tab. 3). Flake fracturing is relatively abundant (29.2% or n=12). The dorsal scar pattern is mostly linear (n=16) or orthogonal (n=3). It is therefore possible to establish a correspondence between the quartz cores and flakes, which seems to suggest the degree of integrity of this reduction sequence. The three retouched quartz flakes are small-sized. The only shaped core recorded is an angular quartz block of reduced size (58x54x53 mm) and weight (123 g) in which the distal region is shaped into a trihedral tip. This tool looks like the large and heavy picks recorded in L6, but on a smaller scale. Two bipolar cores and many types of quartz residues are documented in L4, of which the most common are debris (n=87) and undetermined positives (n=68) (Tab. A in SI).

Basalt is less frequent (10.8% or n=31) and is principally associated with percussive tools (hammers) made on cobbles (n=8). Likewise, there are 11 basalt cobbles without percussion marks (all >100 g). Basalt was employed for flaking: three flaked cores with different reduction schemes (Tab. 2) and three small-sized flakes have been studied. Different types of residues are recorded in this raw material (Tab. A in SI). Chert is infrequent (9.7% or n=28) and is exclusively linked to the production of small-sized flakes. Specifically, we documented a small chert core (6 g) and eight small-sized flakes, two of them retouched. The chert residues are abundant (n=19) and many of them are debris (Tab. A in SI).

The Level 5 assemblage (L5)

L5 contained the highest number of objects (n=1,154). The sediment in this level is composed of coarse sand, but the percentage of objects with fluvial abrasion is not different from those in the other levels (7.7% or n=89). Waste is the best-represented artefact category (65.3% or n=753). Many objects are made from quartz (76.4% or n=882). This raw material is documented in all technological strategies detected in this level (i.e. percussion, shaping, flaking, retouching and bipolar knapping) (Tab. 1). Percussion is represented by MBBs (n=10), since neither cobbles nor hammers are recorded in this material. There are three shaped large quartz blocks or slabs (LCTs): one has a shaped distal trihedral tip (786 g) and the other two display distal dihedrals bifacially shaped (489 g and 1044 g). The flaked cores made from quartz (n=40) were often aimed at producing small to medium-sized flakes (n=35), but some of them show negatives of large-sized flakes (n=5). Bifacial cores (n=16) are more numerous than unifacial (n=10) and multifacial (n=10) ones (Tab. 2). There is a number of bipolar cores (n=8), two of them show large flaked planes (>10 cm) and are heavy (>1000 gr). Flake fracturing is not abundant (17.2% or n=21), but we have to consider many flake fragments could be classified as waste due to insufficient diagnostic technological attributes (i.e. undetermined positive). Most of the whole flakes are small-sized (n=84), but there are also medium-sized (n=21) and large-sized flakes (n=3). All Toth's flake types are recorded in L5, but the best represented are type 6 (n=65), type 5 (n=16) and type 3 (n=13) (Tab. 3). The linear dorsal scar pattern is the most recurrent (n=42), while the orthogonal pattern is less frequent (n=15) and the centripetal pattern is only documented in one flake. The correspondence between the technical attributes of quartz cores and flakes seems to confirm the integrity of the reduction sequences aimed at producing small and medium-sized flakes. Although among the retouched quartz flakes, small-sized is the most common (n=10), medium-sized is also well represented (n=6) and large-sized is represented by one artefact (LCT). The latter object (160 mm and 984 g) displays two scars that formed a distal cutting edge (chopper-like). Different morphotypes are recorded among the small and medium-sized retouched flakes (Tab. 4). The quartz knapping activities carried out in this level generated a huge amount of residues, many are debris (55.4% or n=377) or undetermined positives (40.4% or n=275), but one LCT fragment and other types of fragments are recorded (Tab. A in SI).

Basalt artefacts are documented in different technological strategies (percussion, shaping, flaking and retouching), but to a lesser extent than quartz artefacts, and it was only in the case of percussion that basalt played a prominent role (Tab. 1). There are many basalt cobbles without percussion marks (n=64) and it is reasonable that the lighter ones might have been naturally deposited, since L5 is formed by coarse sands (Tab. B in SI). There are five volcanic cobbles (four of basalt and one of phonolite) that exhibit bifacial (n=4) or unifacial (n=1) shaped working edges, all are <10 mm in length. The basalt flaked cores (n=26) were intended to produce small or medium size flakes, but one core shows a negative of a large-sized flake. These cores displayed different reduction schemes and bifacial production is the most numerous (n=11), but there is also a number of test cores (n=6) (Tab. 2). Despite the relatively numerous cores documented, there are only 11 flakes (one retouched), all of them small or medium-sized. The correspondence between the technical attributes of quartz cores and flakes confirms the integrity of the reduction sequences aimed at producing small or medium-sized flakes.

Tab. 4 - Counts of retouched flakes, sorted by morphotypes, levels (L) and raw materials [Quartz (Q), Chert (C), others (O)].

MORPHOTYPES	L 1	L 2		L 3		L 4		L 5			L 6	
	Q	Q	C	Q	C	Q	C	Q	C	O	Q	C
Scraper			1					2				1
Scraper Bf.								1			1	
Denticulate	1				1	1	1		2		1	2
Spine								5				
Awl		1	1	2	1	1	1	2	3	1	3	4
Notch								2		1		
Diverse				1		1		4	4		2	1
Compound:												
Denticulate + Awl	1	2										
Denticulate + Spine											1	
Awl + Diverse								1	1			
Scraper + Spine									1			

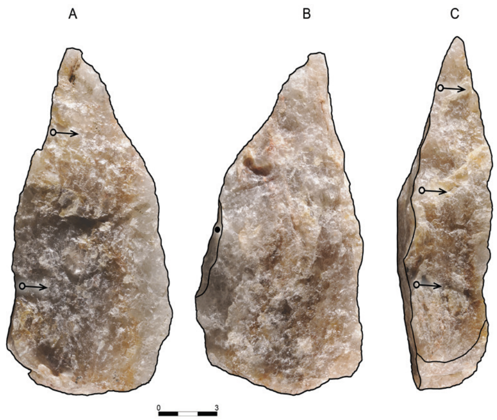

Fig. 2 - Lithic material (level 6). Trihedral pick made on a large quartz flake: A) dorsal face; B) ventral face (the black dot indicates the impact point on the butt); C), abrupt shaped area aimed at tip configuring. The colour version of this figure is available at the JASs website.

Therefore, this reduction sequence is clearly biased. Core fragment is the most represented type of residue (n=11), follow by undetermined positives (n=9) and debris (n=8). In a similar way, chert has a reduced representation (6.4% or n=74) and is exclusively linked to the production of small flakes, many of them retouched (Tab. 1). The chert cores were often reduced by following linear reduction schemes (Tab. 2). There are five fractured flakes and the whole flakes made from chert belong to advanced reduction phases according to the Toth's flake types represented (Tab. 3). Retouching was geared to producing different morphotypes (Tab. 4). Chert flaking generated numerous residues (n=34 or 45.9%) (Tab. A in SI).

Level 6 assemblage (L6)

A supported conglomerate with a matrix of coarse sand was identified at the bottom of the channel and, within this sedimentary unit (L6), 1,138 lithic objects were recorded. Fluvial abrasion is reported in 99 objects (8.6%). Quartz is the most-used raw material (72.1% or n=820), and is documented in all technological strategies (i.e. percussion, shaping, flaking, retouching and bipolar knapping). Percussion is represented by MBBs (n=33), but no cobbles and hammers are recorded in quartz (Tab. 1).

There are 35 LCTs made from quartz blocks or slabs. In general, their shaping is very heterogeneous in technical and volumetric terms, which generates a huge diversity of shapes that are very difficult to classify in formal types. Nonetheless, it is possible to recognize crude versions of picks (n=13), handaxes (n=3) and heavy-duty scrapers or knives (n=2). Almost half of the picks are massive blocks split by the bipolar technique to generate elongated pre-forms in which distal and/or proximal region trihedrals are manufactured (Fig. 2) This manufacture consists of shaping converging and often asymmetric sides with a thick pointed tip formed by semi-abrupt knapping (75º-90º). All picks show triangular distal sections, while their mesial section is more varied, but a quadrangular shape is abundant. The three handaxes are characterised by two bifacially-shaped side dihedrals that converge distally and proximally generating dihedrals or trihedrals. Planform symmetry is absent but a crude frontal symmetry could be recognised. The rest of LCTs made from quartz blocks or slabs show configured obtuse working edges, with indented profiles when they are shaped bifacially.

The numerous quartz flaked cores documented in L6 (n=71) were mainly focused on the production of small-to-medium-sized flakes (n=65), but some were aimed at producing large-sized flakes (n=6) (Fig. 3). Small-to-medium-sized flakes can thus be considered the main production objective. All these cores were reduced through diverse schemes, where multifacial (n=19) and bifacial linear (n=16) are the most represented (Tab. 2). There is a large number of bipolar cores (n=18); about half of them are heavy cores (>900 g) with large bipolar knapped planes (>10 cm) (see Tab. C in SI). These large and heavy bipolar cores were likely linked to the production of LCTs (Fig. 4). The number of fragmented flakes is low (n=12), which suggests many flake fragments were classified as waste because of the lack of diagnostic attributes. About half of the quartz flakes are small-sized (n=75), 30.2% (n=45) medium-sized and 19.4% (n=29) large-sized. One large-sized flake made from quartz is classified as a cleaver since it exhibits a non-retouched transverse cutting edge, at right angles to the length of the piece, formed by the intersection of the ventral face and a scar of the dorsal face. All Toth's flake types are recorded, and the most represented are type 6 (n=62), type 5 (n=37) and type 2 (n=21) (Tab. 3). Linear is the most recurrent dorsal scar pattern (n=52), the orthogonal pattern is also well represented (n=38) and the centripetal pattern is documented in one flake. These attributes of quartz flakes are in accordance with those of quartz cores, which would confirm the integrity of these reduction sequences. 72.4% (n=21) of the retouched flakes are large-sized. The slight modification often displayed by the large-sized flakes (LCTs) is mainly focused on edge modification and hardly ever aimed at managing the whole volume of the piece. It is often conducted through isolated or short series of parallel unifacial removals rather than continuous (scraper-like) or bifacial removals. Bifacial knapping was geared to bevelling dihedrals or small trihedrals rather than shaping bifacial tools. Consequently, a huge panoply of morphologies are generated that are difficult to classify typologically, but a crude retouched cleaver and three heavy-duty scrapers could be identified. Conversely, diverse morphotypes can be identified among the eight small-to-medium-sized flakes (Tab. 4). A large part of the residues generated during the quartz knapping activities carried out in this level are undetermined positives (44.9% or n=211) or debris (39.6% or n=186), in addition to nine fragments of LCT and different types of fragments (Tab. A in SI).

It is possible to distinguish two reduction sequences in quartz aimed at producing LCTs, one centred on shaping quartz blocks/slabs and the other focused on the production of large flakes that are slightly retouched or not (Sánchez-Yustos *et al.*, 2017a). We base this differentiation on the fact that large flakes cannot be the result of block shaping because only three shaped blocks show large scars (≥ 10 cm), whereas there are many flaked-cores with large scars (n=11).

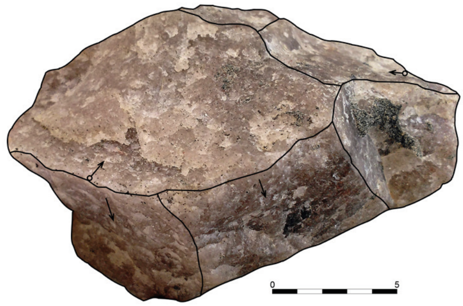

Fig. 3 - Lithic material (level 6). Quartz flaked core aimed at producing large-sized flakes. The colour version of this figure is available at the JASs website.

Furthermore, there is a refitting between a giant core and a large flake (Fig. 5).

With the exception of bipolar knapping, basalt was employed in all technological strategies (percussion, shaping, flaking and retouching), but its total representation in the L6 assemblage is quite discrete (17% or n=194). The presence of basalt in hammers (n=52) and cobbles (n=79) is more numerous than in the rest of artefact categories, and increases if we add hammers (n=18) and cobbles (n=7) in other volcanic rocks such as phonolite (Tab. 1). Some of the cobbles made from volcanic rocks could have been deposited by the channel-flow, especially those that are lighter: 12.7% of the cobbles weigh <100 g and 35.9% weigh <200 g (Tab. B in SI). There is a MBB (503 g) that should be added to the repertory of percussive tools made from basalt. Shaping is represented in three pieces: two shaped cobbles, one unifacial (342 g) and the other bifacial (270 g); and a giant handaxe (310 mm length and 3,660 g weight). The refined shaping of this magnificent handaxe contrasts with the other handaxes and LCTs (crudely manufactured), since it displays both plan view symmetry and accurate bifacial shaping and trimming (Fig. 6). Nearly all basalt flaked cores (n=23) are focused on the production of small-to-medium-sized flakes (but one shows large-sized flake negatives) mainly through bifacial or multifacial reduction models (Tab. 2). Of the basalt flakes (n=15), two

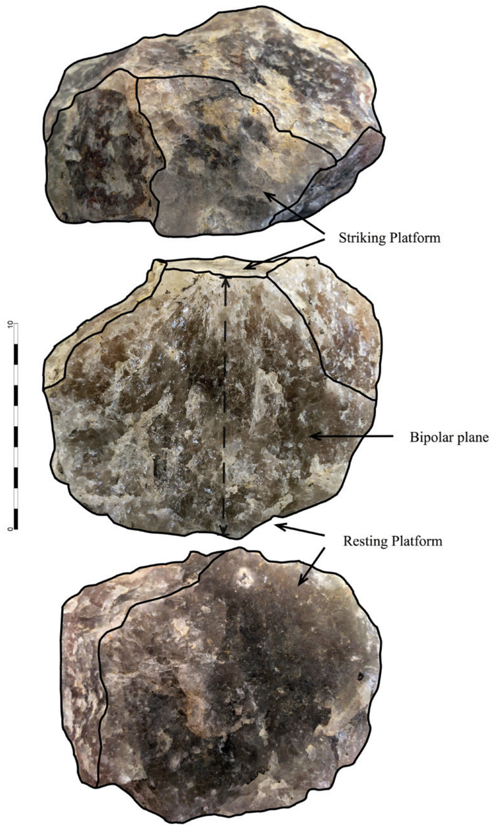

Fig. 4 - Lithic material (level 5). Quartz block fractured by bipolar technique. The colour version of this figure is available at the JASs website.

of them are large-sized and belong to different production phases as indicated by the diversity of Toth's flake types represented (Tab. 3). There are two large-sized retouched basalt flakes (LCTs) with a series of parallel and continuous removals that produce unifacial or bifacial working edges (scraper-like). Additionally, two cleavers made from phonolite were documented; one shows additional retouching. The basalt residues are related to percussion (n=8) or knapping strategies (n=18) (Tab. A in SI).

The artefacts made from chert are poorly represented (5.8% or n=67), and all are linked to flaking strategies. The chert cores (n=9) were used to produce small-sized flakes mainly through the multifacial reduction strategy (Tab. 2). Nearly all flakes (n=17) are small-sized (one is medium-sized) and the majority belong to advanced production stages according to the Toth's flake types represented (Tab. 3). Retouching is extended among the chert flakes in this level (n=8), and, although there are different morphotypes, half of them are awls (Tab. 4). Nearly all the chert artefacts documented in L6 are flaking residues (n=32 or 47.7%).

Inter-assemblage variability

The following inter-assemblage comparison is aimed at detecting techno-economic behavioural patterns in the studied archaeological sequence. With this proposal, the raw material management and selection is first assessed. By far the best-represented raw material in all assemblages is quartz; basalt and chert are secondary materials and other raw materials (e.g. phonolite, quartzite, crystal rock and gneiss) are poorly represented (Tab. 1). The procurement localities are the same in all levels: quartz was procured in the nearby metamorphic inselberg of Naibor Soit (2 km away) and FLK W channel was the closest available source for volcanic cobbles and probably small chert nodules. Although quartz is predominant in all levels (Tab. 1), there is a significant statistical correlation between assemblage and raw material ($p= <0.001$, Chi-squared test). The pairwise combination between level and raw material according to their expected values is shown in SI Tab. D. Regarding artefact categories, cores, flakes and retouched flakes do not show a correlation between assemblage and raw material ($p= >0.05$, Chi-Square tests); on the contrary LCTs and percussion tools show a significant statistical correlation ($p= <0.001$ and $p= 0.001$, Chi-Square tests). The LCTs are preferably made from quartz (89.1%) and only a few are made from volcanic rocks. We also observed that in all assemblages retouching is much more extended among the chert flakes than on those made from other materials (see FRFR in Tab. E in SI). In sum, despite minor differences, common raw material procurement and management behaviour can be recognised in all levels.

We assessed the correlation between levels and artefact categories. The importance given here to artefact categories is because the presence/absence and frequency of some artefacts is traditionally employed as the prime taxonomic marker to arrange Palaeolithic sequences. We examined whether the 12 categories presented in Table 1 were related to assemblage. The results were significant ($p = <0.001$, Chi-squared test), indicating that both variables were related to one another. According to the CA conducted, it is possible to cluster the six assemblages in three or four groups (Fig. 8A). We employed tool-size as the main proxy to reorder artefact categories due to its taxonomic importance within the OAG. There is a broad consensus regarding the idea that the mere presence of either large cutting tools or production of large flake-blanks (i.e. ≥ 10 cm) is indicative of the Acheulean character of the assemblage. Accordingly, we distinguished between small-medium-sized tools (SMSTs) and large-size tools (LSTs). In the case of the flaked cores, the size of the biggest scar was employed to classify them as SMST (< 10cm) or LST (≥ 10cm). Tool length was the criteria employed in flakes (plain or retouched) and shaped tools to classify them as SMST (< 10cm) or LST (≥ 10cm). We distinguished the following nine artefact categories: Percussive tools (PTs: hammers and MBB); SMS chopper cores; SMS flaked cores; SMS flakes; SMS retouched flakes; LS shaped blocks (LCT on block); LS flaked cores; LS flakes; and LS retouched flakes (LCT on flake). Bipolar objects, unmodified objects (i.e. cobbles), waste (i.e. fragments and by-products) and fragmented tools were excluded from this classification because their attribution to any group would result controversial, ambiguous and could falsify the final count of each group. The results of the Chi-squared test performed to assess the relationship between the nine artefact categories and the six assemblages were significant ($p = <0.001$). The CA allows the assemblages to be clustered in three or four groups (Fig. 8B). If we concentrate the nine categories into three categories (PTs, SMSTs and LSTs), the significance between categories and assemblages persists ($p = <0.001$, Chi-squared test). However, as a result of these refinement processes, when a CA was carried out, the assemblages can be easily clustered in three groups dominated by different categories (Fig. 8C). Be that as it may, it is important to bear in mind that SMSTs is quantitatively the most important substrate in the composition of all assemblages; PTs show a relatively discrete representation, except in L3; and LSTs are not documented or represented marginally, with the exception of L6.

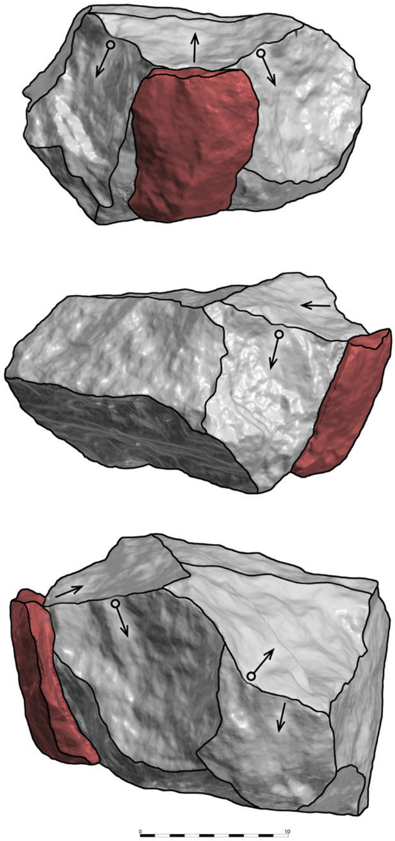

Fig. 5 - Lithic materials (level 6). 3D model of a quartz flaked core aimed at producing large-sized flakes and a flake refitting. The colour version of this figure is available at the JASs website.

We also assessed whether cores and flakes show significant typometrical and weight

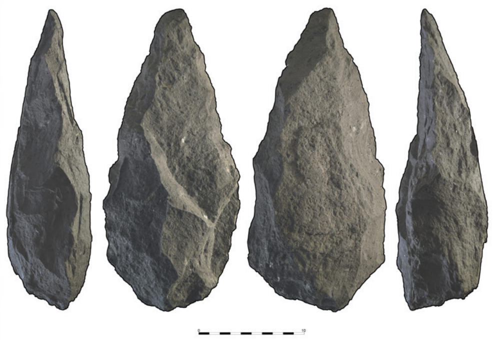

Fig. 6 - Lithic material (level 6). Biface made on volcanic rock. The colour version of this figure is available at the JASs website.

differences among assemblages. We employed a non-parametric test (i.e. Kruskal-Wallis), since these variables did not show a normal distribution (p= <0.05, Lilliefors test). The results indicated that cores (flaked and chopper) did not show significant metrical and weight differences among assemblages (p= >0.005). Conversely, flakes (plain and retouched) showed significant differences (p= <0.005). The following variable pairs displayed the same significant differences in both plain flakes and retouched flakes when we conducted pairwise comparisons between length and assemblage and weight and assemblage: L2-L6, L4-L6, and L5-L6. In other words, the flakes from the L6 assemblage tend to be significantly larger and heavier than those documented in the rest of the FLK W sequence (Figs. A and B in SI).

We cannot infer statistically significant differences in flaking reduction intensity, since flaked core faciality and Toth's flake types did not show significant differences by assemblage (p= >0.05, Chi-squared test). The same pattern of productivity is observed in all assemblages, since quartz blanks are always the most productive (see MSPC and CFR in Tab. E in SI). The same reduction patterns are performed in all levels and raw materials (Tab. 2), exhibiting homogeneous technological competences. Indeed, no assemblage showed evidence of derived traits in this regard, like core-preparation (Sánchez Yustos *et al.*, 2017b). Likewise, a preference for retouching a specific or distinctive flake morphotype was not noted in any assemblage (Tab. 4).

We also examined whether the percussion tools (i.e. cobble, hammers and MBB) showed significant statistical differences in weight among assemblages. Cobbles and MBB did not show significant differences (p= >0.005, Kruskal-Wallis test). Conversely, the mean rank of weight in hammers was significantly different (p= 0.013, Kruskal-Wallis test; Fig. D in SI), and the results of the multiple comparisons indicated significant differences between the following variable pairs: L1-L3 and L2-L3 (Tab. F in SI). We have also observed that cobbles, hammers and MBB did not show a uniform representation in all assemblages (p= 0.004, Chi-Square tests). The results of the multiple comparisons conducted between level and percussion tool type may suggest differences in percussion behaviour among assemblages (Tab. G in SI).

Summarising, the six assemblages documented in FLK W share the following techno-economic traits: (i) raw material selection and management; (ii) the most important substrate in assemblage composition is a core-and-flake technology focused on the production of small-to-medium flakes which show common reduction management and technical competences; (iii) and flake retouching patterns. However, simultaneously, these assemblages show important differences, namely: (i) three groups of assemblages dominated by different artefact categories can be distinguished: PTs in L1 and L3 assemblages; SMSTs in L2, L4 and L5 assemblages; and LSTs in L6 assemblage (Fig. 8c); (ii) and there may be differences in the percussion behaviour among assemblages. From the perspective of the current taxonomical approach, the relatively abundance of LSTs in L6, in contrast with their absence or paucity in the other assemblages, is the most eloquent difference within the archaeological sequence at FLK W.

Having reached this point, the question is how to interpret the FLK W inter-assemblage variability in behavioural and taxonomic terms? To shed light on this issue, we have focused on L5 assemblage for the following reasons: the size

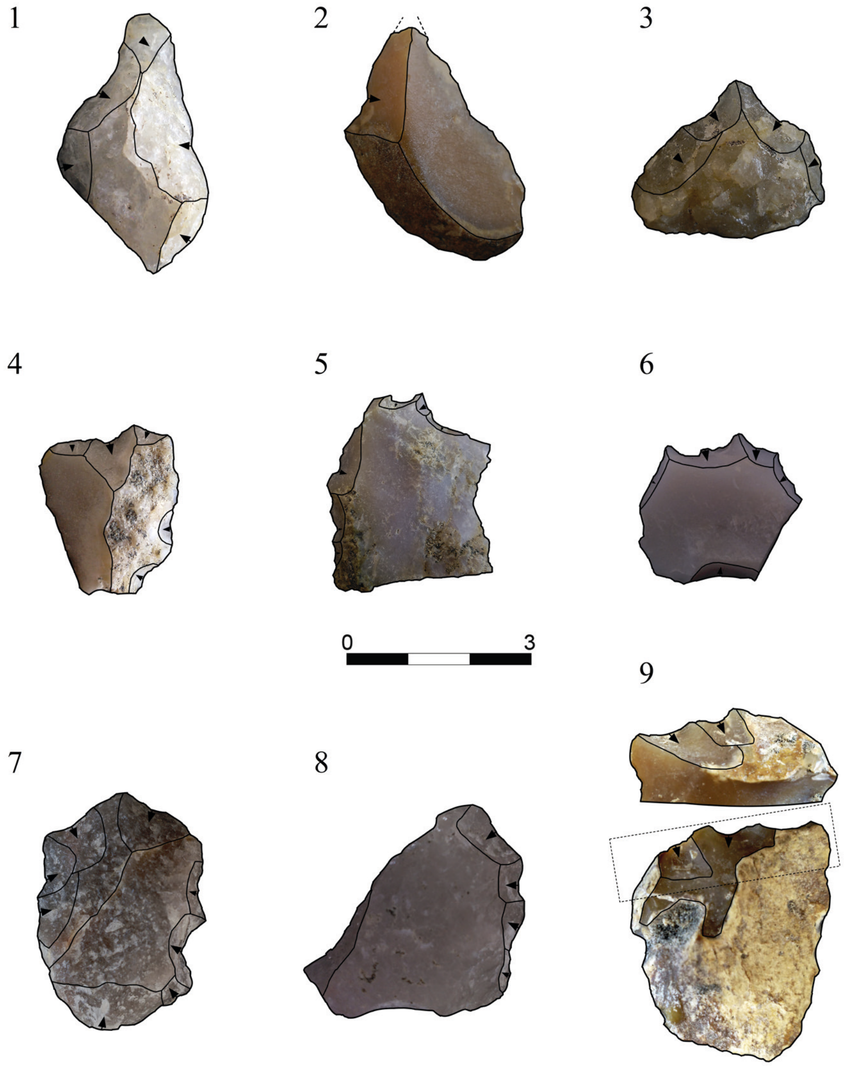

Fig. 7 - Lithic materials. Retouched small flakes from level 2 (1), level 4 (4), level 5 (2, 3, 5 and 9), and level 6 (6-8). The colour version of this figure is available at the JASs website.

of the sample, it is the assemblage with the highest number of artefacts; all categories of LSTs are present, but in small proportions; taxonomically, it could be included within either the Acheulean or Developed Oldowan B, depending on whether we adopt a technological or typological approach; and it is statistically grouped with an assemblage (L4) that would be classified as Oldowan from any approach (Fig. 8). Given the remarkable importance that LCTs still play in the current Palaeolithic taxonomy, the first issue to assess is: do LSTs in L5 have a behavioural or taphonomic origin?

To test the behavioural hypothesis, we compared the typometry and weight of flakes and

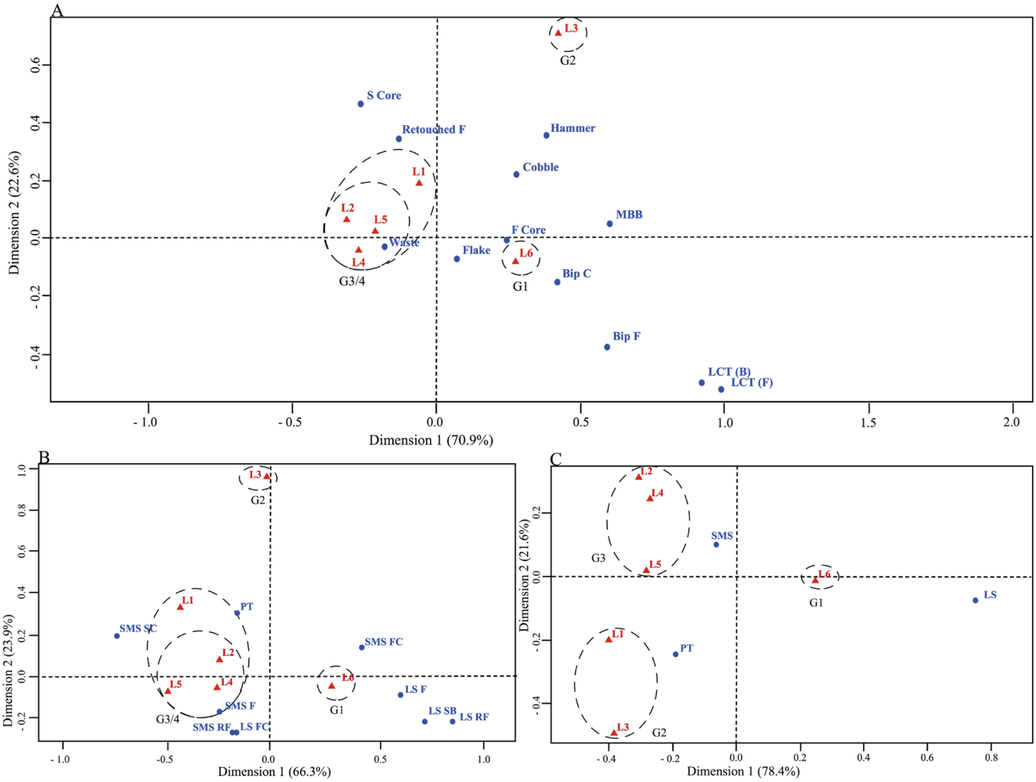

Fig. 8 - Correspondence analysis between levels (L) and tool categories. A) Twelve categories [hammer; cobble; modified battered blocks (MBB); shaped core or chopper (S core); flaked core (F core); bipolar core (Bip C); bipolar flake (Bip F); large cutting tool on block (LCT B); large cutting tool on flake (LCT F); flake; retouched flake; and waste]; B) Nine categories [percussion tool (PT); small-medium-sized (SMS): shaped core or chopper (SC); flaked core (FC); flake (F); retouched flake (RT); large size (LS): shaped core (SC); flaked core (FC); flake (F); retouched flake (RT)]; C) Three categories: percussion tool (PT), small-medium-sized (SMS) and large size (LS). (Group: G). The colour version of this figure is available at the JASs website.

flaked cores made from quartz, as the reduction sequences of LCT production were mostly carried out on this material. On one hand, we clustered the quartz whole flakes in three size groups: small-sized, medium-sized and large-sized. According to the results of the Chi-squared test conducted, there were significant differences between assemblages and the size groups of plain flakes (p= <0.001): L6 is greatly associated with medium and large-size flakes and L1-5 with small-sized flakes. The retouched flakes also showed significant differences between assemblages and size groups (p= <0.001, Chi-squared test): L6 is strongly linked to large-size flakes and L1-5 to small-sized flakes and to medium-size flakes. Such correlations likely suggest that medium-sized flakes are closely associated with LCT production in L6 and, accordingly, their low significance in L5 may suggest the LCT production sequences were biased in some way. On the other hand, we grouped together the quartz flaked cores documented in L1-4 assemblages, and compared them with those retrieved in L5 and L6 assemblages. The results of the non-parametric test applied (p= <0.05, Lilliefors test) indicated that quartz cores show significant differences in weight (p= 0.039, Kruskal-Wallis) and length (p= 0.055, Kruskal-Wallis) by assemblage. The flaked cores in L5 tend to be larger and heavier than those recorded in L6 (Fig. C in SI). More specifically, there are 13 quartz cores in L5 that weigh more than 1000 gr (32.5% of the quartz cores), of which five display large scars (12.5%); while there are 17 quartz cores in L6 that weigh more than 1000 gr (24.2% of the quartz cores), of which six have large scars (15%). Likewise, there are bipolar cores in both assemblages that weigh more than 1000 gr (two in L5 and eight in L6), but bipolar cores of this weight were not recorded in L1-4 assemblages which seems to confirm that the bipolar technique was employed for LCT production in L5-6 assemblages.

The indicators traditionally employed to measure hydraulic disturbance in lithic assemblages suggest that water flow did not play a major role in the formation of the FLK W lithic assemblages (Tab. H in SI). Nonetheless, size sorting (debris swept), minor spatial re-distribution and re-deposition of a few allochthonous materials are likely to have occurred, particularly in L6 and L5, which experienced the highest energy depositional environment (Fig. 1). The flaked core ratio (considered here as the sum of flakes divided by the number of flaked and chopper cores) and the mean of scars in cores suggest that, in general, FLK W assemblages contain substantially fewer flakes than should be expected (Tab. E in SI). This may be explained by two reasons: (i) transport of cores and/or flakes, this is likely in the upper levels where the assemblage composition and the low density of artefacts suggests these assemblages are composed of different and isolated fractions of reduction sequences; (ii) fluvial re-arrangement, presumably higher in L5-6. The fossil assemblages at FLK W confirm the occurrence of hydraulic disturbance, particularly in L5-6. However, neither assemblage, lithic or fossil, was created by water action in any case (Diez-Martín *et al.*, 2015; Yravedra *et al.*, 2017). A similar scenario has recently been proposed for the emblematic early Acheulean site of EF-HR (Middle Bed II), where the main concentration of stone tools is situated in the deepest part of an incised valley formed by river erosion and yet they were mostly unabraded and, therefore, not subjected to major reworking processes, but only rearrangement (de la Torre & Wehr, 2017).

The LSTs are distributed in L5 either at the top (n=8) or at the bottom (n=4), whereas the intermediate space does not contain LSTs. The presence of LSTs at the top could hardly be attributed to a contamination process, for instance vertical movements from L6 to L5 originated by hydraulic processes. Conversely, this process would explain the presence of LSTs at the bottom of L5. In a previous work (Diez-Martín *et al.*, 2015), we pointed out that L5 constitutes a micro-palimpsest in which cross bedding and horizontal fluvial lamination seem to correspond to different sedimentary episodes or sub-units. We have carried out a fine-grained archaeo-stratigraphic analysis, but unfortunately we could neither identify archaeo-stratigraphic disruptions nor individualise groups of items (Diez-Martín *et al.*, 2015). In any case, it is evident that the sedimentary structure of L5 is complex, composed of different fluvial sedimentary episodes, and L5 assemblage is the result of different occupational events; some left LSTs (L5x onward) and others did not.

Be that as it may, and in the light of the results achieved in the inter-assemblage comparison, the difference in LCT frequency between L6 and L5x could be explained in techno-economic terms since LCT reduction sequences are much more complete in L6 than in L5x. Consequently, these assemblages may have been knapped by hominins that shared a common techno-economic behaviour. The point is if the occupational events that did not leave LSTs in L5 were performed by this group. The same question can be formulated about L4. The upper levels (L1-3) can be omitted from this discussion due to the size of the samples (≤ 100 items). As we have already explained, L5 and L4 show significant convergences: (i) both assemblages are clustered in the same statistical group according to their artefact category representation, despite the presence of LSTs in L5; (ii) both exhibit common techno-economic behaviour in the procurement, selection and use of raw materials, core reduction management and flake retouching patterns; (iii) small-to-medium flakes are quantitatively the most important production aim. We should also remember that L6 shares the two latter points. The hypothesis of a common techno-economic substratum among the lower assemblages (L4-6) is also strengthened by a small trihedral in L4 that resembles the massive picks found in L6.

Discussion

The FLK W sequence has revealed singular assemblage variability. It is the only site on the OAG where assemblages with and without handaxes/LCTs are interstratified in the same sequence. In this regard, it is possible to observe the following pattern in the lower assemblages: the presence and absence of LCTs is alternating and the frequency and integrity of their reduction sequences decreased (from bottom to top) in those assemblages in which they occurred. Due to the concentration of resources that may exist in FLK W in contrast with other contemporary sites and the obvious importance of controlling this strategic area (Uribelarrea *et al.*, 2017), this pattern likely responds to a progressive decrease in the occupation of the FLK W bed channel by the same hominin group or taxon rather than to alternate occupation by different hominin groups or taxa. Nevertheless, as we explain below, the hypothesis of a same hominin group or taxon is very well supported on a common techno-economic substratum.

Common raw material procurement, selection and management behaviour is probably one of the most significant behavioural parallels noted in FLK W sequence. The presence of chert throughout the sequence may be understood as contextual rather than cultural since chert only became available during a particular period which coincides with the formation of the FLK W sequence (Kimura, 1999, 2002). However, in Beds I and II, hominins shifted their raw material preference from basalt to quartz, first evident in the lowermost Bed II (e.g. Hay, 1976; Kyara, 1999; de la Torre & Mora, 2005). The quality of the cutting edges of quartz flakes (i.e. edge attrition) could explain the preferential use of this material to produce small-to-medium flakes in Bed II (Schick & Toth, 1994; Sánchez-Yustos *et al.,* 2016). The FLK W sequence, particularly the lower assemblages, represents early evidence of such raw material selection behaviour which, in turn, demonstrates that FLK W hominins understood the physical properties of different lithotypes and selected them accordingly. This variation in raw material selection behaviour is rooted in cultural decisions and cognitive skills rather than mere changes in raw material availability. Therefore, it is possible to infer common raw material procurement and management behaviour in the FLK W sequence, indicative of homogeneous cultural decisions and cognitive skills.

The second affinity documented is that small-to-medium flakes are numerically the most important production aim. This production is supported on a uniform core-and-flake technology in terms of reduction management and technical competences; no assemblages display signs of core-preparation. We would like to emphasize the fact that the production of small-to-medium flakes is also quantitatively more important than LCT production in L6. The co-occurrence of both technologies (core-and-flake and LCT) in the same assemblage is a constant after the Acheulean emergence in East Africa, and the former is often more widely distributed than the latter (e.g. de la Torre 2011; Diez-Martín *et al.*, 2012, 2014a,b; Gallotti, 2013; Sánchez-Yustos *et al.*, 2016; this work). It implies the OAG is an additive/accumulative cultural process rather than a replacement one and, therefore, in some cases core-and-flake assemblages could be a lithic expression of the Acheulean. For this reason, core-preparation has recently employed as an early Acheulean marker in assemblages where LCTs are absent or rare (e.g. de la Torre, 2011; Gallotti, 2013; Sánchez-Yustos *et al.*, 2017b). However, this Acheulean hallmark is not registered in FLK W assemblages.

Acheulean without handaxes is not a new idea at all. It has recurrently been insinuated at local scale in nearby contemporary sites in the Early Stone Age record (e.g. Clark 1953, 1959a,b; Isaac, 1977; Gowlett, 1986; de la Torre, 2009; Diez-Martín *et al*., 2012). Likewise, Bar-Yosef & Goren-Inbar (1993) considered the assemblages with and without handaxes interstratified in Ubeidiya (Israel) were made by hominins with the same technical background, but different needs, since both assemblages reflected the same flaking techniques and systems. This idea was validated by new excavations, as a trihedral pick was found in one of the earliest horizons at Ubeidiya where core-and-flake assemblages occurred (Bar-Yosef & Belfer-Cohen, 2001). Both types of assemblages also occurred at intra-site or local scale in the European Lower Palaeolithic archaeological record and, in such cases, assemblages without handaxes are considered one of the many lithic expressions of the Acheulean (Barsky, 2013; Mosquera *et al*., 2015; Ashton, 2016). Therefore, the possibility of Acheulean without handaxes seems to be accepted at intra-site and local scale. The implications of this assumption are profound. It entails revoking the following culture-historical and typological postulates that impregnate the current taxonomic tradition: (i) the immutable nature of the Acheulean; (ii) handaxes constitute the main Acheulean cultural signifier; (iii) Acheulean without handaxes is a perfect oxymoron (see Diez-Martín & Eren, 2012; Sánchez-Yustos, 2012; Nicoud, 2013).

This line of interpretation would reinforce our thesis that the FLK W lower assemblages could be made by the same group or taxon. However, it is necessary to bear in mind that different hominin taxa (*H. habilis*, *H. erectus* and *P. boisei*) could have inhabited the Olduvai basin when the FLK W sequence was being formed (e.g. Clarke, 2012; Domínguez *et al*., 2015). A long-held consensus among archaeologists is that early *H. erectus* was responsible of the Acheulean emergence since its brain structure and function is the only one that, at that time, could support the cognitive demands required by this technology, whereas the Oldowan industry is linked with *H. habilis* (Stout *et al*., 2015). This direct association must be nuanced as early *H. erectus* chronologically co-occurs with both technologies in Africa and Eurasia.

Be that as it may, there were distinct groups or taxa of early *Homo* with different cognitive skills and technical competences in lowermost Bed II (Leakey, 1971). According to this premise, we should assume the following scenarios once the Acheulean technology appeared in Bed II: (i) core-and-flake assemblages and assemblages with LCTs could be performed by the same group or taxon; (ii) core-and-flake assemblages could be performed by different hominin groups or taxa. Such hominin coexistence would be limited to the lower part of Middle Bed II, between Tuffs II-A and II-B (about 1.7-1.6 Ma), as there are neither core-and-flake assemblages nor *H. habilis* remains above Tuff II-B. This is why the traditional association of early *H. erectus*/early Acheulean works so well in Olduvai (de la Torre, 2016). Among the few sites documented in the lower part of Middle Bed II (e.g. FLK W, FLK N Sandy Conglomerate, HWK EE and HWK E Sandy Conglomerate), MNK Skull Site can be emphasised since it is where the latest evidence of core-and-flake assemblages and *H. habilis* remains were found in Olduvai (Leakey, 1971). This site is also relevant here for another reason. M. Leakey classified the archaeological levels excavated in MNK below and above Tuff II-B as Oldowan and Developed Oldowan B respectively and noted a change in raw material selection behaviour from basalt to quartz (Leakey, 1971, pp. 118 and 264). The change in raw material selection noted in MNK could also be used to validate the co-occurrence of both scenarios in the lower part of Middle Bed II.

Additionally, the FLK W lithic record seems to suggest that the Acheulean emergence was supported on a new economic structure rather than on novel and isolated technical innovations derived from Oldowan technological know-how (Sánchez-Yustos *et al*., 2017a). The co-occurrence of the following circumstances would trigger the emergence of a new economic structure: a demand of stone tools with higher load force and changes in the upper limb of the early *Homo* required to manipulate them. Modern human-like hands and post-cranial anatomy emerged shortly before the earliest Acheulean (Ward *et al.*, 2014; Domínguez *et al.*, 2015). This scenario could be triggered by two factors that also occurred shortly before the Acheulean emergence in East Africa: climatic and ecological changes, in which a long-term drying period favoured the expansion of grasslands and grazing bovid species (Cerling & Hay, 1986; Cerling *et al.*, 2011; deMenocal, 2011); and the emergence of hominins with bigger brains (i.e. early *Homo erectus*) and, in turn, more complex neurophysiological skills (Lepre *et al.*, 2015). However, the Acheulean emergence is often explained by the mere appearance of crude handaxes and other LCTs, but in our opinion the revolutionary innovation would be that these new tools extended the operating scope of the Oldowan toolkit in terms of cutting efficiency, action, load force application, activity duration, and materials to transform (Sánchez-Yustos *et al.*, 2017a). This would allow 'new tasks' to be undertaken and increase efficiency in 'old tasks' (i.e. butchery). In sum, the "Acheulean revolution" would consist of: diet diversification, novel feeding patterns, more effective acquisition and/or consumption of food resources, and novel food processing technology and extractive tools (Sánchez-Yustos *et al.*, 2017a). In the light of this reasoning, the FLK W assemblages would be different expressions of the same economic web practised by early *H. erectus* groups.

Conclusions

Several reasons justify the remarkable importance that FLK W has in understanding the origin of the Acheulean, namely: (i) it constitutes the chronologically best-bracketed earliest Acheulean site (Diez-Martín *et al.*, 2015; (ii) it provides the earliest spatial and taphonomically-supported functional association between an Acheulean assemblage and a fossil assemblage (Yravedra *et al.*, 2017); (iii) it contains the earliest evidence of a handaxe with all the elements that characterize its iconic design (Sánchez-Yustos *et al.*, 2017a); (iv) is the earliest site where lithic assemblages with differences in the absence/presence and frequency of LCTs are interstratified in the same sequence (this work).

The present paper has outlined the major similarities and differences displayed by the lithic assemblages in FLK W, particularly the lower assemblages. On one hand, we have argued that differences in the absence/presence and frequency of LCTs likely respond to occupation differences (e.g. short-term stay *vs* longer-term stay; low impact *vs* higher impact occupation) and, in turn, the type and number of subsistence activities carried out in-site. On the other hand, we have justified the similarities noted in terms of raw material selection, flaking reduction and flake retouching behaviour, which are clear indicators of homogeneous cultural decisions and cognitive skills. Consequently, we conclude these assemblages were likely formed by the same hominin group or taxon (i.e. early *H. erectus*) and are different expressions of the same economic structure. However, there was another hominin group or taxon (i.e. *H. habilis*) in Olduvai about 1.7 Ma with stone tool-making behaviour whose impact in the formation of the FLK W lower assemblages seems to be null or insignificant, and its continuity in the Olduvai basin was likely affected negatively by hominins with more complex techno-economic and cognitive skills (i.e. early *H. erectus*). Although competition for resources between hominin taxa with different cognitive skills and technical competences might cause hypothetical hominin population replacement in the lower part of Middle Bed II, the OAG should be understood as an additive/accumulative cultural process mostly involving early *H. erectus* in which both technologies, core-and-flake and LCT, are complementary expressions of the same economic structure. Thus, the Acheulean could be defined as an economic structure with a mutable nature rather than an immutable cultural tradition. Multidisciplinary fieldwork is in progress at FLK W and new data may validate or falsify the conclusions achieved here.

We would like to finish this paper by noting that the discovery of this extraordinary site has confirmed L. Leakey´s belief that the "beginning of the handaxe idea" occurred at Olduvai in the lowermost Bed II (Leakey, 1951, p. 41).

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Author contributions

PSY organised the structure of the paper and wrote all parts; FDM revised and edited it; FDM, MDR, EB and AM were project managers and responsible for funding acquisition; PSY, FDM, CF, JD, ID and SF participated in field and lab work.

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