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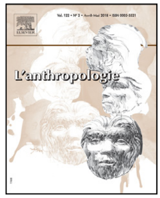

Original article

The evolution of stone tool technology at Olduvai Gorge (Tanzania): Contributions from the Olduvai Paleoanthropology and Paleoecology Project

L'évolution de la technologie des outils en pierre dans la gorge d'Olduvai (Tanzanie) : contributions au projet de Paléoanthropologie et de Paléoécologie d'Olduvai

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ABSTRACT

Since 2006, The Olduvai Paleoanthropology and Paleoecology Project (TOPPP) is conducting intensive research in a number of classical and newly discovered sites throughout the sequence of Olduvai Gorge, in Tanzania. Over these fifteen years of intense fieldwork, efforts have mostly focused on the Oldowan and Acheulean evidence located in Bed I and Bed II, but also intended on more recent and less known resources of the archaeological record, such us those located in the Ndutu beds. In this work we present a synthetic and comprehensive view of the most significant scientific contributions produced by our team in the fields of lithic technology and paleo-economic studies, including: the remarkable enlargement of our knowledge on the technological behaviors undertaken during the Oldowan, as recorded in the various sites recently discovered within the Zinj paleosol (Bed I); the characterization of the oldest Acheulean in the Olduvai basin (and one of the earliest evidence of this techno-complex in East Africa) after the discovery by our team of the exceptional site of FLK West (Lower Bed II); new insights into the enduring debate of the techno-functional meaning of the Developed Oldowan/Acheulean interface through the re-excavation of various classical sites located in Middle and Upper Bed II, such as SHK, TK and BK, and the confirmation of the Acheulean ascription of their lithic assemblages; the discovery of a number of MSA sites, such as VCS and DGS, that confirm the significance of the MSA record in the Olduvai basin and nearby.

Mots clés :
Gorges d'Olduvai
TOPPP
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Acheuléen
Middle Stone Age

RÉSUMÉ

Depuis 2006, le Projet Paléoanthropologie et Paléoécologie d'Olduvai (TOPPP) mène des recherches intensives dans un certain nombre de sites classiques et nouvellement découverts tout au long de la séquence des gorges d'Olduvai, en Tanzanie. Au cours de ces quinze années de travail intense sur le terrain, les efforts se sont principalement concentrés sur les vestiges Oldowayens et Acheuléens situés dans les lits I et II, mais ils ont également porté sur des éléments plus récents et moins connus du patrimoine archéologique, tels que ceux situés dans les lits Ndutu. Dans ce travail, nous présentons une vue synthétique et complète des contributions scientifiques les plus significatives produites par notre équipe dans les domaines de la technologie lithique et des études paléo-économiques, y compris : l'élargissement remarquable de nos connaissances sur les comportements technologiques entrepris pendant l'Oldowayen, tels qu'enregistrés dans les différents sites récemment découverts dans le paléosol de Zinj (Lit I) ; la caractérisation de l'Acheuléen le plus ancien du bassin d'Olduvai (et l'une des premières preuves de ce techno-complexe en Afrique de l'Est) après la découverte par notre équipe du site exceptionnel de FLK West (lit inférieur II); de nouveaux aperçus du débat persistant sur la signification techno-fonctionnelle de l'interface Oldowayen/Acheuléen développée grâce à la ré-excavation de divers sites classiques situés dans le lit II moyen et supérieur, tels que SHK, TK et BK, et la confirmation de l'attribution à l'Acheuléen de leurs assemblages lithiques ; la découverte d'un certain nombre de sites MSA, tels que VCS et DGS, qui confirment l'importance de l'enregistrement MSA dans le bassin d'Olduvai et à proximité.

1. The Oldowan from Bed I: the significance of the Zinj horizon

Bed I is the oldest, thickest and most extensive geological unit in the stratigraphic sequence in Olduvai Gorge. To date, the base of Bed I outcrops in the uppermost part of the Naabi ignimbrite, dated to 2.03 Ma, while its top limit coincides with Tuff IF, deposited at 1.8 Ma (Deino, 2012). Sediments in Bed I are composed of lavas, volcanic tuffs, claystone and tuffaceous clays. Materials related to volcanic activity in the area have been used to establish stratigraphic and sequential subdivisions within this unit. Hay (1976), for instance, subdivided Bed I into two main sections. The Lower Member corresponds to the deposits located below a basaltic horizon formed at 1.95 Ma (Deino et al., 2021), while the Upper Member include the sediments above it. Seven volcanic tuffs (from bottom to top: Tuffs IA, IB, IC, ID, IE, Ng'eju, and IF) are important chronological markers. Clay sediments represent various paleolandscape situations of lake and lake margin deposits linked to the presence of an alkaline, shallow and fluctuating paleolake that occupied the basin during Bed I times (Hay, 1976). The seasonal-driven distribution and availability of fresh water provided by watercourses and local springs created a heterogeneous and diverse lacustrine ecosystem of fluvial deltas, alluvial plains and wetlands, including both open landscapes and wooded areas (Ashley et al., 2010; Barboni et al., 2010; Magill et al., 2013).

Bed I sites represent an extraordinary source of information for our understanding of human evolution and hominin adaptive, economic and technological behaviors during the Oldowan complex. Bed I has been pivotal in several discussions related to the origin of genus *Homo* and the origin of technology. Here, a number of specimens ascribed to the species *Paranthropus boisei* (Leakey, 1959), *Homo habilis* (Leakey et al., 1964) and, more recently, *Homo erectus/ergaster* (Domínguez-Rodrigo et al., 2015) have been found. The lithic sequence identified in Bed I gave name to the oldest known archaeological techno-complex, the Oldowan, and was once considered the earliest evidence of human material culture (Leakey et al., 1961). Although the presence of lithic implements in sediments of the Lower Member, at about 2 Ma, has been recently reported (Stollhofen et al., 2021), the bulk of the archaeological and paleoanthropological information in Bed I comes from localities in the Upper Member, where the classic sites of the Oldowan industry (such as DK (Douglas Korongo), FLK NN (Frida Leakey Korongo NN), FLK 22, and FLK N) were first studied by Mary Leakey (1971). The detailed archaeological sequence presented in Leakey's monograph became an absolute referential framework for the study of the earliest industries in Africa and, thus, constitutes a historiographic milestone in paleoanthropological studies.

FLK 22 "Zinj floor" (Leakey, 1971), in particular, is the most influential Early Pleistocene site for the research on the archaeology of human origins in Africa. The extensive excavation plus the abundance and optimal preservation of its faunal and lithic remains have prompted a large number of studies (e.g., Blumenschine, 1995; Bunn and Kroll, 1986; Domínguez-Rodrigo et al., 2007, 2010; Kimura, 2002; Kroll, 1994; Kroll and Isaac, 1984; Ludwig, 1999; Potts, 1988, 1991) that place FLK 22 in the center of interpretations on a variety of aspects related to early human behavior (Domínguez-Rodrigo et al., 2007). For this reason, TOPPP (The Olduvai Paleoanthropology and Palaeoecology Project) has devoted a significant effort to the study of both FLK 22 and its paleolandscape (Arráiz et al., 2017; Ashley et al., 2010; Domínguez-Rodrigo and Cobo-Sánchez, 2017; Domínguez-Rodrigo et al., 2010). Intense fieldwork has also led to the identification of new sites in the same stratigraphic position as FLK 22: DS (David's Site), AMK (Amin Mturi Korongo), PTK (Phillip Tobias Korongo) and AGS (Alberto Gómez's Site) (Fig. 1). All the sites but AMK (a paleontological locality devoid of stone tools) constitute dense patches of faunal remains and lithic artifacts. The discovery and study of these new localities in the

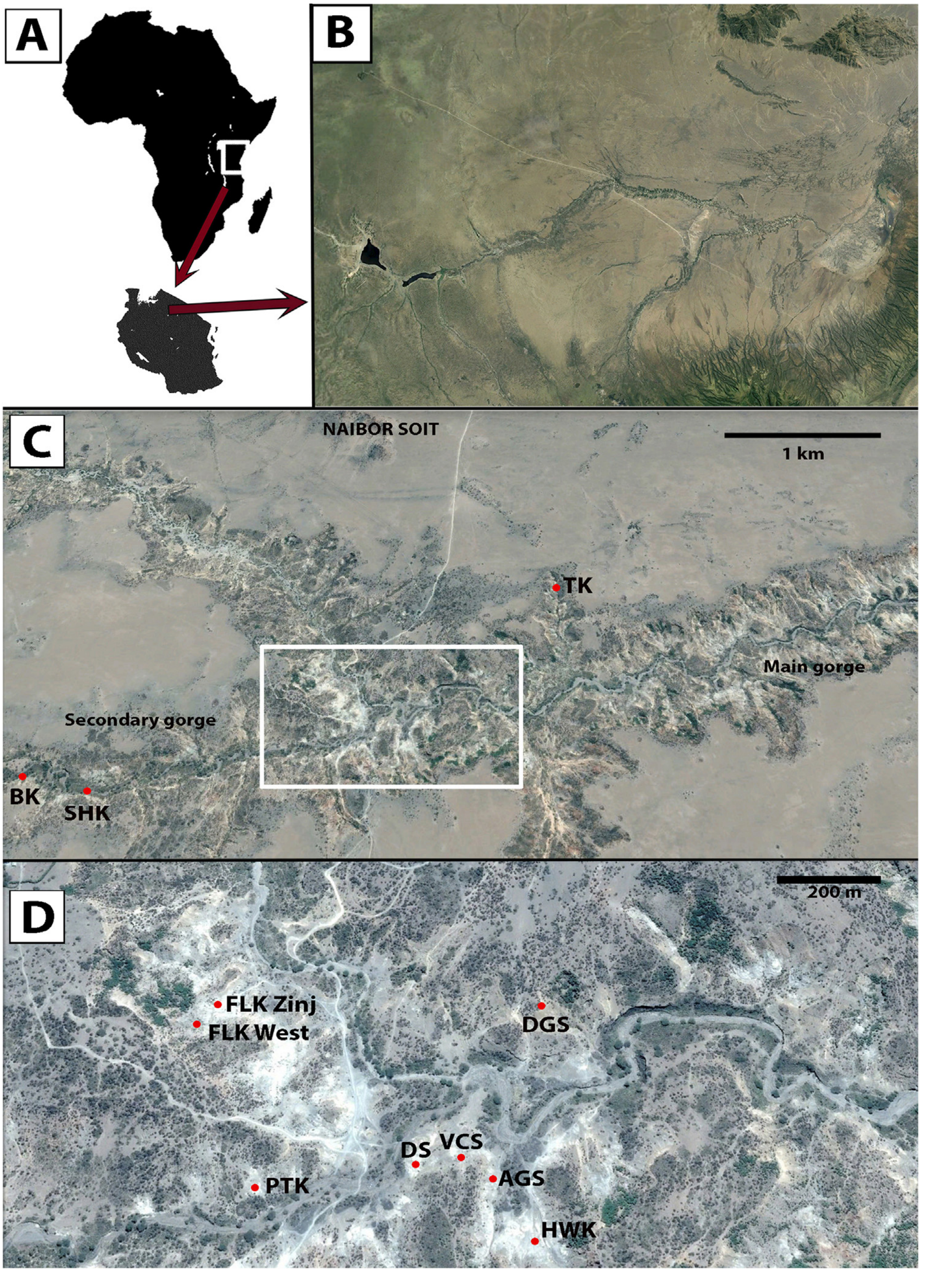

Figure 1. Location of the cited sites. **A**: general location; **B**: Olduvai Gorge; **C**: central area of Olduvai Gorge with Bed II sites; **D**: Junction area of Olduvai Gorge with the Bed I and Ndutu sites mentioned in the text.
*Localisation des sites cités. **A** : localisation générale ; **B** : Gorge d'Olduvai ; **C** : zone centrale de la gorge d'Olduvai avec les sites Bed II ; **D** : Zone de jonction des gorges d'Olduvai avec les sites Bed I et Ndutu mentionnés dans le texte.*

very same paleosol, a ~20-cm clay stratum deposited at 1.84 Ma within an alluvial-lacustrine paleolandscape (Domínguez-Rodrigo et al., 2017; Uribelarrea et al., 2014) constitute an exceptional opportunity to broaden our understanding of human adaptations to specific areas of lacustrine paleolandscapes and to explore the different factors (ecological, economic or functional) operating in synchronic technological variability within the Oldowan (Aramendi et al., 2017; Arráiz et al., 2017; Diez-Martín et al., 2021; Domínguez-Rodrigo and Cobo-Sánchez, 2017; Domínguez-Rodrigo et al., 2017).

Mary Leakey's approach to the Oldowan industries of Bed I was typological and described the percentage variation of various types of, preferentially, core forms (such as choppers, polyhedrons, discoids and spheroids) produced mainly on volcanic rocks (basalt and phonolite) and quartzite (Leakey, 1967, 1971, 1975). A number of authors have revisited the Bed I technology, following Leakey's typological parameters more or less strictly (Brantingham, 1998; Kimura, 2002; Ludwig, 1999; McNabb, 1998; Potts, 1988; Sahnouni, 1991; Willoughby, 1987) or following a more independent reanalysis of the collections (Torre de la and Mora, 2005). In our case, our re-excavations in FLK 22 and FLK N and the discovery of those new sites on the Zinj paleolandscape, have made it possible to add new empirical data to the definition of the Oldowan in Bed I. To date, we have published technological characterizations of DS (Diez-Martín et al., 2021) and FLK N (Diez-Martín et al., 2010), while specific studies devoted to the technology of PTK and AGS are in progress. In any instance, our own fieldwork in the Zinj Horizon (ZH hereafter), has allowed us to significantly enlarge the lithic sample in this extremely important archaeological paleosol. We have studied a total of 5597 lithic specimens unearthed from the various sites in the ZH (including 2564 items recovered by Leakey from FLK 22). Out of this count, 54.22% of these specimens have been retrieved from the sites discovered by TOPPP: DS (n = 1229), PTK (n = 1135), and AGS (n = 671). The general technological trends that we have identified in the Oldowan of the ZH, at 1.84 Ma are the following.

Raw material selection and use. In all the ZH sites the assessment of rock-type use varies dramatically depending on the type of approach applied. If we consider absolute number of lithic specimens per site, then quartzite would be the most employed raw material, always above 60% of the total sample (90.78% in FLK 22, 81.48% in PTK, 75.85% in AGS and 64.84% in DS). However, this approach masks the actual ratio of quartzite and volcanic materials. A different perspective to raw material selection and use, based on counting total mass instead of number of specimens per rock type, shows a completely different picture: volcanic rocks rise to 68.2% in FLK 22, 72.83% in PTK, 78.15% in AGS, and 84.56% in DS, representing a mean percentage of 76%. Hominins were transporting to these spots enormous amounts of lavas (for instance, almost 114 kg of volcanic rocks versus 19.7 kg of quartzite in DS) to undertake their lithic activities. The absolute discrepancy between specimen count and mass count points to another significant characteristic of these collections: the overrepresentation of detached specimens and waste produced in quartzite. If we specifically look at waste (flake fragments, rejuvenation flakes, core fragments, undetermined shatter and debris $\leq$ 25 mm), this overrepresentation is particularly evident in FLK 22, where this category represents 84.7% of the total sample. Although in lower percentages, quartzite waste still contributes over 60% of the lithic collections of PTK and AGS. DS is the only site where the percentage contribution of this category is moderate (38%, still the most representative category). These discrepancies account for the different use of rocks by hominins. Volcanic rocks are, in all instances, primarily related to the heaviest, core-based categories (hammerstones, cores and chopper-cores, and unmodified cobbles discarded at these sites), while Naibor Soit quartzite mostly contributes to detached categories (flakes and waste). If we consider the percentage ratio between these two groups in number of specimens, a conspicuous pattern emerges: a mean of 85.14% of the items included in core categories are volcanic rocks (ranging from 90.2 in DS to 82.1 in FLK 22), while a mean of 64.21% of specimens included in detached categories are quartzite (ranging between 75.6 in FLK 22 and 48.84 in PTK). We are aware that this dual pattern is intimately related to parameters such as rock type response to breakage and raw material circulation across the landscape (particularly input/output of cutting edges).

Unmodified material. Specimens devoid of anthropogenic use represent less than 6% of the samples retrieved from PTK and AGS, while they constitute 10.8% in DS. When unmodified cobbles are considered in relation to their mass contribution to the total sample, then FLK 22, DS, PTK and AGS show similar numbers, representing a mean of 23.49% of the total rock mass discarded at the sites. The bulk of these pieces are volcanic cobbles (mean percentage of volcanic unmodified cobbles is 96.2) that are preferentially basalt (both vesicular and regular). In FLK 22 this category is mainly constituted by low-quality amorphous and vesicular specimens, a characterization that can support the hypothesis that these pieces correspond to clasts transported to the site locus by natural agents rather than by hominins (Torre de la and Mora, 2005), probably prior to site formation, since a taphonomic study of all the variables sensitive to fluvial transport indicate that the FLK Zinj assemblage did not undergo any significant post-depositional modification by hydraulic flows (Domínguez-Rodrigo et al., 2013b). In contrast, this local presence of naturally-deposited unmodified cobbles might not have been the case for the rest of the sites, particularly at DS. Here, the significant amount of rounded (47%) and fine-grained (56%) basalt cobbles would suggest that a considerable number of these specimens is the result of intentional transport to the site, from suitable outcrops nearby, for future use, as an example of curated behavior implying extensive foresight (Potts, 1988). The fact that maximum length of unmodified cobbles and hammerstones is statistically alike, reinforces this hypothesis (Diez-Martín et al., 2021).

Percussion activities. In line with the importance of percussion activities in Bed I sites and other Oldowan records elsewhere (Arroyo and Torre de la, 2016; Arroyo et al., 2020; Barsky et al., 2011), our work supports the qualitative importance of artifacts related to pounding and hammering activities during the Oldowan. Our previous analysis of FLK N, the uppermost site of Bed I, capped by Tuff 1F at 1.8 Ma (Deino, 2012), suggests an absolute predominance of percussive behaviors at this spot, while knapping activities are identified through subsidiary and fragmented sequences (Diez-Martín et al., 2010) (Fig. 2.1). The human presence in FLK N, a site virtually devoid of signs of anthropogenic activity on faunal remains (Domínguez-Rodrigo et al., 2007), might be related to the exploitation of alternative vegetal resources in which percussion behavior played a prominent role. In the sites located in the ZH, specimens with formal signs of percussion (hammerstones, anvils and percussion flakes and fragments) represent a mean 14.7% of the total mass of rocks introduced in the sites (FLK 22 = 9%, DS = 15.53, AGS = 20.9, PTK = 13.66). As in the case of unmodified material, 80.97% of the specimens included in this category correspond to volcanic cobbles (FLK 22 represents the most remarkable case of bias towards lavas, as 93.33% of percussive specimens retrieved here are volcanic). Hominins carried out a selection of the most suitable and ergonomic blanks for hammering tools, as the majority of specimens show oval shapes (87.82%, ranging from 82 in FLK 22 to 94.4 in PTK), followed by angular (mean 9.2%). DS and PTK have rendered small collections of MBB (Modified Battered Blocks) on quartzite; the classic categories of spheroids and subspheroids, which might be related to percussion tasks (Sánchez-Yustos et al., 2015).

Knapping strategies. The relevance of flaking cores in the ZH sites is demonstrated by the fact that a mean of 43% of the total mass discarded at these sites is composed by this category. Most of the cores that have been exploited from volcanic blanks (mean of 74.4% versus mean of 24.7% in quartzite) tend to be fine-grained and oval-shaped (mean of 48.12%). However, the use of amorphous and low-quality specimens for exploitation is common, as this type of lava forms a significant 27.64% in the ZH sites. Regarding handheld percussion, the most representative group of cores, in all instances, is unorganized or test specimens (i.e. those items with few and isolated negative scars). This group represents a mean of 28.6% of cores. It is noteworthy that a high number of casual cores have been exploited on vesicular basalt. In AGS and FLK 22, 76.92% and 68.7% of test cores, respectively, are vesicular basalt. Considering these numbers, it seems that low quality lavas (due to the abundance of cavities or vesicles in their structure) were repeatedly tested by hominins, although they were probably not found suitable enough to undertake more systematic series of detachments. The same pattern has been observed in FLK N (Diez-Martín et al., 2010). In all instances, the most abundant reduction strategy carried out in these sites is unifacial (25%), mostly characterized by short series of, preferentially, subparallel removals, but also opposed or orthogonal arrangements. Bifacial simple cores (following lineal or alternating patterns) contribute 16% to the total sample. Multipolar/multifacial cores (the classical spheroids) are, as usual, a significant group (mean of 19.3%) (Fig. 2.7). However, there are remarkable differences between those sites where their percentage reaches 25 (PTK and AGS), and those others where they are below 14% (FLK 22 and DS). Bifacial complex specimens (i.e. cores following orthogonal and centripetal patterns) represent a mean of 11% in all sites. However, it is important to note that examples of radial rotations have only been documented in

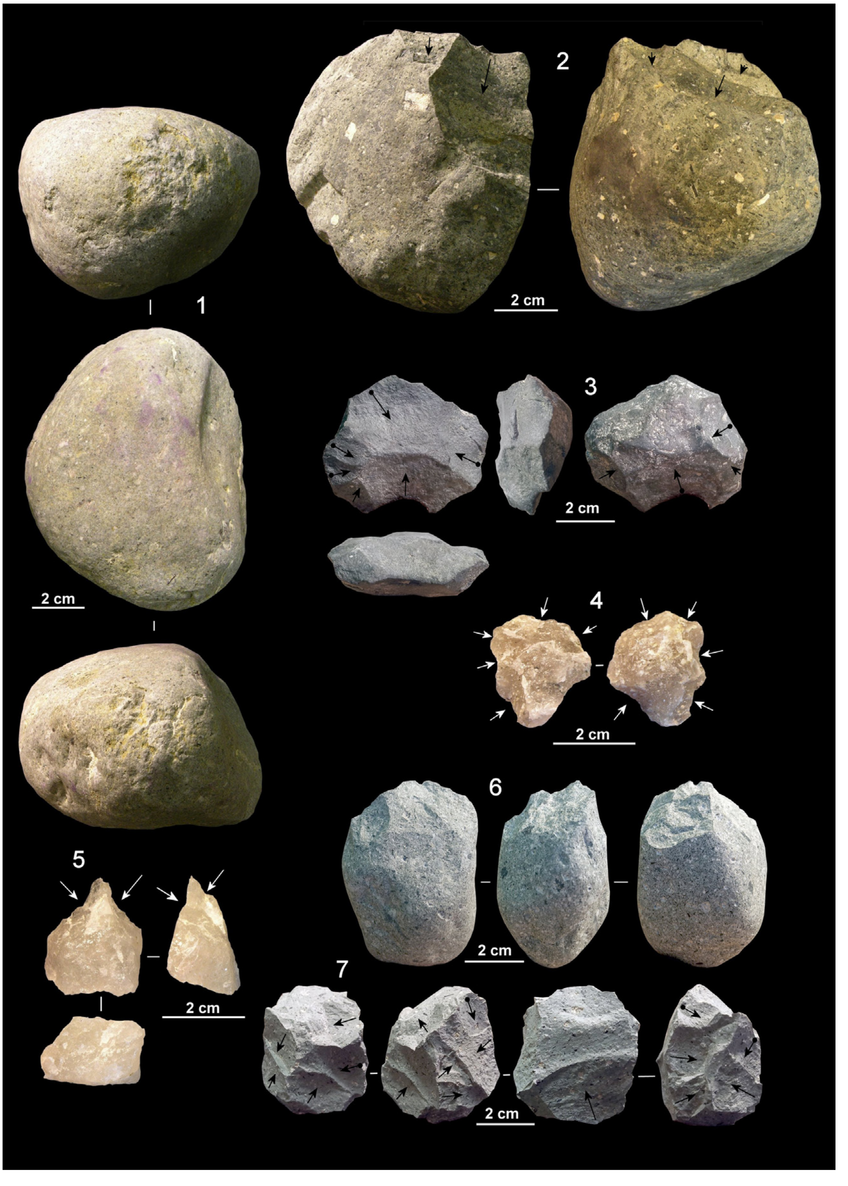

Fig. 2. Oldowan artifacts from Bed I. DS: **3**. Bifacial centripetal core in basalt; **6**. Bifacial chopper on phonolite; **7**. Phonolite multifacial/multipolar core in a final stage of exploitation. FLK N: **1**. Basalt hammerstone; **2**. Bifacial chopper in phonolite; **4**. Quartzite denticulate; **5**. Borer on quartzite.

*Artefacts Oldowayens de la Bed I. DS : **3**. Nucleus centripète bifacial en basalte ; **6**. Chopper bifacial en phonolite ; **7**. Nucleus multifacial/multipolaire en phonolite dans un stade final d'exploitation. FLK N : **1**. Percuteur en basalte ; **2**. Chopper bifacial en phonolite ; **4**. Denticulé en quartzite ; **5**. Perçoir en quartzite.*

DS (Fig. 2.3). Exhausted cores have been observed in all sites. It is significant that, particularly in the case of FLK 22 and DS, the majority of these are quartzite specimens. Bipolar cores, exploiting quartzite tabular slabs, have been documented in all sites and are particularly numerous in FLK 22 (41% of all examples of anvil technique were found here) and DS (32% of the total sample of bipolar cores). In sum, handheld reduction strategies documented in the Zinj Horizon are characterized by the predominance of volcanic rocks, a significant percentage of unorganized cores (a number of which are low quality lavas) and the preference for unifacial (particularly lineal) and multipolar exploitations. Core rotation is mostly observed through unifacial and bifacial orthogonal series. However, fully centripetal series are rare in these sites. The anvil technique is irregularly present at the various sites studied here.

Choppers. Core-like pieces showing a rectilinear cutting edge and/or secondary trimming, which might be considered intentionally-shaped tools, are very scarce in the ZH (Fig. 2.2, 2.6). They represent a mean of 0.2% of the total collection and a mean of 3% of all the core-like specimens (including knapping cores). In total, 60% of these pieces have been produced in volcanic rocks and the rest in quartzite (FLK 22 is the only site in which all the choppers have been shaped on quartzite blanks). Both unifacial and bifacial choppers are similarly represented in all the sites.

Detached pieces. Complete and broken handheld flakes have been mostly produced from quartzite blanks. Numbers are quite consistent and quartzite flakes constitute a mean of 76.8% (sd = 2.6). This percentage is in contradiction with the data provided by the core sample, where quartzite cores only represent a mean of 24.73% (sd = 6). Overrepresentation of quartzite flakes and deficit of volcanic flakes represents a consistent pattern in Bed I sites (Brantingham, 1998; Kimura, 2002; Leakey, 1975; McNabb, 1998; Potts, 1988) and might be related to: **a)** a longer life of volcanic cutting edges (Key et al., 2020) and consequently more intense circulation of volcanic flakes across the landscape (Brantingham, 1998; Diez-Martín et al., 2021); **b)** the specific crystallographic traits of Naibor Soit quartzite (coarse-grained structure and abundant cleavage planes) that accelerate reduction and promote a faster and more intensive reduction of cores (Potts, 1988). Less controlled quartzite response to breakage might account for significant amounts of quartzite waste in the ZP sites, particularly in the case of FLK 22. Here 86% of all the specimens with signs of anthropogenic action are considered waste. Furthermore, 79% of the FLK 22 waste is debris, and 96% of this debris has been produced in quartzite. In PTK and AGS the waste category represents percentages of over 65 of the total sample, while DS is the site with a lower proportion of waste (38%, 38% of which is debris). Flakes produced in the various sites of the Zinj paleolandscape tend to be small, as a mean of 66% of them are $\leq$ 35 mm. Most of the flakes belong to later phases of the reduction sequence (Toth types 5 and 6), both in lavas (63.4%) and quartzite (89%). However, first generation flakes are more common in volcanic rocks (21.1%) than in quartzite (5.4%). In general lavas are more prone to cortical retention (54.5% of volcanic rocks retain some dorsal cortex versus 18.6% of quartzite), a trait that might support the idea that second and third generation volcanic flakes could have been taken off-site more easily (Diez-Martín et al., 2021). In line with the previous statement, cortical butts are more common in lavas than in quartzite (26 versus 7%). However, the most common platform type in both groups of raw materials is plain (54.7% in lavas and 68.6% in quartzite). Other representative types of butts in quartzite are lineal (11%) and punctiform (7.5%). More complex facetted buts are not representative of these collections. However, they are slightly more abundant in lavas (4.6%) than they are in quartzite (2.1%). Only a mean of 9.3% of the detached specimens have been subjected to some sort of retouch. In most instances, retouch is casual, unifacial and discontinuous. Trimmed specimens represent 33% of retouched flakes, while the most representative normative types are notches (28%), scrapers (21%) and awls (8%) (Fig. 2.4 and 2.5).

2. FLK West and the earliest Acheulean in Olduvai

In her interpretation of the archaeological sequence of Olduvai, Mary Leakey placed the emergence of the Acheulean complex in Middle Bed II, at the site of EF-HR (Evelyn Fuchs-Hans Reck site) (Leakey, 1971). Although in previous publications Louis Leakey had proposed an alternative scenario for the origin of the Acheulean in Olduvai, placing its appearance at the base of Bed II (Leakey, 1951), EF-HR emerged as referential evidence to understand the dawn of the Acheulean in Africa, a process that was placed at ~1.5 Ma (Isaac, 1986; Isaac and Curtis, 1974; Leakey, 1975). Although earlier dates for the first Acheulean were subsequently suggested (Roche et al., 2003), the consensual lower boundary for the Early Acheulean was definitely surpassed with the publication of new evidence from the sites of Kokiselei 4 (Lepre et al., 2011) in Kenya and Konso (Beyene et al., 2013) in Ethiopia, placing the origin of the Acheulean at ~1.7 Ma.

Inspired by these remarkable discoveries and the change of chronological paradigm they represented, in 2012 our team undertook a systematic archaeological survey in sediments of similar age in Olduvai, aiming at tackling the same temporal framework of the newly dated sites. As a result of this effort we discovered the site of FLK West, about 50 m to the west of FLK and in the same locality where in1969 remains ascribed to *Paranthropus boisei* (OH26) had been discovered (Leakey, 1971). This is a remarkable site that, at present, is the oldest Acheulean evidence in Olduvai and is part of the triad of sites defining the earliest Acheulean in East Africa (Diez-Martín et al., 2015).

Bed II was deposited between the top of Tuff 1F and the last of the main five marker tuffs identified in this unit, Tuff IID, dated at 1.35 Ma (Domínguez-Rodrigo et al., 2013b). As in Bed I, marker tuffs have been used to subdivide this unit in three main sections (Lower, Middle and Upper). EF-HR (and some of the most relevant archaeological sites documented in this unit, such as HWK E (Henrietta Wilfrida Korongo East), MNK (Mary Nicol Korongo) and SHK (Sam Howard Korongo)) was deposited in Middle Bed II. However, Bed II tuffs have been severely altered due to water action and the available dates are not as clear-cut as those in Bed I (Hay, 1976; Manega, 1993; Stanistreet, 2012; Uribelarrea et al., 2014). During most of the basal section of the sequence, the same lacustrine environmental conditions described for Bed I dominated the Basin. However, after the deposition of the aeolian tuffs Twiglet and Tuff IIA, included in the so-called Lemuta Member, at ~1.7 Ma (Hay, 1976; Curtis and Hay, 1972), intense tectonic processes and climatic changes in the basin prompted an increase in fluvial activity and intensive erosion of previous Bed II lowermost levels (an erosive process known as the Lower Disconformity). The onset of a fluvial regime favored the deposition of a fluvial unit known as the Lower Augitic Sands (LAS), which in the Main Junction outcrops from the HWK site complex to FLK NN (Uribelarrea et al., 2014, 2019). The LAS fluvial system included a network of braided channels flowing SE-NW towards the central paleo-lake and merging progressively in fewer water courses downstream. FLK West is precisely deposited in one of these downstream channels closer to the lake margin (Uribelarrea et al., 2014, 2019). The FLK West channel is ~40 m wide and has a maximum depth of 1.2 m and it is infilled with six stratigraphic levels fining upwards (from bottom to top, L6 to L1). The channel is embedded in a clay substratum that rests ~1.5 m on top of the marker tuff 1F (1.8 Ma) and it is bracketed between two local tuffs that have been $^{40}Ar/^{39}Ar$ dated between 1.69 ± 0.15 Ma (tuff FLKWa) and 1.66 ± 0.16 Ma (tuff FLKWb) (Diez-Martín et al., 2015). This chronological framework places FLK West right above Tuff IIA, previously dated to 1.7 Ma (Manega, 1993; Stanistreet, 2012) (Fig. 3).

FLK West is a multicomponent site with six archaeological levels deposited within the corresponding fluvial events mentioned above. The information already published is the result of the first phase of fieldwork that, between 2012 and 2015, focused on an area of 17 m^2 (Diez-Martín et al., 2015, 2019; Sánchez-Yustos et al., 2017, 2018; Sistiaga et al., 2020; Uribelarrea et al., 2017, 2019; Yravedra et al., 2017). A second phase of research is currently devoted to the excavation of an extra area of 100 m^2, where archaeological work in progress is tacking levels 1 to 3. For obvious reasons, this new phase will enlarge significantly our knowledge of FLK West. For instance, we know now that diagnostic Acheulean elements (such as LCTs and large flakes) are documented in the whole sequence, including the uppermost levels. This fact will affect our previous assessments of the technological inter-assemblage variability in the FLK West sequence (Sánchez-Yustos et al., 2018). Still, the richest accumulations of stone tools and fossil bones are deposited in the lowermost levels 5 and 6, where impressive accumulations of archaeological remains have been unearthed. Of the three examples of the earliest Acheulean in East Africa dated to ~1.7 Ma, FLK West represents, without doubt, the most complete document at hand for our understanding of this transcendental event in human evolution, as it is unique in the following aspects: **a)** it is directly dated radiometrically and precisely bracketed between a defined time-span (Diez-Martín et al., 2015); **b)** it is a multi-component site, with enormously rich accumulations of archaeological remains (Diez-Martín et al., 2015, 2019; Sánchez-Yustos et al., 2017, 2018; Yravedra et al., 2017) **c)** post-depositional processes in a fluvial context have moderately affected the integrity of the archaeological aggregates (Yravedra et al., 2017); **d)** it is the

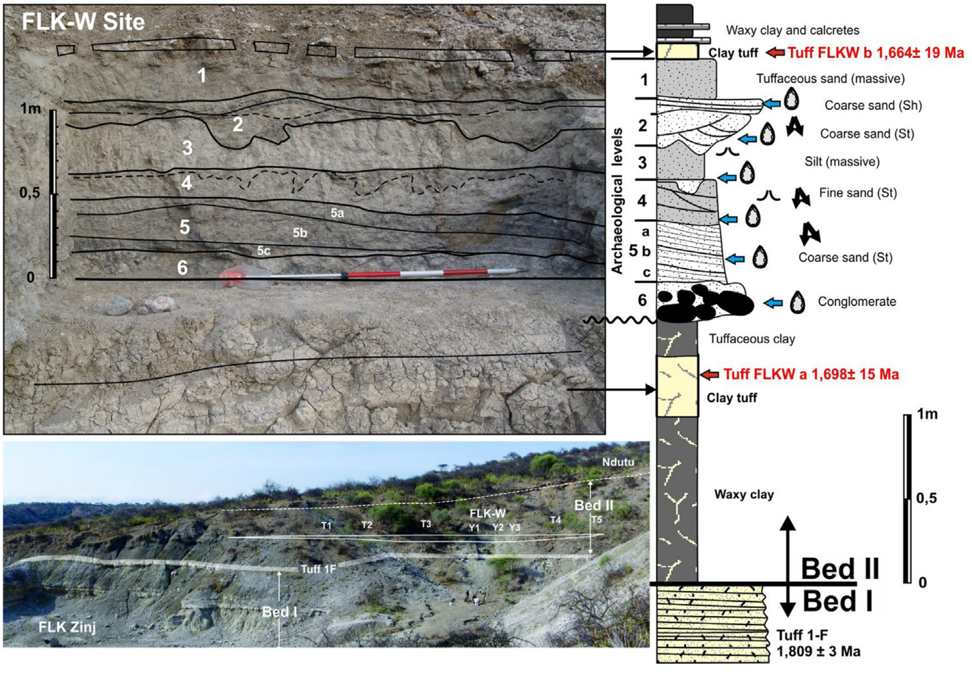

Fig. 3. Stratigraphic column of FLK West site and position of the channel within Bed II.
Colonne stratigraphique du site FLK West et position du canal dans la Bed II.

oldest Acheulean site showing a functional association between faunal remains and lithic artifacts (Yravedra et al., 2017); **e)** the site has been the subject of a variety of paleoecological and functional studies that contextualize the emergence of the Acheulean complex (Arráiz Rodríguez, 2017; Francisco de, 2019; Sistiaga et al., 2020; Uribelarrea et al., 2017, 2019; Yravedra et al., 2017).

During the first phase of research in FLK West, a collection of 3833 archaeological remains (2790 lithics and 1043 fossil bones) were retrieved. Regarding the lithic sample, 82.14% of the total collection was recovered from the two lowermost levels (L5 and L6). Specific diagnostic Acheulean artifacts (i.e. large flake cores, large flakes and LCTs) constitute 3.4% of the total collection. By far, most of these artefacts (95%) have been identified in L6. In total, diagnostic Acheulean artifacts ($n = 71$) represent 6.2% of the lithic sample retrieved from L6. The most representative technological traits of FLK West are the following:

Raw material selection and use. Naibor Soit quartzite is, by far, the preferred raw material used in FLK West, representing 74.4% of the total sample. Volcanic rocks sum 15.7%, followed by chert (6.6%) and other marginal rocks (such as gneiss and rock crystal). This preference of quartzite over basalt points to a new raw material procurement and use tendency observed in Bed II sites (Torre de la and Mora, 2005). This shift towards quartzite might be indicative of new functional and/or spatial strategies arising during Bed II times, when more efficient and expedient short-term activities might have been conducted via cutting-edges produced on quartzite (Key et al., 2020). However, preference for quartzite is also observed in the production of large flakes and in LCT shaping processes, showing that the new rock procurement and management strategy might be related to more complex cultural decisions (Sánchez-Yustos et al., 2018). Although chert was moderately employed, this rock type was available in the basin during a specific period of time, coinciding with the formation of Lower Bed II (Hay, 1976; Kimura, 1999).

Percussion activities. Specimens related to percussion tasks represent 9.3% of the total sample. In this category, both hammerstones and MBB are included. As in the case of Bed I, there is a clear preference for volcanic rocks in percussive and pounding activities, as 84% of hammerstones are basalts and only 0.7% are quartzite. In this particular case, the abundance of volcanic cobbles in the fluvial matrix of the coarse gravels of the lowermost L5 and L6 levels must have driven the preferential selection of volcanic material for percussive activities. At these lowermost levels, for instance, unmodified cobbles represent 5.5% and 7.5%, respectively, of the total sample, 93% of which are basalt specimens. Another group of percussive tools is constituted by quartzite MBB, representing 27% of all the percussive tools. These specimens have been documented throughout the whole sequence, although they are more abundant in L6 (2.9% of the total sample).

Small/medium flake production strategies. Knapping processes aimed at the production of small and medium-sized flakes are one of the goals in FLK West. Thus, 26% of the total sample is made up of handheld cores and flakes (including plain and retouched specimens). Considering the scarce presence of bipolar knapping (small bipolar cores and flakes on quartzite represent 0.75% of the sample), a significant number of specimens counted in the category of waste (including debris, shatter and fragments, a group that represents 56.5% of the total collection) can also be considered by-products of these handheld knapping activities. Cores aimed at producing small/medium flakes (7.3% of the collection) have been exploited preferentially in quartzite (60.4%), followed by volcanic rocks (22.9%) and chert (8.87%) (Fig. 4.3). Regarding the reduction strategies, the most common patterns are bifacial simple (mostly including lineal arrangements of negative scars: 28.9%) and multifacial (28.4%), followed by unifacial patterns (lineal, orthogonal or centripetal, 20.3%). Bifacial complex (orthogonal and centripetal) arrangements are scarce (12.2%). In contrast with what we have previously seen in Bed I sites, test or unorganized cores barely represent 10% of the sample. It is significant to note that, despite what has been suggested by other authors for more recent early Acheulean sites (Gallotti, 2013; Torre de la, 2009), no signs of possible core preparation have been identified here. The lack of this type of cores has also been reported in the early Acheulean of Peninj (Diez-Martín et al., 2014a, 2014b). When we look at cores by raw material, multifacial cores are the most representative among quartzite (28.6%) and bifacial simple among lavas (36.7%) and chert (42%). In agreement with the preponderance of quartzite cores, most flakes have been produced in this rock type (77.35%). However, bearing in mind the percentage contribution of raw material type in the core sample, chert flakes are somewhat overrepresented (14%), while volcanic flakes are clearly underrepresented in the sample (7.2%). Flakes are preferentially small-sized (specimens with a maximum length $\leq$ 49 mm constitute 77.3% of the sample) (Fig. 4.6). When dimensions are sorted by raw material, volcanic flakes are the largest (mean maximum length of 45 mm) and chert flakes the smallest (28.4 mm). However, most of the medium-sized flakes ($\geq$ 50 mm) have been produced from quartzite cores (86.4%). Most flakes belong to the latest stages of reduction (79.5%), while first generation flakes represent 12%. This pattern applies for all raw material types, although it is particularly evident in the case of chert, where 88.3% of flakes belong to these advanced stages of reduction. In total, 12.4% of flakes have been transformed by retouch. The most common retouched types are borer (31.7%), denticulate (14.28%) and notch (12.7%). Specimens that cannot be accommodated in normative types represent 20.6% of the sample, and specimens showing combinations of two different morphotypes represent 11% of the retouched collection.

Large flake production strategies. A qualitatively significant collection of large flake cores and large flakes ($\geq$ 10 cm) identify what has been claimed as the most characteristic technological trait of the Acheulean innovation, the ability to produce usable large flakes ($\geq$ 10 cm) that, in a number of cases, can constitute the blank for further transformation into LCTs (Isaac, 1969, 1986). In FLK West, 1.9% of artifacts can be identified as large cores and flakes. As already mentioned, most of these specimens belong to L6, where these pieces represent 3.9% of the total sample. All large flake cores are large quartzite blocks (mean mass of 4 kg), showing moderate to scarce exploitation. Although in all cases, negative scars exceed 10 cm in maximum length (on occasion detached by means of bipolar technique), reduction tends to be casual. One exception to this rule is a very heavy quartzite block (9 kg) recovered from L6 showing two perpendicular series of detachments. A large flake (maximum length 110 mm and 300 g mass) refits with this core (Sánchez-Yustos et al., 2018). Regarding large flakes, 88% have been retrieved from L6 and their mean maximum length and width is 13 $\times$ 10 cm,

Fig. 4. Acheulean artifacts from FLK West: **1**. Large olivine basalt symmetric handaxe (300 × 138 × 93 mm); **2. and 7**. Large flakes (≥10 cm) on quartzite; **3**. Chert multifacial core; **4**. Unifacial lateral LCT on a quartzite tabular slab (200 × 94 × 47 mm); **5**. Bifacial pointed LCT on a quartzite tabular slab (184 × 109 × 48 mm); **6**. Small plain flakes on chert; **8**. LCT with a bifacial edge on a quartzite tabular slab (179 × 92 × 55 mm); **9**. Bifacial invasive handaxe on a quartzite slab (186 × 97 × 62 mm).
*Artefacts acheuléens provenant du site FLK West: **1**. Grand biface symétrique en basalte à olivine (300 × 138 × 93 mm) ; **2. and 7**. Grands éclats en quartzite (≥10 cm) ; **3**. Nucleus multifacial en chert ; **4**. Large Cutting Tool unifacial latéral en quartzite (200 × 94 × 47 mm) ; **5**. Large Cutting Tool présentant une pointe bifaciale sur une plaque tabulaire en quartzite (184 × 109 × 48 mm) ; **6**. Petits éclats en chert ; **8**. Large Cutting Tool avec un bord bifacial en quartzite (179 × 92 × 55 mm) ; **9**. Biface en quartzite (186 × 97 × 62 mm).*

which means that at FLK West knappers were mostly producing quadrangular and heavy (in excess of 400 g) specimens (Fig. 4.2 and 4.7). Although the collection of large flake bipolar cores is remarkable (Sánchez-Yustos et al., 2018), most of the retrieved large flakes have been detached by handheld percussion (87%). Regarding their position in the reduction sequences, large flakes tend to retain some cortex on dorsal areas while their butts tend to be plain. Dorsal patterns tend to be longitudinal lineal, followed by side lineal, a trait that agrees with the pattern observed in cores. A significant number of specimens (56%) shows casual trimming on their cutting edges.

Large Cutting Tool (LCT) configuration processes. LCTs, the hallmark of the Acheulean innovation, represent 1.43% of the total sample (including LCT fragments) and 6.2% of L6. LCTs shaped on volcanic blanks are rare, as 94% of these pieces are in quartzite tabular slabs, blocks and flakes. Most specimens (59%) have been shaped on tabular slabs or blocks, while the rest is made up of LCTs produced on flake blanks. Mean maximum length of the whole collection of LCTs is 160 mm and mean mass is 1100 g. At FLK West it is very difficult to systematize the wide range of LCT shaping strategies identified at the site. In previous works (Diez-Martín et al., 2015; Sánchez-Yustos et al., 2017, 2018) we have followed a techno-functional perspective to describe the LCT collection, combining both tool design and functional potentiality (Boëda, 2001, 2013). In general, LCTs have been partially and/or superficially shaped via marginal and abrupt or semi-abrupt retouch, within a volumetric treatment that, in the majority of cases, does not show bifacial or invasive concerns. Simple shaping processes produce two basic morphological features, pointed areas (in 60% of the cases) and broad cutting edges, which can be produced exclusively or, in many cases, combined in the same tool (Fig. 4.4, 4.5, 4.8). However, it is important to underline that the following traits are undoubtedly part of the technological know-how of the FLK West artisans: **a)** invasive knapping and complex volumetric treatment; **b)** clear bifacial reduction; **c)** canonical tool shapes (i.e. bifaces) (Fig. 4.9). The most significant example of this knowledge is expressed in an exceptional olivine basalt handaxe retrieved from L6 (Diez-Martín et al., 2019) (Fig. 4.1). This specimen is significantly large (maximum length 300 mm) and heavy (3660 g) when compared with the rest of the LCTs. Its blank has been intensely transformed through invasive detachments. In fact, a sequence of 12 different series of detachments has been identified: **a)** peripheral, invasive and centripetal detachments focused on the first volumetric reduction; **b)** abrupt and semi-abrupt series arranged the basal and passive area for ergonomic purposes; **c)** point shaping and tip configuration created the final symmetric form. These configuration traits suggest some sort of punctuated origin (rather than progressive) for some of the formal characteristics of the Acheulean complex. They also reveal a number of cognitive abilities of the Acheulean knappers that, at 1.7 Ma, could also bear aesthetic and symbolic purposes (Diez-Martín et al., 2019). As stated before, this massive olivine handaxe does not accord with the LCT sample retrieved from FLK West. This might suggest that, as already proposed for other early Acheulean sites (Diez-Martín et al., 2014a), despite knowing the principles of invasive shaping, volumetric control and bilateral symmetry, LCT configuration strategies during the Early Acheulean preferentially focused on maximizing effective functional solutions through the implementation of simple and pragmatic shaping actions (i.e. more casual pointed end forms).

3. New insights into the Developed Oldowan/Acheulean debate

Mary Leakey considered that the Acheulean evidence unearthed from EF-HR in Middle Bed II was intrusive in Olduvai and that it represented a "distinct cultural element" unrelated to the rest of the industry recovered from Bed II (which followed a more coherent technological progression rooted in the Oldowan of Bed I) (Leakey, 1967). Thus, the early Acheulean in the Olduvai sequence was interbedded in Bed II with a group of archaeological sites defined as Developed Oldowan, DO (Leakey, 1967, 1971, 1975), in which development towards an increase in percussion artefacts and "crude small handaxes" could be identified. A further subdivision of the DO entity was based on the stratigraphic position of the various sites and variations in their artefact composition (Leakey, 1971, 1975). As those assemblages identified as DO B co-occurred in Middle Bed II (above Tuff IIB, dated to ~1.6 Ma) with the Early Acheulean in EF-HR, Leakey's interpretation of the technological variability in Middle and Upper Bed II was grounded on quantitative and typological criteria. This rationale implied also the assumption that different human species were responsible for such diversity of technological behaviors (Leakey, 1971, 1975). Leakey's perspective, again, had a huge impact on the interpretations of the lithic sequences in other parts of Africa. It also prompted an enduring discussion on the actual meaning of the DO/A dichotomy (see references in Diez-Martín and Eren, 2012). In line with previous researchers (Gowlett, 1986; Isaac, 1969; Jones, 1994; Stiles, 1979), at present most scholars tend to place those sites previously labelled as DO within the variability range of the early Acheulean concept (Diez-Martín and Eren, 2012; Gallotti, 2013; Semaw et al., 2009; Torre de la and Mora, 2005). TOPPP's research in two of Leakey's classical DO sites, SHK and BK, are placed in the middle of this current perspective.

The SHK site complex, located in a fluvial environment on top of Middle Bed II, was first excavated by Mary Leakey in two pene-contemporaneous localities (SHK Main and SHK Annex) and ascribed to the DOB (Leakey, 1971). In 2009, our team resumed archaeological research at SHK Main (Diez-Martín et al., 2014c; Domínguez-Rodrigo et al., 2014; Sánchez-Yustos et al., 2019), where remains of an infant *Homo erectus/ergaster* was found (Domínguez-Rodrigo et al., 2012). Subsequently, a new window located between the main site and the Annex, identified as SHK Extension, was excavated (Diez-Martín et al., 2017). Detailed geological work in the area confirmed that both windows have preserved fractions of an isochronous overbank fluvial paleolandscape at both sites (Diez-Martín et al., 2014c, 2017). In the course of our research, a total collection of 3074 lithic artifacts was retrieved. The most significant technological traits retrieved from the new lithic sample include: a) overall predominance of quartzite (mean of 77% in both sites) over volcanic materials (that tend to be more abundant in SHKM, where they represent 33%); b) as usual in Olduvai, there is a preference for basaltic cobbles in percussion activities. Thus, volcanic oval hammerstones (6.6%) are significantly more common than quartzite MBB (0.83%); c) cores are significantly more abundant in SHKM (13.7%) than in SHKE (3.55%). Most specimens have been exploited on quartzite blanks (57.15%), although volcanic specimens contribute significantly to the core sample (41.5%). The exploitation patterns observed in handheld percussion are preferentially multifacial (29.27%) followed by bifacial complex, including orthogonal (16.96%) and centripetal patterns (4.85%). Unifacial and bifacial simple specimens are moderately represented. Casual cores are only represented in SHKE, where they contribute with a significant percentage of 24. The anvil technique is scarce in SHK and few bipolar cores and flakes have been identified; d) core exploitation is mostly aimed at the production of small ($\geq$ 49 mm, 74%) and medium-sized flakes. Considering the significant presence of volcanic cores, there is a clear under-representation of volcanic flakes, as they only represent 16% of the flake sample. Imbalance between volcanic and quartzite flakes is, as we have seen, a constant trait of the archaeological record in Olduvai. A number of these flakes (17.2%) have been subjected to retouch; in many instances casual trimming that does not configure clear morphotypes. However, denticulates, notches, borers and scrapers have been recorded.

Regarding the ascription of SHK to the Acheulean complex, Mary Leakey had found a significant sample of small handaxes characteristic of her DO (Leakey, 1971). A recent assessment of a partial sample of the Leakey collection has substantially lowered the contribution of large tools to the SHK old collection, although they have determined the presence of clear LCTs, including both casually transformed specimens and more normative bifacial invasive handaxes (Torre de la and Mora, 2014). As a result of the new round of fieldwork in SHK, we have retrieved a new sample of 36 lithic specimens in both sites (27% in SHKM and 72% in SHKE), linked with the Acheulean concept. This sample includes large flake cores, large flakes and LCTs. The last is a heterogeneous group with a similar contribution of raw materials (quartzite and volcanic rocks), dimensions and shaping strategies (casually transformed specimens by means of unifacial retouch, pointed pieces and normative bifaces). The percentage contribution of normative Acheulean types is low in SHK. However, this evidence is enough to confirm competence in both systematic production of large flakes and volumetric management of forms and, thus, a clear link to the Acheulean technological substratum. A limited percentage contribution of Acheulean tools (mostly produced on volcanic rocks) can be seen as a functional response to the specific characteristics of sites located in the fluvial landscapes of Middle Bed II.

BK is a complex multicomponent fluvial site (Uribelarrea and Domínguez-Rodrigo, 2017) located in the uppermost part of Bed II, immediately above Tuff IID, recently dated to 1.3 Ma (Domíguez-Rodrigo et al., 2013a). In the framework of the new round of archaeological work started by TOPPP in 2006, we undertook the study of the archaeological collections retrieved from levels 3 and 4. In our collections, an overwhelming predominance of quartzite (this rock constitutes almost 95% of the total lithic sample) was directed to the production of small and medium flakes. Among the reduction strategies identified, a significant presence of specimens obtained by means of bipolar technique was identified, amounting to 40% of the sample (Diez-Martín et al., 2009). Complex bifacial hierarchical freehand reduction strategies were also identified (Diez-Martín et al., 2009; Sánchez-Yustos et al., 2016). Although LCTs have not been found in our excavation, a reassessment of the old collections has confirmed the Acheulean identity when considering the technology of this site (Torre de la and Mora, 2014). A relevant contribution of our work in BK is the confirmation of the significance of anvil technique in the reduction processes undertaken in sites where quartzite tabular blanks were particularly available or abundant (Diez-Martín et al., 2009, 2011). Further analyses have shown that this method is also suitable to shape cuboid quartzite blocks for percussive purposes (Sánchez-Yustos et al., 2015).

4. The influence of functionality in the variability of the technological strategies during the early Acheulean stages: assessment from Thiongo Korongo T

There are not many Acheulean sites older than 1.2 Ma (Beyene et al., 2013; Quade et al., 2004; Texier, 1995; Isaac and Curtis, 1974; Diez-Martín et al., 2014a, 2014b, 2015; Mussi et al., 2021; Gallotti et al., 2021). A difference between the sites older than 1.2 Ma and those that are younger has been proposed based on analysis of the technological strategies implemented on the manufacturing of lithic tools (Torre de la and Mora, 2005; Sharon, 2007, 2010; Stout, 2011; Diez-Martín and Eren, 2012; Beyene et al., 2013; Sahnouni et al., 2013; Gallotti, 2013; Gallotti and Mussi, 2017, 2018a; Texier, 2018). Thus, sites older than 1.2 Ma are considered as early Acheulean. To establish these differences, it has not been taking into account variables that may influence those strategies. Among these variables, functionality of the archaeological sites is determinant (Presnyakova et al., 2018).

The highest concentration of early Acheulean sites has been recorded at Olduvai Gorge (Leakey, 1971; Santonja et al., 2014; Diez-Martín et al., 2009, 2014a, 2014b, 2014c, 2015; Sánchez-Yustos et al., 2016; Rubio-Jara et al., 2017; Torre de la and Mora, 2018), where it is possible the analysis of the variability of this technocomplex during its early stages in a confined geographical frame, with similar availability of lithic raw materials.

In the Olduvai Gorge, Thiongo Korongo (TK) preserves one of the highest concentrations of Acheulean lithic tools of the early Acheulean (Leakey, 1971; Santonja et al., 2014; Rubio-Jara et al., 2017), in autochthonous position together with a large number of bones (Yravedra et al., 2016; Panera et al., 2019). TK is located in the upper part of Olduvai Bed II. Its estimated dating is close to that of Tuff IID, ca. 1.3 Ma (Domíguez-Rodrigo et al., 2013a).

M. Leakey excavated two areas, where she distinguished two different levels, the TK Lower Floor (TKLF) and the TK Upper Floor (TKUF), both characterized by an important industrial component and a lesser presence of fauna (Leakey, 1971).

Our study of TK was based on controlled and extensive archeological excavations, with the objective to understand the local technological variability from an interactive standpoint that includes cultural, conceptual, technological, behavioral and economical aspects. The excavations we have been carrying out at TK since 2010 have made it possible to establish the Acheulean character of the TKLF's lithic industry (Santonja et al., 2014, 2018; Rubio-Jara et al., 2017), reinterpret the stratigraphy of the site and verify that it is more complex than was thought up to now (Leakey, 1971). Besides, we have identified a new archeological floor situated between TKLF and TKUF, which we have called TK Sivatherium Floor (TKSF). The industrial and faunal contents of this new archeological unit are markedly different from those recorded in the TKLF (Rubio-Jara et al., 2017).

TK became a key reference in the discussion on the relationships between Oldowan and Acheulean, to which several other scholars contributed. The generally accepted chronology given for TK places the lithic industry found here in the Early Acheulean phase (Santonja et al., 2018), within a time range conventionally set between 1.5 and 1.0 Ma (Lepre et al., 2011; Diez-Martín and Eren, 2012; Sahnouni et al., 2013). In TK, M. Leakey interpreted TKLF as Acheulean and TKUF as Developed Oldowan (Leakey, 1975). From then on, TK played a key role in the discussion about the relationships between Oldowan and Acheulan (Bower, 1977; Stiles, 1977, 1979; Willoughby, 1987; Sahnouni, 1991; Ludwig and Harris, 1998; Kimura, 2002). Nevertheless, the environmental hypothesis proposed at that time (Hay, 1976; Leakey, 1971) did not support different interpretations of TKUF and TKLF. Furthermore, the stratigraphy interpretation of one of the areas excavated by M. Leakey was incorrect. In the view of M. Leakey, the observations made throughout the Olduvai Gorge rather indicated that the Acheulean and Developed Oldowan B shared similar environments and the sites presented common elements (tools, débitage, fauna) suggesting that similar activities were carried out in different places. All in all, she concluded that Developed Oldowan B and Acheulean constituted two independent technological entities that were produced by two different human species, *H. habilis* and *H. erectus* (Leakey, 1971).

Our results at TK invalidate the published comparisons between the industry in the TKLF and that in the TKUF, which Leakey and other authors took to be representative respectively of Acheulan and of Developed Oldowan B (Leakey, 1971, 1975; Bower, 1977; Stiles, 1977, 1979; Kimura, 2002; Torre de la, 2004; Torre de la and Mora, 2005). The area excavated by Leakey in one of the trenches (Leakey, 1971), corresponds stratigraphically and topographically to TKLF not to TKUF (Santonja et al., 2018), as the scholars who have studied the TK industry accepted (Torre de la, 2004). The consequences of this are very significant. In all studies made to date, part of the assemblages assigned to the TKUF, are mixed up with materials that actually correspond to the TKLF. Only the industry that M. Leakey attributed to the TKLF is homogeneous as regards its stratigraphic origin.

The Acheulean technocomplex narrative has been constructed mainly from the technological strategies implemented in the manufacturing of lithic tools, from that starting point, the Acheulean, considered in its overall time period and its African geography, has often been divided into three periods: early, late or middle and terminal (Diez-Martín and Eren, 2012; Sahnouni et al., 2013). These three phases are identified primarily on the basis of the definition of shaped tools and especially the refinement of the bifaces (handaxes, cleavers, picks and knives). The initial appearance of the African has been recorded at specific sites (Semaw et al., 2018; Diez-Martín and Eren, 2012; Mussi et al., 2021; Duval et al., 2021). The industry at these places have been characterized by the presence of scarce and crude bifaces and large cutting tools, some of them shaped on large flakes. On the other hand, early Acheulean have lasted longer than previously thought, extending from 1.7 to 1.2 Ma, and to have spread throughout the African continent (Diez-Martín and Eren, 2012; Sahnouni et al., 2013; Gallotti et al., 2021), Considering the complex processes in handaxe configuration at FLK West (Diez-Martín et al., 2015) and TK (Santonja et al., 2014, 2018; Rubio-Jara et al., 2017), the current view of this industrial phase may turn out to be overly simplified.

At TK, the technological differences between TKLF and TKSF, especially associated to LCTS, allows to assess the hypotheses related to the periods in which the Acheulean has usually been divided.

Several authors have re-examined the industry of TK, focusing either on particular aspects (Bower, 1977; Willoughby, 1987; Sahnouni, 1991) or on one or both of the main levels (Ludwig, 1999; Kimura, 2002; Torre de la, 2004; Torre de la and Mora, 2005). Since there were doubts about whether absolutely all lithic materials at the site were in fact collected during those excavations (Torre de la and Mora, 2005; Diez-Martín and Eren, 2012), the lithic series we found at TK (Santonja et al., 2014, 2018; Rubio-Jara et al., 2017) have filled the gaps noted in the collections formed at this location by M. Leakey (Torre de la and Mora, 2005), in particular the under-representation of minor elements such as non-retouched flakes and shatter in general (Diez-Martín and Eren, 2012).

The technological and techno-economic study of the chaîne opératoire phases identified in TKSF (Rubio-Jara et al., 2017) reveal that this unit shows strong differences with the lithic industry and faunal remains of TKLF (Santonja et al., 2014, 2018; Yravedra et al., 2016). Both levels are clearly Acheulean, and are located stratigraphically very close to each other (between 21 and 42 cm), with no significant temporal diachrony, as it discussed in Rubio-Jara et al., 2017. The dominant raw materials are Naibor Soit quartzite (NQ) and volcanic rocks (VR), which are present in similar proportions in both levels. While most of the NQ was brought to the site unworked, at least part of the VR may have reached the site partly worked. Highlights the higher density per square meter of stone tools in TKLF than in TKSF (38.4 and 12.1 items respectively, shatter excluded, and 9.5 and 5.3 kg respectively, shatter included), perhaps due to the longer exposure of the palaeosurface on which the TKLF rests.

Taphonomic analysis tells us that the bones found in the TKLF had been exposed for a long period of time (Yravedra et al., 2016). The TKSF archeopaleontological record was quickly buried and was not exposed for long to atmospheric agents (Panera et al., 2019). Our analysis of the lithic industry has shown a differentiated economy of tool manufacturing: at TKLF, debitage of NQ and VR was transformed on site, whereas in TKSF only the NQ cores were knapped, and VR cores were flaked, at least in part, outside the site. Bipolar and freehand percussion are more represented in TKSF than in TKLF; cores exploited opportunistically are more frequent in TKLF, whereas discoid and bifacial discoid cores dominate in TKSF; flakes with rectangular formats prevail in TKSF. However, the greatest differences have been observed among the handaxes: 85 pieces in TKLF and 53 items in TKSF (Rubio-Jara et al., 2017; Santonja et al., 2018). In TKSF items heavier than 1 kg and longer than 19 cm are rare, whereas in TKLF items > 19 cm and on occasions as heavy as 3 kg were dominant. In the TKLF pieces, the functional area is concentrated on the apical third and they have backs on the base or on the edges, however in TKSF the whole perimeter is the cutting edge, and points and edges are more rejuvenated in TKSF than in TKLF (Figure 5).

To understand the identity of the Acheulean we need to discriminate between the variables that influenced the technological strategies. To achieve this goal, first of all, is necessary to study the functionality. Among the Olduvai early Acheulean sites, the particular features of the lithic assemblages and sedimentary environments identified in TK offer great potential for analyzing the influence of functionality in the variability of the technological strategies during the early Acheulean stages.

At TKLF and TKSF we have studied the zooarchaeological and taphonomic study of the bone remains and stone tools, the geoarchaeological analyses; the depositional patterns and degree of disturbance; the analysis of the spatial integrity; the spatial distribution of faunal and lithic remains; as well as the statistical spatial analysis (Panera et al., 2019). TKLF and TKSF are related to a paleo-surface in which the archaeological assemblages are found in autochthonous position. At TKSF the bone remains seem to indicate an assemblage of megaherbivores, without the intervention of carnivores, and without an intensive human intervention (Panera et al., 2019), which is corroborated by spatial and geostatistical analyses. The wide dispersion of flakes and shatter indicates that other human activities unrelated to processing of mammals were also carried out on these surfaces. The TKLF paleosurface, only 20–40 cm below TKSF, took much longer to be buried, the density of lithic industry is considerably higher, and the preservation of the bone surface is poorer. The large taxonomic diversity, with no cut marks and only one percussion mark, can be interpreted being a result of natural processes, so the main anthropogenic input could be related to other resources where large handaxes were necessary. The technological and techno-economic study reveals strong differences between the lithic industry in TKLF and TKSF, especially amongst the handaxe configuration.

The technological studies carried out in TK have identified three main tool classes in the assemblage; pounding tools, bifaces, and flakes with potentially functional edges. We have analyzed the flakes with potentially functional edges, and for the first-time microscopic use-wear traces have been identified in an African Acheulean flake assemblage after a systematic study (Bello-Alonso et al., 2020). Unfortunately, the proportion of pieces with use-wear does not allow to assess how different the activities were at TKLF and TKSF. At these paleo-surfaces, animal carcasses were consumed, but both levels suggest that butchery activities were less important than the processing of wood or underground storage organs, especially in the case of TKSF (Bello-Alonso et al., 2020). These results are relevant to understanding the role flake tools played in the Acheulean. We are currently trying to recognize activities through LCT's use-wear and biomarker analyses on stone tools.

Without assessment of site functionality and chronological context, this data could have led to the differences observed at TKLF and TKSF being assigned to different Acheulean stages.

The main quantitative differences we recorded between the TKLF and the TKSF, could be explained by the different lengths of time that the floors were. However, the differences we highlighted as regards the industrial assemblages of each of the two levels are due to different production methods, and were not influenced by sedimentary or erosive processes that could have affected the archeological record. The lapse of time between the two industrial assemblages is small, hence these differences cannot be explained by evolutionary dynamics; they may be more plausibly correlated with different behaviors and practices. This is what has been observed at sites like Gesher Benot

Ya'aqov, where 14 occupation levels deposited over 50 ka show that the marked variability of the lithic chaînes opératoires was correlated to distinct activities (Goren-Inbar et al., 2002).

The technological changes that occurred at TK over a short span of time encourage to examine the technological variability identified in the Acheulean in close correlation with patterns of behavior (Soressi and Dibble, 2003). The situation observed in the TKLF and TKSF levels underlines the importance of understanding sites as functional areas and suggests, as does the ecological hypothesis (Hay, 1976; Domínguez-Rodrigo et al., 2005), that there is a close connection between tools—especially LCTS in the case of the Acheulean (Sharon, 2007)—and activities dependent on the landscape.

5. The Ndutu Bed and the Middle Stone Age

Ndutu Bed are associated with the Middle Stone Age (MSA) and modern human occupations in Olduvai Gorge. These Beds have been the focus of mild and intermittent attention until recently. The chronology of these beds is not well defined. For Hay, Upper Ndutu had a chronology of 60–32 ka BP, and Lower Ndutu between 60–400 ka BP (Hay, 1976: 152). On the other hand, Manega (1993) considers that Upper Ndutu would be between 210–450 ka BP (using the Single Cristal Laser Fusion technique, SCLF) and, using Amino acids, around 260–500 ka BP. Manega also dates the start of Naisiusiu Bed in 42 Ka BP using SCLF. The onset of Naisiusiu Bed has more recently been dated to 62 ka BP by Skinner et al. (2003).

Two human remains have been found in the Ndutu Bed. The first one, a palate and maxillary fragment of *Homo* sp. known as OH-11, was found near DK and assigned to the Ndutu Bed (Hay, 1976; Leakey et al., 1972: 230). It presents a robust morphology (Rightmire, 1980: 227). Recently, a partial calvaria known as OH-83 has also been discovered and partially recovered in Upper Ndutu levels, close to the PLK site (Reiner et al., 2017). From an archaeological point of view, the first discoveries of MSA occupations at Olduvai were made by Mary Leakey and colleagues, who presented initially two MSA sites (Leakey et al., 1972). Although both sites were not geographically placed in the original paper, follow-up work placed them in the localities 4b and 26 (Hay, 1976, pp. 159). Regarding their stratigraphic position, one of them belonged to Upper Ndutu and the other one to Lower Ndutu (Hay, 1976, pp. 28). The lithics of both sites were presented uniformly and characterized by prepared core technology (Levallois and Discoid) and a few retouched blanks. The assemblages, although with due precaution, were linked to the Early MSA of Lake Eyasi.

The second and third projects on the MSA at Olduvai were led by A. Mabulla and M. Eren respectively. The first one revealed numerous find-spots with lithic industry and faunal remains (Mabulla, 1990), all of them surface remains except for locality 26 (Nduty type-site according to Hay, 1976). M. Eren led the most intensive project on the MSA in 2013. He carried out a systematic surface survey between the second fault and the Olbalbal depression, besides other selective surveys in the junction of both gorges, resulting in the discovery of 72 find-spots which provided flaked pieces and faunal remains (Eren et al., 2014).

These projects demonstrate the potential of the Olduvai Gorge for an MSA study. With this premise, since 2016 a project led by J.M. Maíllo also aims to know the human occupations of the MSA, characterize their material culture, their settlement patterns and the interrelation between humans and the environment in Olduvai Gorge. As a result, our project has focused on the location of stratified sites. Two are the sites discovered by us up to this moment. The first is VCS (Victoria Cabrera Site) (Maíllo-Fernández et al., 2019a) and the second, still unpublished, is DGS (Dorothy Garrod Site). Both sites are located at the junction between the two gorges (Fig. 1). To contextualize the regional MSA, J.M. Maíllo is also working on Nasera rockshelter (Martín-Perea et al., 2020; Solano-Megías et al., 2021) and studying the Loiyangalani site in the Serengeti (Maíllo-Fernández et al., 2019b).

VCS is an open site on the southern rim of the Gorge, stratigraphically located in Upper Ndutu. It is characterised by a six-layer stratigraphy with MSA lithic industry and associated fauna, although the fauna could not be related to anthropic action. The lithic industry is scarce ($n = 99$ blanks in total) and is knapped in different raw materials such as Naibor Quarzite (the most abundant), basalt and phonolite among others. The knapping methods are discoid and Levallois (Fig. 6). There are hardly any

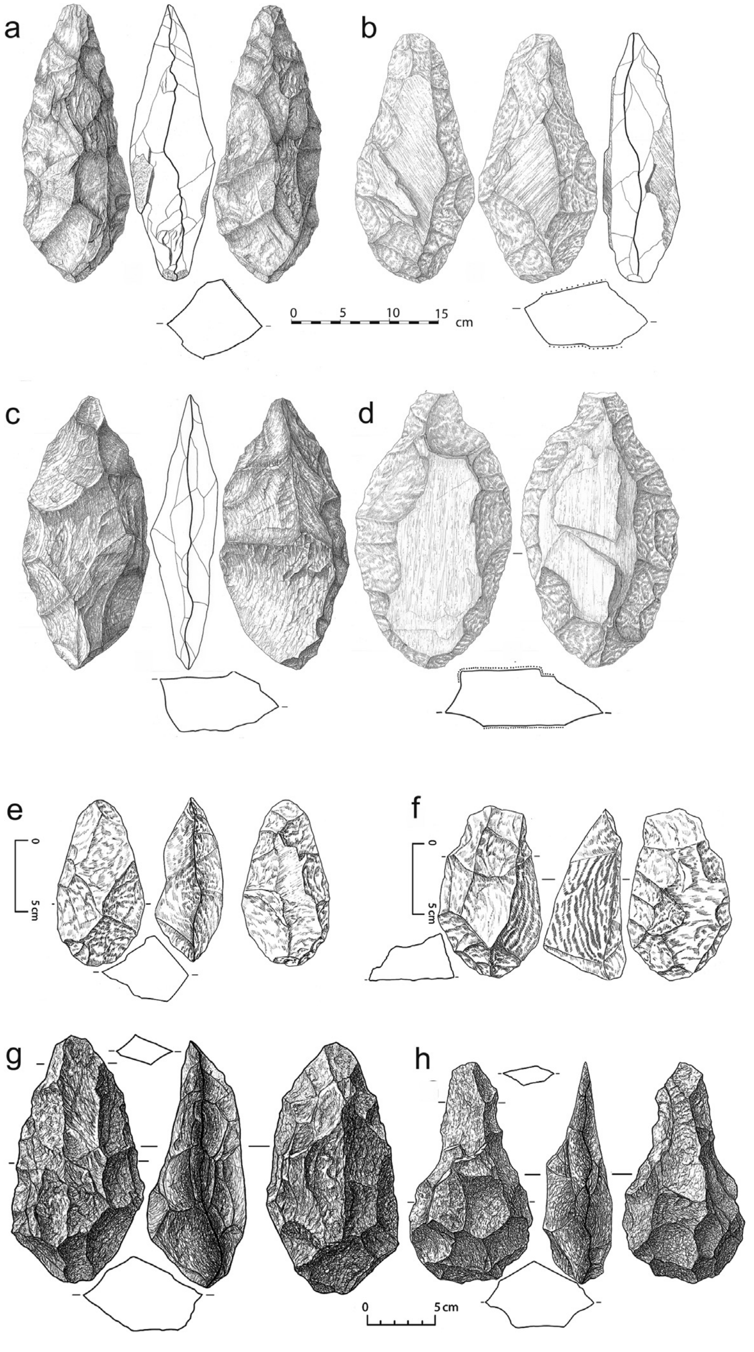

Fig. 5. Thingo Korongo (TK) handaxes. TK Lower Floor: **a-b**, pointed handaxes (VR and NQ); **c-d**, oval handaxes (VR and NQ). TK *Sivatherium* Floor: **e**, NQ oval handaxe; **f**. NQ transverse-edge handaxe; **g**, VR pointed handaxe; **h**, VR pointed handaxe. (Drawings by R. Rojas-Mendoza).

*Bifaces de Thingo Korongo (TK). TK Niveau inférieur : **a-b**, bifaces pointus (VR et NQ) ; **c-d**, bifaces ovales (VR et NQ). TK Niveau du Sivatherium : **e**, NQ, biface ovale ; **f**. NQ, biface à bord transversal ; **g**, VR biface pointu ; **h**, VR biface pointu. (Dessins de R. Rojas-Mendoza).*

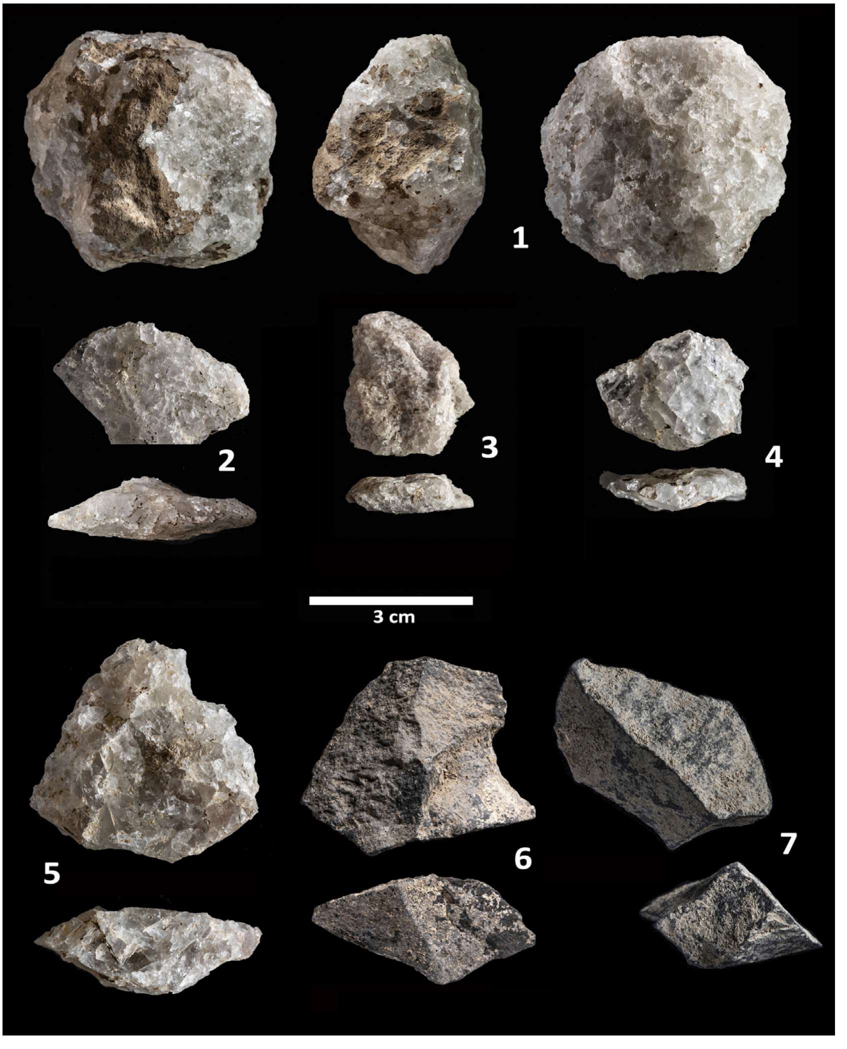

Fig. 6. Lithics from VCS and DGS. DGS: **1**. Discoid core; **2-6**. Discoid flakes. VCS: **7-8**- Discoid flakes. Raw materials: **1-6**: Naibor quartzite; **7-8**: basalt.
*Lithique provenant de VCS et DGS. DGS : **1**. Nucleus discoïde ; **2-6**. Éclats discoïdes. VCS : **7-8**- Éclats discoïdes. Matières premières : **1-6** : quartzite de Naibor ; **7-8** : basalte.*

retouched blanks ($n = 8$) and these are notches, denticulates and a Heavy-Duty piece. The fauna found in the different levels ($n = 148$) corresponds taxonomically to Equidae, Alcephalini, Antilophini, Hippopotamidae and Rodentia and for the unidentifiable remains the most abundant are those of ungulates of weight Size 3. The site was dated within a range between 75.3 ka BP and 86.2 ka BP (Maíllo-Fernández et al., 2019a). All of this makes VCS the first dated site of the MSA in Olduvai Gorge.

DGS, located 400 m north of VCS, is another open-air site with a single archaeological level that has provided a large number of remains. The site has not yet been successfully dated, but a stratigraphic approximation places it in a chronology similar to VCS in Upper Ndutu. Although it is currently being excavated, it has already provided 1179 lithics and 280 faunal remains. The lithic industry follows patterns similar to those of VCS. The most widely used raw material is Naibor Quarzite (79.8%), which is just 2 km north, followed by phonolite or sandstone. The knapping methods are discoid, Levallois or single platform (Fig. 6). The number of retouched blanks is scarce (n = 40) and most are denticulate or retouched blanks. There are no heavy duty or points.

The identifiable fauna is composed of Alcelaphini, Hippotragini and Equidae. Among the unidentifiable fauna can be found remains which most of the weight Size class 3 and 2. Although the preservation of the bone surfaces is not good, we have been able to identify burning and bone breakage.

6. Conclusions

The most significant conclusions that can be drawn from our technological research in Olduvai Gorge are the following.

The various sites located in the Zinj paleosol constitute an exceptional opportunity to broaden our understanding of human adaptations to lacustrine palaeolandscapes and to explore the different factors (ecological, economic or functional) operating in synchronic technological variability within the Oldowan. Lithic behaviors documented in these sites can be observed as must be observed as varied expressions of hominin inter-dependent activities and needs within this alluvial-lacustrine plain of Bed I. In general, hominins were selecting different types of rocks for different tasks. Volcanic materials were involved in a variety of percussion activities and knapping processes (preferentially via casual, unifacial and multifacial reduction patterns). Naibor Soit materials were processed differently, as they show evident signs of reduction intensity (via predominance of detached materials and, particularly, waste).

To date, FLK West represents the richest archaeological resource for our understanding of the down of the Acheulean techno-complex in East Africa. This site is directly dated radiometrically and precisely bracketed between a defined time-span. It is a multi-component site, with enormously rich accumulations of archaeological remains, moderately affected by post-sedimentary processes. Furthermore, this is the oldest Acheulean site showing a functional association between faunal remains and lithic artifacts. The study of the varied lithic collection recovered here shows that Early Acheulean hominins were undertaking two different but complementary strategies. Knapping processed aimed at the production of small and medium-sized flakes were conducted via bifacial and multifacial processes rather than through more complex radial schemes. To date, core preparation does not constitute an identifiable trait of the Early Acheulean of FLK West. Large flake production has been identified through both a remarkable collection of large flake cores in which simple reduction models have been observed and large flakes. LCTs have been produced mostly on quartzite and they have been partially shaped via a marginal and abrupt or semi-abrupt retouch that does not tend to show invasive concerns. Resulting shaped tools produce basic pointed shapes or broad cutting edges. However, as a number of canonic bifaces clearly show, the technological know-how of the FLK West Acheulean artisans included a complex volumetric treatment of invasive and bifacial knapping. This suggests that, despite knowing the principles of invasive shaping, volumetric control and bilateral symmetry, LCT configuration strategies during the Early Acheulean preferentially focused on maximizing effective and pragmatic functional solutions.

Some of them most significant sites located in Middle and Upper Bed II (SHK, TK and BK) have been directly involved in the debate of the archaeological meaning of the Developed Oldowan/Acheulean gradient. Or work in SHK has shown a clear ascription to the Acheulean of the lithic collections retrieved from the two pene-contemporaneous sites of SHK Main and SHK Extension. Although in lower numbers, technological components of the Acheulean substratum have been clearly found in both sites, including the production of large flakes and a variety of LCTs. TK, in particular, a locality that includes the highest concentration of Acheulean implements during the Early Acheulean, epitomized both the rationale of Leakey's hypothesis on the DO/A sequence and the subsequent debate. In-depth re-analysis of the site has put forward a correct stratigraphic and cultural connection between TKLF and TKUF. Both horizons show significant technological differences, particularly regarding handaxe size and shaping strategies that can be related to specific or different behavioral patterns. For the first time in the African Acheulean record, microwear analyses have shown the existence of use-wear traces in a relevant flake sample.

Until recently, interest in the post-Acheulean record of Olduvai has been discontinuous. Work in progress in the Ndutu beds of Olduvai has led to the discovery of two promising MSA sites, VCS and DGS, showing associations of lithic artifacts and fauna. MSA technology shows the concurrence of discoid and Levallois reduction techniques, with a moderate presence of small or medium-sized retouched tools.

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References

Aramendi, J., Uribelarrea, D., Arriaza, M.C., Arráiz, H., Barboni, D., Yravedra, J., Ortega, M.-C., Gidna, A., Mabulla, A., Baquedano, E., Domínguez-Rodrigo, M., 2017. The paleoecology and taphonomy of AMK (Bed I, Olduvai Gorge) and its contributions to the understanding of the "Zinj" paleolandscape. Paleogeography, Paleoclimatology, Paleoecology 488, 35–49, http://dx.doi.org/10.1016/j.palaeo.2017.02.036.

Arráiz Rodríguez, H., 2017. Reconstrucción de la paleovegetación y uso de útiles líticos en el yacimiento de homínidos de la garganta de Olduvai (Tanzania) mediante el uso de microfósiles vegetales (Doctoral disertación). Universidad Complutense de Madrid, Madrid, Spain.

Arráiz, H., Barboni, D., Ashley, G.M., Mabulla, A., Baquedano, E., Domínguez-Rodrigo, M., 2017. The FLK Zinj paleolandscape: Reconstruction of a 1.84 Ma wooded habitat in the FLK Zinj-AMK-PTK-DS archaeological complex, Middle Bed I (Olduvai Gorge, Tanzania). Paleogeography, Paleoclimatology, Paleoecology 488, 9–20, http://dx.doi.org/10.1016/j.palaeo.2017.04.025.

Arroyo, A., Harmand, S., Roche, H., Taylor, N., 2020. Searching for hidden activities: percussive tools from the Olduwan and Acheulean of West Turkana, Kenya (2.3–1.76 Ma). Journal of Archaeological Science 123, 105238, http://dx.doi.org/10.1016/j.jas.2020.105238.

Arroyo, A., Torre de la, I., 2016. Assessing the function of pounding tools in the Early Stone Age: A microscopic approach to the analysis of percussive artefacts from Beds I and II, Olduvai Gorge (Tanzania). Journal of Archaeological Science 74, 23–34, http://dx.doi.org/10.1016/j.jas.2016.08.003.

Ashley, G.M., Domínguez-Rodrigo, M., Bunn, T.H., Mabulla, A., Diez-Martín, F., 2010. A spring and wooded habitat at FLK Zinj and their relevance to origins of human behavior. Quaternary Research 74, 304–314, http://dx.doi.org/10.1016/j.yqres.2010.07.015.

Barboni, D., Ashley, G.M., Domínguez-Rodrigo, M., Mabulla, A., Bunn, H.T., Baquedano, E., 2010. Phytoliths infer locally dense and heterogeneous paleovegetation at FLK North and surrounding localities during upper Bed I times. Quaternary Research 74, 244–254, http://dx.doi.org/10.1016/j.yqres.2010.09.005.

Barsky, D., Chapon-Sao, C., Bahain, J.-J., Beyene, Y., Cauche, D., Celiberti, V., Desclaux, E., de Lumley, H., de Lumley, M.-A., Marchal, F., Moullé, P.-E., Pleurdeau, D., 2011. The early Oldowan stone-tool assemblage from Fejej FJ-1a, Ethiopia. Journal of African Archaeology 9, 207–224, http://dx.doi.org/10.3213/2191-5784-10196.

Bello-Alonso, P., Rios-Garaizar, J., Panera, J., Martín-Perea, D., Rubio-Jara, S., Pérez-González, A., Santonja, M., 2020. Experimental approaches to the development of use-wear traces on volcanic rocks: basalts. Archaeological and Anthropological Sciences 12 (7), 1–26, http://dx.doi.org/10.1007/s12520-020-01058-6.

Beyene, Y., Katoh, S., Wolde, G., Hart, W.K., Uto, K., Sudo, M., Kondo, M., Hyodo, M., Renne, P.R., Suwa, G., Asfaw, B., 2013. The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia. PNAS 477, 82–89, http://dx.doi.org/10.1073/pnas.1221285110.

Blumenschine, R.J., 1995. Percussion marks, tooth marks, and experimental determinations of the timing of hominid and carnivore access to long bones at FLK Zinjanthropus, Olduvai Gorge, Tanzania. Journal of Human Evolution 29, 21–51, http://dx.doi.org/10.1006/jhev.1995.1046.

Boëda, E., 2013. Techno-logique et Technologie : une paléo-histoire des objets lithiques tranchants. Archeo éditions, Paris.

Boëda, E., 2001. Détermination des unités techno-fonctionnelles de pièces bifaciales provenant de la couche acheuléenne C'3 base du site de Barbas I. In: Cliquet, D. (Ed.), Les industries à outils bifaciaux du Paléolithique moyen d'Europe occidentale. ERAUL 98, Liège, pp. 51–75.

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

Brantingham, P.J., 1998. Mobility, competition, and Plio-Pleistocene hominind foraging groups. Journal of Archaeological Method and Theory 5, 57–98, http://dx.doi.org/10.1007/BF02428416.

Bunn, H.T., Kroll, H.M., 1986. Systematic butchery by Plio-Pleistocene hominids at Olduvai Gorge, Tanzania. Current Anthropology 27, 431–452., http://www.jstor.org/stable/2742852.

Curtis, G.H., Hay, R.L., 1972. Further geologic studies and K-Ar dating at Olduvai Gorge and Ngrorongoro Crater. In: Bishop, W.W., Miller, J.A. (Eds.), Calibration of Hominoid Evolution. Recent advances in isotopic and other dating methods as applicable to the origin of man. Scottish Academic Press, Edinburgh, pp. 107–134.
Deino, A.L., Heil Jr., C., King, J., McHenry, L.J., Stanistreet, I.G., Stollhofen, H., Njau, J., Mwankunda, J., Schick, K.D., Toth, N., 2021. Chronostratigraphy and age modeling of Pleistocene drill cores from the Olduvai Basin, Tanzania (Olduvai Gorge Coring Project). Paleogeography, Paleoclimatology, Paleoecology 571, 109990, http://dx.doi.org/10.1016/j.palaeo.2020.109990.
Deino, A., 2012. ^{40}Ar/^{39}Ar dating of Bed I, Olduvai Gorge, Tanzania, and the chronology of early Pleistocene climate change. Journal of Human Evolution 63, 251–273, http://dx.doi.org/10.1016/j.jhevol.2012.05.004.
Diez-Martín, F., Cobo-Sánchez, L., Baddeley, A., Uribelarrea, D., Mabulla, A., Baquedano, E., Domínguez-Rodrigo, M., 2021. Tracing the spatial imprint of Oldowan technological behaviors. A view from DS (Bed I, Olduvai Gorge, Tanzania). Plos One 16, e0254603, http://dx.doi.org/10.1371/journal.pone.0254603.
Diez-Martín, F., Wynn, T., Sánchez-Yustos, P., Duque, J., Fraile, C., Francisco, S., Uribelarrea, D., Mabulla, A., Baquedano, E., Domínguez Rodrigo, M., 2019. A faltering origin for the Acheulean? Technological and cognitive implications from FLK West (Olduvai Gorge, Tanzania). Quaternary International 526, 49–66, http://dx.doi.org/10.1016/j.quaint.2019.09.023.
Diez-Martín, F., Fraile, C., Uribelarrea, D., Sanchez-Yustos, P., Dominguez-Rodrigo, M., Duque, J., Diaz, I., Francisco, S., de Yravedra, J., Mabulla, A., Baquedano, E., 2017. SHK Extension: A new archaeological window in the SHK fluvial landscape of Middle Bed II (Olduvai Gorge, Tanzania). Boreas 46, 831–859, http://dx.doi.org/10.1111/bor.12246.
Diez-Martín, F., Sánchez-Yustos, P., Uribelarrea, D., Baquedano, E., Mark, D.F., Mabulla, A., Fraile, C., Duque, J., Díaz, I., Pérez-González, A., Yravedra, J., Egeland, C.P., Organista, E., Domínguez-Rodrigo, M., 2015. The origin of the Acheulean: The 1.7 million-Year-Old site of FLK-West, Olduvai Gorge (Tanzania). Scientific Reports 5, 17839, http://dx.doi.org/10.1038/srep17839.
Diez-Martín, F., Sánchez Yustos, P., Gómez de la Rúa, D., Gómez González, J.A., Luque, L., Barba, R., 2014a. The early Acheulean technology at ES2-Lepolosi (ancient MHS-Bayasi) in Peninj (Lake Natron, Tanzania). Quaternary International 322–323, 209–236, http://dx.doi.org/10.1016/j.quaint.2013.08.053.
Diez-Martín, F., Sánchez Yustos, P., Gómez González, J.A., Luque, L., Gómez de la Rúa, D., Domínguez-Rodrigo, M., 2014b. Reassessment of the Early Acheulean at EN1-Noolchalai (ancient RHS-Mugulud) in Peninj (Lake Natron, Tanzania). Quaternary International 322–323, 237–263, http://dx.doi.org/10.1016/j.quaint.2013.10.011.
Diez-Martín, F., Sánchez-Yustos, P., Uribelarrea, D., Domínguez-Rodrigo, M., Fraile-Márquez, C., Obregón, R.A., Díaz Muñoz, I., Mabulla, A., Baquedano, E., Pérez-González, A., Bunn, H.T., 2014c. New archaeological and geological research at SHK main site (Bed II, Olduvai Gorge, Tanzania). Quaternary International 322–323, 107–128, http://dx.doi.org/10.1016/j.quaint.2013.11.004.
Diez-Martín, F., Eren, M.I., 2012. The Early Acheulean in Africa: Past paradigms, current ideas, and future directions. In: Domínguez Rodrigo, M. (Ed.), Stone Tools and Fossil Bones: Debates in the Archaeology of Human Origins. Cambridge University Press, Cambridge, pp. 310–358.
Diez-Martín, F., Sánchez Yustos, P., Domínguez Rodrigo, M., Prendergast, M.E., 2011. An Experimental Study of Bipolar and Freehand Knapping of Naibor Soit Quartz from Olduvai Gorge (Tanzania). American Antiquity 76, 690–708, http://dx.doi.org/10.7183/0002-7316.76.4.690.
Diez-Martin, F., Sánchez-Yustos, P., Domínguez-Rodrigo, M., Mabulla, A., Bunn, H.T., Ashley, G.M., Barba, R., Baquedano, E., 2010. New insights into hominin lithic activities at FLK North Bed I (Olduvai Gorge, Tanzania). Quaternary Research 74, 376–387, http://dx.doi.org/10.1016/j.yqres.2010.07.019.
Diez-Martín, F., Sánchez, P., Domínguez-Rodrigo, M., Mabulla, A., Barba, R., 2009. Were Olduvai Hominins making butchering tools or battering tools? Analysis of a recently excavated lithic assemblage from BK (Bed II, Olduvai Gorge, Tanzania). Journal of Anthropological Archaeology 28, 274–289, http://dx.doi.org/10.1016/j.jaa.2009.03.001.
Domínguez-Rodrigo, M., Cobo-Sánchez, L., 2017. A spatial analysis of stone tools and fossil bones at FLK Zinj 22 and PTK 1 (Bed I, Olduvai Gorge, Tanzania) and its bearing on the social organization of early humans. Paleogeography, Paleoclimatology, Paleoecology 488, 21–34, http://dx.doi.org/10.1016/j.palaeo.2017.04.010.
Domínguez-Rodrigo, M., Cobo-Sánchez, L., Uribelarrea, D., Arriaza, M.C., Yravedra, J., Gidna, A., Organista, E., Sistiaga, A., Martín-Perea, D., Baquedano, E., Aramendi, J., Mabulla, A., 2017. Spatial simulation and modeling of the early Pleistocene site of DS (Bed I, Olduvai Gorge, Tanzania): a powerful tool for predicting potential archaeological information from unexcavated areas. Boreas 46, 805–815, http://dx.doi.org/10.1111/bor.12252.
Domínguez-Rodrigo, M., Pickering, T.R., Almécija, S., Heaton, J.L., Baquedano, E., Mabulla, A., Uribelarrea, D., 2015. Earliest modern human-like hand bone from a new >1.84-million-year-old site at Olduvai in Tanzania. Nature Communications 6,, http://dx.doi.org/10.1038/ncomms8987 (article number 7987).
Domínguez-Rodrigo, M., Diez-Martín, F., Yravedra, J., Barba, R., Bunn, H.T., Mabulla, A., Baquedano, E., Uribelarrea, D., Sánchez, P., Eren, M.I., 2014. A study of the SHK Main Site faunal assemblage, Olduvai Gorge, Tanzania: Implications for Bed II taphonomy, paleoecology, and hominin utilization of mega-fauna. Quaternary International 322–323, 153–166, http://dx.doi.org/10.1016/j.quaint.2013.09.025.
Domíguez-Rodrigo, M., Pickering, T.R., Baquedano, E., Mabulla, A., Mark, D.F., Musiba, C., Bunn, H.T., Uribelarrea, D., Smith, V., Diez-Martin, F., Pérez-González, A., Sánchez, P., Santonja, M., Barboni, D., Gidna, A., Ashley, G., Yravedra, J., Heaton, J.L., Arriaza, M.C., 2013a. First Partial Skeleton of a 1.34-Million-Year-Old Paranthropus boisei from Bed II, Olduvai Gorge, Tanzania. Plos One 8, e80347, http://dx.doi.org/10.1371/journal.pone.0080347.
Domínguez-Rodrigo, M., Uribelarrea del Val, D., Santonja, M., García-Pérez, A., Al, A., Panera, J., Mabulla, A., Yravedra, J., 2013b. Autochthonous anisotropy of archaeological materials by the action of water: Experimental and archaeological reassessment of the orientation patterns at the Olduvai sites. Journal of Archaeological Science 41, 44–68, http://dx.doi.org/10.1016/j.jas.2013.07.025.
Domínguez-Rodrigo, M., Pickering, T.R., Diez-Martín, F., Mabulla, A., Musiba, C., Trancho, G., Baquedano, E., Bunn, H.T., Barboni, D., Santonja, M., Uribelarrea, D., Ashley, G.M., Martínez- Ávila, M., Barba, R., Gidna, A., Yravedra, J., Arriaza, M.C., 2012. Earliest Porotic Hyperostosis on a 1.5-Million-Year-Old Hominin, Olduvai Gorge, Tanzania. Plos One 7, e46414, http://dx.doi.org/10.1371/journal.pone.0046414.

Domínguez-Rodrigo, M., Bunn, H.T., Mabulla, A.Z.P., Ashley, G.M., Diez-Martín, F., Barboni, D., Prendegast, M.E., Yravedra, J., Barba, R., Sánchez, A., Baquedano, E., Pickering, T.R., 2010. New excavations at the FLK Zinjanthropus site and its surrounding landscape and their behavioral implications. Quaternary Research 74, 315–332, http://dx.doi.org/10.1016/j.yqres.2010.07.003.

Domínguez-Rodrigo, M., Barba, R., Egeland, C.P., 2007. Deconstructing Olduvai. A taphonomic study of the Bed I sites. Springer, New York.

Duval, M., Sahnouni, M., Parés, J., van der Made, J., Abdessadok, S., Harichane, Z., Pérez-González, A., 2021. The Plio-Pleistocene sequence of Oued Boucherit (Algeria): A unique chronologically-constrained archaeological and paleontological record in North Africa. Quaternary Science Reviews, http://dx.doi.org/10.1016/j.quascirev.2021.107116 (271.107116).

Eren, M., Durant, M.E., Prendergast, M., Mabulla, A.Z.P., 2014. Middle stone age archaeology at Olduvai gorge, Tanzania. Quaternary International 322–323, 292–313.

Francisco de, S., 2019. El estudio funcional lítico en la Early Stone Age africana. Aplicación analítica, metodológica y experimental en los yacimientos arqueológicos del Lecho II de la Garganta de Olduvai, Tanzania. (Unpublished PhD dissertation). Universidad de Valladolid, Valladolid.

Gallotti, R., Muttoni, G., Lefèvre, D., Degeai, J.P., Geraads, D., Zerboni, A., Raynal, J.P., 2021. First high resolution chronostratigraphy for the early North African Acheulean at Casablanca (Morocco). Scientific Reports 11 (1), 1–14, http://dx.doi.org/10.1038/s41598-021-94695-3.

Gallotti, R., Mussi, M., 2018a. Before, During, and After the Early Acheulean at Melka Kunture (Upper Awash, Ethiopia): A Techno-economic Comparative Analysis. In: Gallotti, R., Mussi, M. (Eds.), The Emergence of the Acheulean in East Africa and Beyond. Contributions in Honor of Jean Chavaillon. Vertebrate Paleogeology and Paleoanthropology Series. Springer, Cham, pp. 53–92.

Gallotti, R., Mussi, M., 2017. Two Acheuleans, two humankinds: From 1.5 to 0.85 Ma at Melka Kunture (Upper Awash, Ethiopian highlands). Journal of Anthropological Sciences 95, 1–46, http://dx.doi.org/10.4436/JASS.95001.

Gallotti, R., 2013. An older origin for the Acheulean at Melka Kunture (Upper Awash, Ethiopia): techno-economic behaviors at Garba IVD. Journal of Human Evolution 65, 594–620, http://dx.doi.org/10.1016/j.jhevol.2013.07.001.

Goren-Inbar, N., Sharon, G., Melamed, Y., Kislev, M., 2002. Nuts, nut cracking, and pitted stones at Gesher Benot Ya'aqov, Israel. PNAS 99 (4), 2455–2460, http://dx.doi.org/10.1073/pnas.032570499.

Gowlett, J.A.J., 1986. Culture and conceptualization: the Oldowan-Acheulian gradient. In: Bailey, G.N., Callow, P. (Eds.), Stone Age Prehistory. Studies in memory of Charles McBurney. Cambridge University Press, Cambridge, pp. 243–260.

Hay, R., 1976. The Geology of Olduvai Gorge. University of California Press, Berkeley.

Isaac, G.L., 1986. Foundation stones: early artifacts as indicators of activities and abilities. In: Bailey, G.N., Callow, P. (Eds.), Stone Age Prehistory: studies in Memory of Charles McBurney. Cambridge University Press, Cambridge, pp. 21–241.

Isaac, G.L., 1969. Studies of early culture in East Africa. World Archaeology 1, 1–27, http://dx.doi.org/10.1080/00438243.1969.9979423.

Isaac, G.L., Curtis, G.H., 1974. Age of early Acheulian industries from the Peninj Group, Tanzania. Nature 249, 624–6627, http://dx.doi.org/10.1038/249624a0.

Jones, P.R., 1994. Results of experimental work in relation to the stone industries of Olduvai Gorge. In: Leakey, M.D., Roe, D.A. (Eds.), Olduvai Gorge, Volume 5. Excavations in Beds III, IV and the Masek Beds, 1968–1971. Cambridge University Press, Cambridge, pp. 254–298.

Key, A., Proffitt, T., de la Torre, I., 2020. Raw material optimization and stone tool engineering in the Early Stone Age of Olduvai Gorge (Tanzania). Interface 17, 20190377, http://dx.doi.org/10.1098/rsif.2019.0377.

Kimura, Y., 2002. Examining time trends in the Oldowan technology at Beds I and II, Olduvai Gorge. Journal of Human Evolution 43, 291–321, http://dx.doi.org/10.1006/jhev.2002.0576.

Kimura, Y., 1999. Tool-using strategies by early hominids at Bed II, Olduvai Gorge, Tanzania. Journal of Human Evolution 37, 807–831, http://dx.doi.org/10.1006/jhev.1999.0316.

Kroll, H.M., 1994. Behavioral implications of Plio-Pleistocene archaeological site structure. Journal of Human Evolution 27, 107–138, http://dx.doi.org/10.1006/jhev.1994.1038.

Kroll, H.M., Isaac, G.L., 1984. Configurations of artifacts and bones at early Pleistocene sites in East Africa. In: Hietala, H.J. (Ed.), Intrasite Spatial Analysis in Archaeology. Cambridge University Press, Cambridge, pp. 4–31.

Leakey, L.S.B., Tobias, P.V., Napier, J.R., 1964. A New Species of the Genus Homo from Olduvai Gorge. Nature 202, 5–7.

Leakey, L.S.B., Evernden, J.F., Curtis, G.H., 1961. The age of Bed I, Olduvai Gorge, Tanzania. Nature 191, 478–479.

Leakey, L.S.B., 1959. A new fossil skull from Olduvai. Nature 184, 491–493.

Leakey, L.S.B., 1951. Olduvai Gorge. A report on the evolution of the hand-axe culture in Beds I-IV. Cambridge University Press, Cambridge.

Leakey, M.D., 1975. Cultural patterns in the Olduvai sequence. In: Butzer, K.W., Isaac, G.L. (Eds.), After the Australopithecines. Mouton, Chicago, pp. 477–493.

Leakey, M.D., 1971. Olduvai Gorge Vol 3. Excavations in Beds I and II, 1960–1963. Cambridge University Press, Cambridge.

Leakey, M.D., 1967. Preliminary Survey of the Cultural Material from Beds I and II, Olduvai Gorge, Tanzania. In: Bishop, W.W., Clark, J.D. (Eds.), Background to evolution in Africa. University of Chicago Press, Chicago, pp. 417–446.

Leakey, M.D., Hay, R., Thurber, D., Protsch, R., Berger, R., 1972. Stratigraphy, archaeology, and age of the Ndutu and Naisiusu beds, Olduvai gorge, Tanzania. World Archaeology 3, 328–341.

Lepre, C.J., Roche, H., Kent, D.V., Harmand, S., Quinn, R.L., Brugal, J.P., Texier, P.J., Lenoble, A., Feibel, C.S., 2011. An earlier origin for the Acheulian. Nature 477, 82–85, http://dx.doi.org/10.1038/nature10372.

Ludwig, B.V., 1999. A technological reassessment of East African Plio-Pleistocene lithic artifact assemblages (Unpublished PhD dissertation). Rutgers University, New Brunswick.

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

Mabulla, A.Z.P., 1990. Preliminary report on an archaeological survey of the Ndutu beds, Olduvai gorge, Tanzania. Nyame Akuma 33, 20–25.

McNabb, J., 1998. On the move. Theory, time averaging and resource transport at Olduvai Gorge. In: Asthon, N., Healy, F., Pettit, P. (Eds.), Stone Age Archaeology. Essays in honour of John Wymer. Oxbow Monograph 102, Oxford, pp. 15–22.
Magill, C.R., Ashley, G.M., Freeman, K.H., 2013. Water, plants and early human habitats in eastern Africa. Proceedings of the National Academy of Sciences 110, 1167–1174, http://dx.doi.org/10.1073/pnas.1209405109.
Maíllo-Fernández, J.M., Marín, J., Solano-Megías, I., Uribelarrea, D., Martín-Perea, D., Aramendi, J., Medialdea, A., Arteaga, C., Pernas-Hernández, M., Gidna, A., Neogi, S., Baudot, E., Narváez, E., Mabulla, A.Z.P., 2019a. Victoria Cabrera Site: A Middle Stone Age site at Olduvai Gorge, Tanzania. Quaternary International 526, 129–154, http://dx.doi.org/10.1016/j.quaint.2019.07.032.
Maíllo-Fernández, J.M., Solano-Megías, I., Mabulla, A., Arriaza, M.C., Bower, J.F.R., 2019b. Lithic Technology at Loiyangalani, a Late Middle Stone Age Site in the Serengeti, Tanzania. African Archaeological Review 36, 291–315, http://dx.doi.org/10.1007/s10437-019-09340-2.
Manega, P., 1993. Geochronology, Geochemistry, and Isotopic Study of the Plio-Pleistocene Hominid Sites and the Ngorongoro Volcanic Highland in Northern Tanzania (Ph.D. Thesis). University of Colorado at Boulder, USA1993.
Martín-Perea, D., Maíllo-Fernández, J.M., Medialdea, A., Marín, J., Solano-Megías, I., Gidna, A., Mabulla, A., 2020. Revisiting an old profile: an updated geoarchaeological study at Nasera Rockshelter (Tanzania). Journal of Quaternary Science 35, 951–960, http://dx.doi.org/10.1002/jqs.3237.
Mussi, M., Altamura, F., Di Bianco, L., Bonnefille, R., Gaudzinski-Windheuser, S., Geraads, D., Melis Rita, T., Panera, J., Piarulli, F., Pioli, L., Ruta, G., Sánchez-Dehesa Galán, S., Méndez-Quintas, E., 2021. After the emergence of the Acheulean at Melka Kunture (Upper Awash, Ethiopia): From Gombore IB (1.6 Ma) to Gombore Iγ (1.4 Ma), Gombore Iδ (1.3 Ma) and Gombore II OAM Test Pit C (1.2 Ma). Quaternary International, http://dx.doi.org/10.1016/j.quaint.2021.02.031.
Panera, J., Rubio-Jara, S., Domínguez-Rodrigo, M., Yravedra, J., Méndez-Quintas, E., Pérez-González, A., Bello-Alonso, P., Moclán, A., Baquedano, E., Santonja, M., 2019. Assessing functionality during the early Acheulean in level TKSF at Thiongo Korongo site (Olduvai Gorge, Tanzania). Quaternary International 526, 77–98, http://dx.doi.org/10.1016/j.quaint.2019.09.013.
Potts, R., 1991. Why the Oldowan? Plio-Pleistocene toolmaking and the transport of resources. Journal of Anthropological Research 47, 153–176., https://www.jstor.org/stable/3630323.
Potts, R., 1988. Early hominid activities at Olduvai. Aldine de Gruyter, New York.
Presnyakova, D., Braun, D.R., Conard, N., Feibel, C., Harris, J.W., Pop, C.M., Schlager, S., Archer, W., 2018. Site fragmentation, hominin mobility and LCT variability reflected in the early Acheulean record of the Okote Member, at Koobi Fora, Kenya. Journal of Human Evolution 125, 159–180, http://dx.doi.org/10.1016/j.jhevol.2018.07.008.
Quade, J., Levin, N., Semaw, S., Renne, P., Rogers, M.J., Simpson, S., 2004. Paleoenvironments of the earliest stone toolmakers, Gona, Ethiopia. Geological Society of America Bulletin 16, 1529–1544.
Reiner, W.B., Masao, F., Sholts, S.B., Songita, A.V., Stanistreet, I., Stollhofen, H., Taylor, R.E., Hlusko, L.J., 2017. OH 83: a new early modern human fossil cranium from the Ndutu beds of Olduvai Gorge, Tanzania. American Journal of Physical Anthropology 164, 533–545, http://dx.doi.org/10.1002/ajpa.23292.
Rightmire, G.P., 1980. Middle Pleistocene hominids from Olduvai gorge, northern Tanzania. American Journal of Physical Anthropology 53, 225–241.
Roche, H., Brugal, J.-P., Delagnes, A., Feibel, C., Harmand, S., Kibunjia, M., Prat, S., Teie, P.J., 2003. Les sites archéologiques plio-pléistocènes de la formation de Nachukui, Ouest-Turkana, Kenya: bilan synthétique 1997–2001. Comptes Rendus Palevol 2, 663–673, http://dx.doi.org/10.1016/j.crpv.2003.06.001.
Rubio-Jara, S., Panera, J., Santonja, M., Pérez-González, A., Yravedra, J., Domínguez-Rodrigo, M., Bello, P., Rojas, R., Mabulla, A., Baquedano, E., 2017. Site function and lithic technology in the Acheulean technocomplex: a case study from Thiongo Korongo (TK), Bed II, Olduvai Gorge, Tanzania. Boreas, http://dx.doi.org/10.1111/bor.12275 (ISSN 0300-9483).
Sahnouni, M., 1991. Étude comparative des galets taillés polyédriques, subsphériques et sphériques des gisements d'Ain Hanech (Algérie Orientale) et d'Olduvai (Tanzanie). L'Anthropologie 97, 51–68.
Sahnouni, M., Semaw, S., Rogers, M.J., 2013. The African Acheulean. An archaeological summary. In: Mitchell, P., Lane, P. (Eds.), The Oxford Handbook of African Archaeology. Oxford University Press, Oxford, pp. 307–323.
Sánchez-Yustos, P., Diez-Martín, F., Diaz, I., Fraile, C., Uribelarrea, D., Mabulla, A., Baquedano, E., Domínguez-Rodrigo, M., 2019. What comes after the Developed Oldowan B debate? Techno-economic data from SHK main site (Middle Bed II, Olduvai Gorge, Tanzania). Quaternary International 526, 67–76, http://dx.doi.org/10.1016/j.quaint.2019.07.034.
Sánchez-Yustos, P., Diez-Martín, F., Domínguez-Rodrigo, M., Fraile, C., Duque, J., Díaz, I., de Francisco, S., Baquedano, E., Mabulla, A., 2018. Acheulean without handaxes? Assemblage variability at FLK West (Lowermost Bed II, Olduvai, Tanzania). Journal of Anthropological Sciences 96, 53–73, http://dx.doi.org/10.4436/jass.96007.
Sánchez-Yustos, P., Diez-Martín, F., Domínguez-Rodrigo, M., Duque, J., Fraile, C., Díaz, I., de Francisco, S., Baquedano, E., Mabulla, A., 2017. The origin of the Acheulean. Techno-functional study of the FLK-W lithic record (Olduvai, Tanzania). PlosOne 12, e0179212, http://dx.doi.org/10.1371/journal.pone.0179212.
Sánchez-Yustos, P., Diez-Martín, F., Domínguez-Rodrigo, M., Fraile, C., Duque, J., Uribelarrea, D., Mabulla, A., Baquedano, E., 2016. Techno-economic behavior in a context of recurrent megafaunal exploitation at 1.3 Ma. Evidence from BK4b (Upper Bed II, Olduvai Gorge, Tanzania). Journal of Archaeological Science Reports 9, 386–444, http://dx.doi.org/10.1016/j.jasrep.2016.08.019.
Sánchez-Yustos, P., Diez-Martín, F., Díaz, I., Fraile, C., Duque, J., Domínguez-Rodrigo, M., 2015. Production and use of percussive Stone tools in the Early Stone Age: experimental approach to the lithic record of Olduvai Gorge, Tanzania. Journal of Archaeological Science Reports 2, 367–383, http://dx.doi.org/10.1016/j.jasrep.2015.03.005.
Santonja, M., Rubio-Jara, S., Panera, J., Pérez-González, A., Rojas-Mendoza, R., Domínguez-Rodrigo, M., Mabulla, A., Baquedano, E., 2018. The Bifacial shaping in the TK Acheulean site (Bed II, Olduvai Gorge, Tanzania): New excavations 50 years after Mary Leakey. In: Galloti, R., Mussi, M. (Eds.), The Emergence of the Acheulean in East Africa in East African and Beyond. Contributions in Honor of Jean Chavaillon. Vertebrate Paleogiology and Paleeoanthropology Series. Springer, pp. 153–181.
Santonja, M., Panera, J., Rubio-Jara, S., Pérez-González, A., Uribelarrea, D., Domínguez-Rodrigo, M., Mabulla, A., Bunn, H.T., Baquedano, E., 2014. Technological strategies and the economy of raw materials in the TK (Thiongo Korongo) lower occupation, Bed II, Olduvai Gorge, Tanzania. Quaternary International 322–323, 181–208, http://dx.doi.org/10.1016/j.quaint.2013.10.069.

Semaw, S., Rogers, M.J., Cáceres, I., Stout, D., Leiss, A.C., 2018. The Early Acheulean~ 1.6-1.2 Ma from Gona, Ethiopia: Issues related to the Emergence of the Acheulean in Africa. In: Galloti, R., Mussi, M. (Eds.), The Emergence of the Acheulean in East Africa in East African and Beyond. Contributions in Honor of Jean Chavaillon. Vertebrate Paleobiology and Paleoanthropology Series. Springer, pp. 115–128.

Semaw, S., Rogers, M.J., Stout, D., 2009. The Oldowan-Acheulean Transition: Is there a "Developed Oldowan" Artifact Tradition? In: Camps, M., Chauhan, P. (Eds.), Sourcebook of Paleolithic transitions. Methods, theories, and interpretations. Springer, New York, pp. 173–193.

Sharon, G., 2010. Large flake Acheulean. Quaternary International 223–224, 226–233, http://dx.doi.org/10.1016/j.quaint.2009.11.023.

Sharon, G., 2007. Acheulean large flake industries: Technology, chronology, and significance. Archaeopress, BAR (British Archaeological Reports) International Series 1701. Oxford.

Sistiaga, A., Husain, F., Uribelarrea, D., Martín-Perea, D., Ferland, T., Freeman, K.H., Diez-Martín, F., Baquedano, E., Mabulla, A., Domínguez-Rodrigo, M., Summons, R.E., 2020. Microbial biomarkers reveal a hydrothermally active landscape at Olduvai Gorge at the dawn of the Acheulean, 1.7 Ma. Proceedings of the National Academy of Sciences 117, 24720–24728, http://dx.doi.org/10.1073/pnas.2004532117.

Skinner, A., Kay, R., Masao, F., Blackwell, B., 2003. Dating the Naisiusiu beds, Olduvai gorge, by electron spin resonance. Quaternary Sciences Reviews 22, 1361–1366, http://dx.doi.org/10.1016/S0277-3791(03)00015-5.

Solano-Megías, I., Maíllo-Fernández, J.M., Marín, J., Martín-Perea, D., Mabulla, A., 2021. Lithic Technology in the Earliest Later Stone age at Nasera Rockshelter (Tanzania). Lithic Technology 46, 60–79, http://dx.doi.org/10.1080/01977261.2020.1832180.

Soressi, M., Dibble, H., 2003. Multiple approaches to the study of bifacial technologies. University of Pennsylvania, Museum of Archaeology and Anthropology, Boston.

Stanistreet, I.G., 2012. Fine resolution of early hominin time, Beds I and II, Olduvai Gorge, Tanzania. Journal of Human Evolution 63, 300–308, http://dx.doi.org/10.1016/j.jhevol.2012.03.001.

Stiles, D., 1979. Early Acheulean and developed Oldowan. Current Anthropology 20, 126–129., https://www.jstor.org/stable/2741876.

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

Stollhofen, H., Stanistreet, I.G., Toth, N., Schick, K.D., Rodríguez-Cintas, A., Albert, R.M., Farrugia, P., Njau, J.K., Pante, M.C., Herrmann, E.W., Ruck, L., Bamford, M.K., Blumenschine, R.J., Masao, F.T., 2021. Olduvai's oldest Oldowan. Journal of Human Evolution 150,, http://dx.doi.org/10.1016/j.jhevol.2020.102910 (article number 102910).

Stout, D., 2011. Stone toolmaking and the evolution of human culture and cognition. Philosophical Transactions of the Royal Society B: Biological Sciences 366 (1567), 1050–1059, http://dx.doi.org/10.1098/rstb.2010.0369.

Texier, P.-J., 2018. Technological Assets for the Emergence of the Acheulean? Reflections on the Kokiselei 4 Lithic Assemblage and Its Place in the Archaeological Context of West Turkana, Kenya. In: Galloti, R., Mussi, M. (Eds.), The Emergence of the Acheulean in East Africa in East African and Beyond. Contributions in Honor of Jean Chavaillon. Vertebrate Paleogeology and Paleoanthropology Series. Springer, pp. 33–52.

Texier, P.-J., 1995. The Oldowan assemblage from NY18 site at Nyabusosi (Toro-Uganda). C.R. Acad. Sci. Paris 320, série IIa 647–665.

Torre de la, I., 2009. Technological strategies in the Lower Pleistocene at Peninj (West of Lake Natron, Tanzania). In: Shick, K.D., Toth, N. (Eds.), The cutting edge: new approaches to the archaeology of humans origins. The Stone Age Institute Publication Series 3, Bloomington, pp. 93–113.

Torre de la, I., 2004. Estrategias tecnológicas en el Pleistoceno inferior de África oriental (Olduvai y Peninj, norte de Tanzania) (Doctoral dissertation). Universidad Complutense, Madrid, Spain.

Torre de la, I., Mora, R., 2018. Technological behaviour in the early Acheulean of EF-HR (Olduvai Gorge, Tanzania). Journal of Human Evolution 120, 329–377, http://dx.doi.org/10.1016/j.jhevol.2018.01.003.

Torre de la, I., Mora, R., 2014. The Transition to the Acheulean in East Africa: An Assessment of Paradigms and Evidence from Olduvai Gorge (Tanzania). Journal of Archaeological Method and Theory 21, 781–823, http://dx.doi.org/10.1007/s10816-013-9176-5.

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

Uribelarrea, D., Domínguez-Rodrigo, M., 2017. Geoarchaeology in a meandering river: A study of the BK site (1.35 Ma), Upper Bed II, Olduvai Gorge (Tanzania). Paleogeography, Paleoclimatology, Paleoecology 488, 76–83, http://dx.doi.org/10.1016/j.palaeo.2017.05.006.

Uribelarrea, D., Martín Perea, D., Diez-Martín, F., Baquedano, E., Mabulla, A., Barba, R., Gidna, A., Domínguez-Rodrigo, M., 2019. A geoarchaeological reassessment of the co-occurrence of the oldest Acheulean and Oldowan in a fluvial ecotone from lower middle Bed II (1.7ma) at Olduvai Gorge (Tanzania). Quaternary International 526, 39–48, http://dx.doi.org/10.1016/j.quaint.2019.09.037.

Uribelarrea, D., Domínguez-Rodrigo, M., Pérez-González, A., Vegas Salamanca, J., Baquedano, E., Mabulla, A., Musiba, C., Barboni, D., Cobo-Sánchez, L., 2014. Geo-archaeological and geometrically corrected reconstruction of the 1.84 Ma Zinj palaeolandscape at Olduvai Gorge, Tanzania. Quaternary International 322–323, 7–31, http://dx.doi.org/10.1016/j.quaint.2013.12.023.

Willoughby, P.R., 1987. Spheroids and Battered Stones in the African Early Stone Age. BAR International Series 321, Oxford.

Yravedra, J., Diez-Martin, F., Egeland, C.P., Mate-González, M.A., Palomeque-González, J.F., Arriaza, M.C., Aramendi, J., García Vargas, E., Estaca-Gómez, V., Sánchez, P., Fraile, C., Duque, J., de Francisco-Rodriguez, S., González-Aguilera, D., Uribelarrea, D., Mabulla, A., Baquedano, E., Dominguez-Rodrigo, M., 2017. FLK West (Lower Bed II, Olduvai-Gorge, Tanzania): A new early Acheulean site with evidence for human exploitation of fauna. Boreas 46, 816–830, http://dx.doi.org/10.1111/bor.12243.

Yravedra, J., Domínguez-Rodrigo, M., Santonja, M., Rubio-Jara, S., Panera, J., Pérez-González, A., Uribelarrea, D., Egeland, C., Mabulla, A., Baquedano, E., 2016. The larger mammal palimpsest from TK (Thiongo Korongo), Bed II, Olduvai Gorge, Tanzania. Quaternary International 417, 3–15, http://dx.doi.org/10.1016/j.quaint.2015.04.013.