C. R. Palevol 17 (2018) 201–219

Contents lists available at ScienceDirect

Comptes Rendus Palevol

www.sciencedirect.com

Human Palaeontology and Prehistory (Prehistoric Archaeology)

The emergence and significance of heavy-duty scrapers in ancient stone toolkits

L'émergence et la signification des heavy-duty scrapers *dans les assemblages lithiques archaïques*

Deborah Barsky [a,b,*], Josep-Maria Vergès [a,b], Stefania Titton [a,b], Miquel Guardiola [a], Robert Sala [a,b], Isidro Toro Moyano [c]

[a] *Institut Català de Paleoecologia Humana i Evolució Social, c/Marcelli Domingo s/n, Campus Sesceladis, URV, Edifici W3, 43007 Tarragona, Spain*
[b] *Area de Prehistoria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya 35, 43002 Tarragona, Spain*
[c] *Museo Arqueológico de Granada, Carrera del Darro 41–43, 18010 Granada, Spain*

ARTICLE INFO

Article history:
Received 16 May 2017
Accepted after revision 28 September 2017
Available online 11 January 2018

Handled by Marcel Otte

Keywords:
Heavy-duty scraper
Oldowan
Technology
Typology
Acheulian
Rostro-caréné
Stone tools

ABSTRACT

Heavy-duty scrapers are documented as a specific morphotype in ancient African and Eurasian toolkits from the Oldowan into the Acheulian. They are characterized by a flat platform perpendicularly oriented to a carinated edge. The convex surface of that edge displays semi-peripheral, unidirectional removals associated with steep retouch and/or crush marks. This morphotype has been described from numerous sites covering a long temporal scale and are diversely referred to in French as "*rostro-carénés*" or "*nucléus-racloirs*" and in English as "*massive scrapers*", "*core scrapers*", "*large scrapers*", or "*heavy end-scrapers*". Morpho-technological definitions and interpretations are reviewed to track the origin and evolution of heavy-duty scrapers over time and space. Results show that tools referred to as heavy-duty scrapers were made on thick cobbles during the Oldowan, and later, at the onset of the Acheulian, on Large Flakes, while smaller-sized items in Late Acheulian sites assume end-scraper morphologies. But should all of these tools really be grouped under a single denomination? Experimental work explores whether heavy-duty scrapers are the result of knapping processes, or if their morphology could be derived from other kinds of activities. Chronological continuity of the attributes specific to heavy-duty scrapers points to their role in ancient toolkits, suggesting that these scarce but ubiquitous primitive implements are, on equal footing with chopper-cores, one of the oldest morphotypes in the world.

Mots clés :
Heavy-duty scraper
Oldowayen
Technologie
Typologie

RÉSUMÉ

Les *heavy-duty scrapers* sont documentés comme un morphotype spécifique dans de nombreux assemblages lithiques oldowayens et acheuléens en Afrique et en Eurasie. Ils sont caractérisés par une surface plate, orientée perpendiculairement à un bord de forme carénée. La surface convexe de ce bord révèle des enlèvements et/ou des retouches multiples, semi-périphériques et unidirectionnelles, souvent associés à des écrasements. Ce

* Corresponding author. Institut Català de Paleoecologia Humana i Evolució Social, c/Marcelli Domingo s/n, Campus Sesceladis, URV, Edifici W3, 43007 Tarragona, Spain.
E-mail address: dbarsky@iphes.cat (D. Barsky).

https://doi.org/10.1016/j.crpv.2017.09.002

Acheuléen
Rostro-caréné
Outillage lithique

morphotype a été décrit dans de nombreux sites couvrant une longue période temporelle et sont diversement désignés comme « rostro-carénés » ou « nucléus-racloirs » en français, et *massive scrapers*, *core scrapers*, *large scrapers* ou encore *heavy end-scrapers* en anglais. Cet article examine les définitions et les interprétations morpho-technologiques de ces outils, afin de pouvoir tracer leur origine et d'observer leur évolution dans le temps et dans l'espace. Les résultats montrent que les outils répondant à la dénomination *heavy-duty scrapers* ont été fabriqués sur des galets épais pendant l'Oldowayen et, plus tard, au début de l'Acheuléen, sur de grands éclats (*sensu stricto*). Pendant l'Acheuléen tardif, d'autres objets à bord caréné ont été aménagés intentionnellement sur des supports plus petits, assumant ainsi la diversité formelle des « grattoirs ». Tous ces derniers outils devraient-ils alors être regroupés sous la même dénomination? En outre, nous proposons d'explorer la signification du concept de *heavy-duty scraper* à travers un programme de travail expérimental, et de discuter si la morphologie de ces objets résulte simplement de procédés de débitage unidirectionnels récurrents, ou bien si leur configuration pourrait être dérivée d'autres types d'activités, en l'occurrence, celles liées à la percussion. La continuité chronologique des attributs spécifiques aux *heavy-duty scrapers* souligne leur rôle dans les assemblages lithiques anciens, ce qui semble suggérer que ces outils primitifs, toujours peu représentés dans les assemblages lithiques, mais cependant omniprésents, devraient être considérés, sur un pied d'égalité avec les choppers, comme un des morphotypes les plus anciens au monde.

1. Introduction

Throughout much of the Lower Pleistocene in Africa and Eurasia (*ca.* 2.5–0.78 Ma), hominin technological aptitude is reflected by the non-standardized flakes and simple but well-structured cores composing their material culture. These ancient toolkits are attributed to the Oldowan (Leakey, 1936) Techno-Complex, a cultural unit lasting nearly 2 Myrs (Barsky, 2009). Throughout the Oldowan, stone knapping strategies maintained low diversity, while reflecting variability through subtle innovations developed within the unifacial-unidirectional and orthogonal knapping strategies (Carbonell et al., 2009, 2016). Small cores and flakes are the most common items, but assemblages also comprise larger, summarily modified "*heavy-duty tools*" and "*utilized material*" (Leakey, 1971), frequently displaying traces of percussion (Barsky et al., 2015) or pounding (Isaac, 1986). This feature of Oldowan assemblages has long been a source of semantic and interpretative inconsistencies, notably because of difficulties relating to categorizing objects that do not fit neatly into any of the defined typological groups. At the root of this polemic is the low degree of standardization, which characterizes Oldowan tools. Indeed, how might we recognize tool-types from within the range of Oldowan formal variability when it is so largely dictated by the quality and availability of raw materials (Goldman-Neuman and Hovers, 2012)? One solution has been to consider use-wear on worked edges as a determining factor with which to distinguish "cores" from "tools" (de la Torre and Mora, 2005; de Lumley and Beyene, 2004; de Lumley et al., 2005; Leakey, 1971). This key notion places implements with percussion stigma in a different link within the *chaîne opératoire* (Soressi and Geneste, 2011), setting these 'used' items apart from flaked ones (cores) and projecting them into the realm of 'tools'.

The most commonly documented Oldowan tool 'type' is the *chopper* (Movius, 1943), which, perhaps because of its technical simplicity, presents a high degree of morphological variability for which different authors have proposed descriptive (Collina-Girard, 1986; Leakey, 1971) or conceptual (Carbonell et al., 1983, 1995; Laplace, 1972, 1974) study methodologies. Analysis of the Oldowan assemblages from Orce (Barsky et al., 2015) reveals that some macro tools (i.e. intentionally repeated morphotypes) exist only within site-specific contexts because of the particular features of the raw materials used there (see fig. 6 in Barsky et al., 2015). It follows that tool 'types' might not necessarily be common to different Oldowan sites. However, it may be assumed that the persistence of a specific form over time must be indicative of a task-specific shape and size relationship. Recent enlargement of the archaeological record and renewed interest in the study of archaic industries continue to fuel discussions about just where to draw the very fine line separating Oldowan core forms from tools. Examples demonstrating this conceptual tangle are terms like "*chopper-core*", or "*core-tool*", coined in the 1970s and still largely employed today. In Oldowan studies, this fine conceptual boundary has motivated the elaboration of systematic techno-typological manuals intended to overcome this challenge. But growing awareness of the influence of external impact factors on assemblage morpho-technical features, such as raw material size and qualitative variability or changeable site contexts, raises questions about the value of maintaining strict categorical separations within the Oldowan (Carbonell et al., 2009, 2016; Isaac, 1986; Shea, 2013; Toth, 1985). The core-tool dichotomy is so significant because tools are viewed as "standardized" items that reflect the repeated manufacture of a planned model in stone. When this template is acquired and transmitted through time and space, it becomes emblematic of human culture itself and, in the traditional, typological sense, carries the burden of chrono-cultural meaning. The shift from opportunistic flake production to the intentional shaping of tools (on a reasonably large scale) is a major feature marking the arrival of an entirely new techno-complex: the Acheulian. This paper examines the case of heavy-duty scrapers (heretofore: HDS), a little known and poorly defined morphotype that emerges in the oldest Oldowan toolkits and persists well into the Acheulian. Following a review of the historical aspects explaining the appearance of this morphotype in the literature, we discuss whether the observed continuity in the morphology of HDS over time is related to functional aspects or intentionality. These different interpretations are examined and tested experimentally. The evolutionary trajectory of the HDS is traced in Africa and Eurasia, contributing to a more coherent designation of these tools.

2. Materials and methods

The term “morphotype” has multiple applications in different disciplines, but is normally applied in taxonomy to designate “a specimen chosen to illustrate a morphological variation within a species population” (Allaby, 1999). In this paper, ‘morphotype’ pertains to a recognizable, repeated morphology within stone toolkits. Specifically, the heavy-duty scraper (heretofore: HDS) is defined and tracked throughout its evolutionary trajectory from the Oldowan into the Acheulian. Examples are presented from Oldowan, Developed Oldowan and Acheulian sites in Africa and Eurasia, where tools with matching morpho-technological descriptors are documented. The Oldowan evidence is contrasted with that from more recent Acheulian sites. Disparities in the designation “heavy-duty scraper” and incongruities in its technological and/or functional meanings are then dealt with by: (1) providing a historical view of existing definitions and interpretations, (2) reviewing the evidence from some key sites, (3) performing experiments, and (4) proposing a new definition. Our methodology examines the volumetric features of HDS and their relationship with the traces of percussion they present (Barsky et al., 2015: Box 1). Qualitative and quantitative data was collected to identify HDS and to bring to light volumetric selection criteria. Methods from different schools of morpho-techno-typological analysis are combined (Carbonell et al., 1983, 1995; Collina-Girard, 1986; Laplace, 1972, 1974; Tavoso, 1978 and Lumley and collaborators' unpublished *Lexique des caractéristiques de l'industrie lithique*). Repeated morphologies are considered indicative of standardization and/or predetermination and, by extension, provide descriptors for classification purposes. Techno-morphological features of HDS are assessed: (1) to define their specificity, (2) to confirm their existence within earliest stone toolkits, and (3) to consider their structural utility over time. In addition, raw material variability, blank type, breakage patterns, traces of percussion in relation to volumetric features, geometric and diachritical analysis are among the morpho-technical criteria used in this study.

Limestone cobbles of different shapes and sizes were collected from the Orce environs to perform the experimental work, which included reproducing HDS by knapping and then using the objects to work on different materials. The aptness of the limestone cobbles from Orce for knapping depended on their varying degrees of silicification. Unifacial, unidirectional stone knapping was carried out by a professional stone knapper (MG) to test the incidence of the obtaining of HDS morphotypes using this method. Special attention was paid to the morphology of the knapped edges to ascertain whether the typical localized crush marks would be produced during knapping. The knapper avoided intentionality by reproducing simple core forms typically observed in the Orce assemblages, where neither the flakes nor the unifacial unidirectional cores show any evidence of angle rectification by friction or any other preparatory method. Hammerstones and matrixes were arbitrarily chosen by the knapper from an array of cobbles made available to him. Experimental work, performed in controlled conditions, was filmed and photographed. A total of 13 HDS morphotypes were manufactured and photographed in order to control the modification of their edges in subsequent use experiments (Fig. 1).

3. Results

The denomination “*heavy-duty scraper*” has dual connotations: (1) an object of considerable volume (heavy-duty) and (2) a specific gesture or suggested use (scraping). Relating volume, form and use is a common strategy employed to distinguish different categories of tools in Oldowan assemblages. For example, compact, fist-sized, round or oval morphologies are often called ‘hammerstones’ while quadrangular, flat stones are considered as potential ‘anvils’. Such semantic-conceptual links may then be experimentally tested to reproduce analogous tools and discover their uses. This paper aims to convey the HDS morphotype in Oldowan stone toolkits as precisely as possible, by examining how it has been defined and recognized by different authors since its introduction into the literature. Once the HDS morphotype is clearly acknowledged, the significance of its recurrence in Oldowan and Acheulian toolkits is considered. Finally, questions relating to intentionality and functionality are addressed. The HDS morphotype is conveyed using examples from dif-

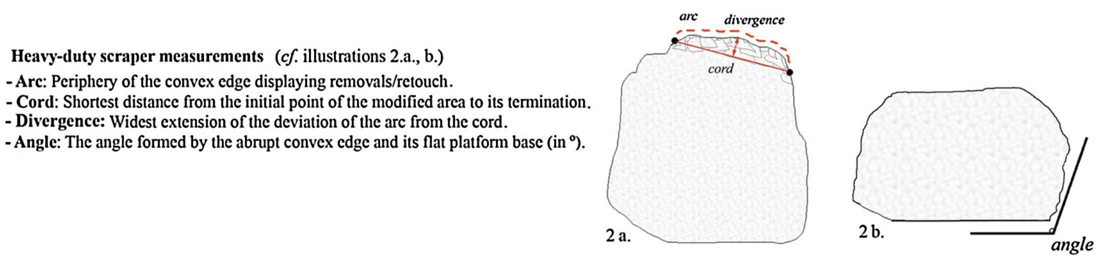


Fig. 1. Example of specific measurements taken to study heavy-duty scrapers (Barsky et al., 2015).

Fig. 1. Exemple de mesures spécifiques prises lors de l'étude des *heavy-duty scrapers* (Barsky et al., 2015).

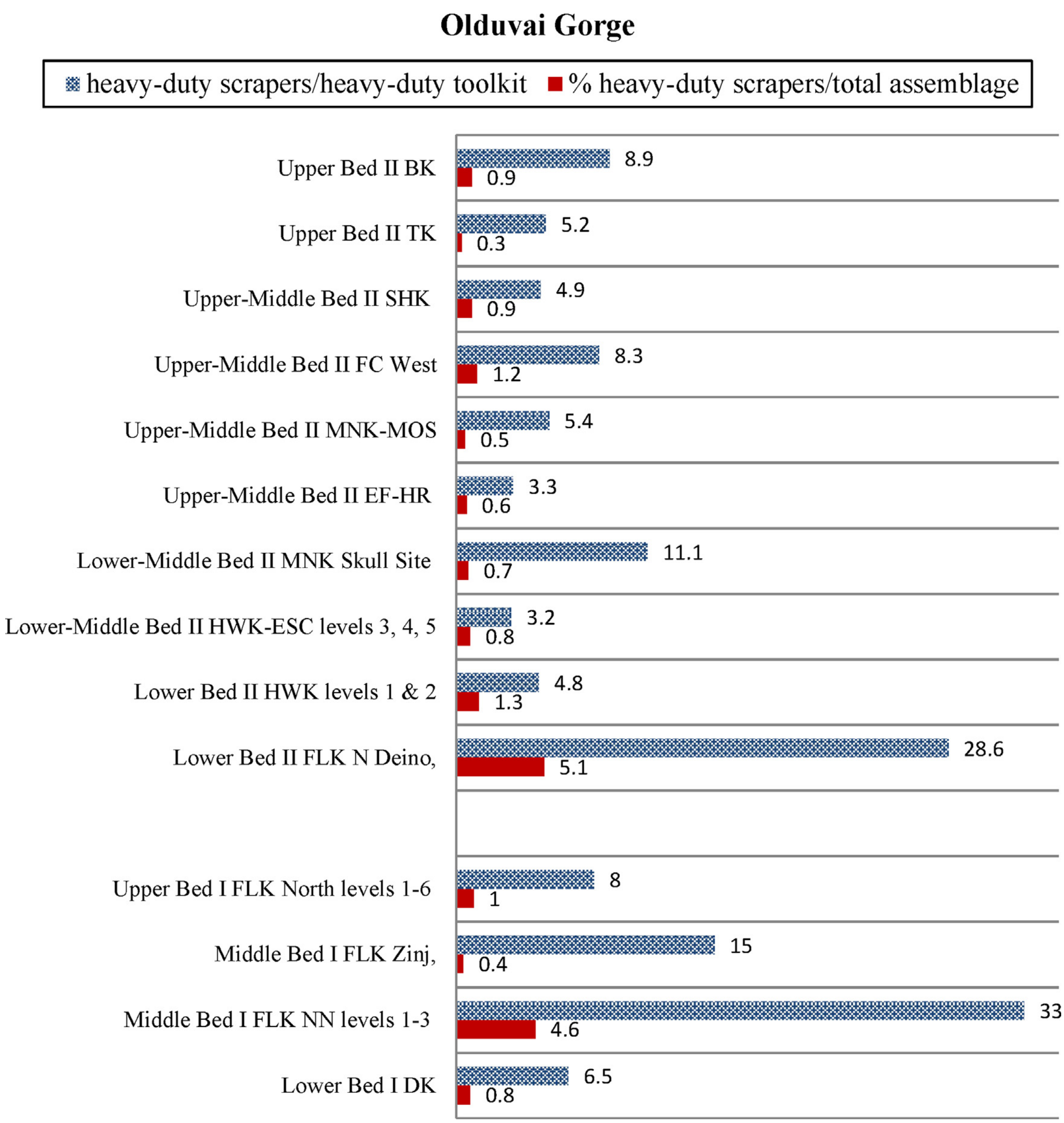


Fig. 2. Frequency of heavy-duty scrapers in different sites at Olduvai Gorge: (blue) % of HDS relative to the heavy-duty tool group; (red) relative to the total assemblage (tools, utilized material and debitage), after Leakey (1971). Note that HDS show a constant but low representation in all levels.

Fig. 2. Fréquence des *heavy-duty scrapers* dans différents sites de la Gorge d'Olduvai : en bleu, pourcentage d'HDS par rapport au groupe d'outils *heavy-duty scrapers* ; en rouge, par rapport à l'assemblage total (outils, matériel utilisé et débitage), d'après Leakey (1971). À noter que les HDS sont représentés de manière constante, mais faible dans tous les niveaux.

ferent sites, checking divergences in their denominations to provide a synthetic definition and establish limits to its range of techno-morphological variability. This analysis does not constitute an exhaustive inventory (other sites in East and South Asia have documented analogous tool forms), but rather it is intended as a referent that is sufficient to deal with the issues at hand.

3.1. A starting point: Heavy-duty scrapers from Olduvai Gorge and Koobi Fora

3.1.1. The HDS from Olduvai Gorge

Given the considerable and long-lasting impact that the Olduvai Gorge sites have had on the study of stone toolkits attributed to this eponymous cultural grouping, it is only fitting to begin this discussion of HDS evidence with the work published by Mary Leakey (1971). In her typological descriptions, Leakey (1971) emphasized the importance of the position of the tool on the blank. She employed the same qualifiers to describe both heavy and light-duty scrapers, establishing a size limit of > 50 mm to differentiate between them. Accordingly, HDS are present but scarce in most of the Bed I and Bed II localities (Fig. 2). Throughout her work on the Olduvai industries, Leakey provides noteworthy remarks for recognizing HDS, by way of two main criteria: (*1*) *the presence of a curved working edge affected by vertical or semi-vertical trimming and (2) crush marks or* *other forms of edge damage almost uniquely on the upper (worked) surface* (Leakey, 1971). This definition is designed to facilitate the distinction HDS from choppers or discoids, which, contrastingly, present more oblique and denticulate worked edges. Leakey further notes that HDS appear on cobbles or on cores, and that they generally present natural, non-prepared striking surfaces opposite to another plane surface. In some cases, their convexities were even accentuated by notches whose origin could be intentional or use-related (Leakey, 1971). Apart from these special features, the HDS at Olduvai Gorge are not standardized. Most of them were made on tabular quartz or quartzite, probably because these materials provided natural cleavage planes that were convenient as steep flaking platforms. Significantly, from Bed II, Leakey notes that HDS were made on Large Flakes (*sic*. Kleindiest, 1962).

The term “heavy-duty scraper” is not validated in the technological analysis of the assemblages by de la Torre and Mora (2005). This study underlines a divergence from typological classifications, towards a more procedural, interpretative approach, considering additional variables, such as: site formation processes, human organizational strategies, site function, etc., recalling Isaac's work at Koobi Fora (Isaac, 1984, 1986). This reduces variability stemming from artificial constructs and limits subjective, functional connotations. Starting from the technological genesis of each artifact, the categories are reduced to: flaked, detached, pounded and unmodified. In this way, artifacts are linked not to a given activity, but rather to their corresponding stage within the reduction sequences from which they were derived (de la Torre and Mora, 2009). In their analysis of the Bed I and II assemblages, de la Torre and Mora (2005) also note that fractures in some pieces are due to battering instead of shaping, and that pieces once considered as tools are actually cores. This explains why many pieces considered as tools in Leakey's typological approach (choppers, polyhedrons, discoids, heavy-duty scrapers) were later classified as cores by these and other authors (Jelineck, 1977; de la Torre and Mora, 2005). At FLK *Zinjanthropus*, for example, de la Torre and Mora (2005) consider many of Leakey's (1971) HDS to be unifacial, unidirectional cores with abrupt removals and no platform preparation, unlike the “bifacial abrupt” cores (de la Torre and Mora, 2009). Yet, according to Leakey (1971), the lack of prepared striking surfaces and the presence of crush marks on the upper worked edges constitute the main descriptors of the HDS group. Meanwhile, de la Torre and Mora (2005) do not discuss such stigma as a characteristic feature of the unifacial abrupt core systems. In sum, these authors conclude with different interpretations of the same morphotype: tool or core.

3.1.2. The HDS from Koobi Fora

In their study of the stone artefacts from Koobi Fora (East Turkana), Isaac and Harris (1997) specifically mention different denominations in equivalence to Leakey's “heavy-duty scrapers” (1971), choosing to refer to them rather as “core scrapers” and specifying their correspondence with what Harris (1978) termed as “cobble scrapers”. Meanwhile, Braun et al. (2008) maintain Leakey's terminology in their type lists for the Oldowan sites of FxJj82 and FxJj16. Importantly, Isaac and Harris (1997) classed HDS amongst “flaked pieces”, whereas Harris (1978) had previously classed them as “tools” (following Leakey, 1971). They conclude that the categorization is polythetic since observed features actually “intergrade across the arbitrary boundaries” (Isaac and Harris, 1997). They do however make an important distinction based on blank type (cobble *vs.* flake), rather than on size, as in Leakey (1971), maintaining that standardized tool ‘types’ appear only in assemblages attributed to the Acheulian. In agreement with de la Torre and Mora (2005), they maintain only the broadest categories of tools that do not imply specific functionality, stating (as Toth, 1985) that many tool types (such as choppers), were probably cores, and that flakes, wrongly relegated amongst simple waste products, were most likely the tools sought after by hominins. Their main conclusion is that the “core scrapers” from Koobi Fora (*sic*. HDS) were intended mainly for flake production.

Karari scrapers are a distinctive element of the assemblages from the basal part of the Okote Member of the Koobi Fora Formation and correlates (suggested age of the Okote Tuff: 1.56 ± 0.05 Ma, McDougall and Brown, 2006: their fig. 6, No. 1) that deserve special mention in the context of this study. These assemblages stratigraphically precede the appearance of clearly Acheulian industries, distinguished by the production of Large Flakes (Kleindiest, 1962). Aware of the wide formal variability of the Karari assemblages, the authors note that ‘Karari scrapers’ stand out because of their relatively high level of standardization (Isaac and Harris, 1997). While there is not necessarily ‘continuity’ between the KBS Oldowan core scrapers and the Karari scrapers, they observe that the manufacture of dome-shaped scrapers could be considered as a ‘habit’ reflecting a systematic, least-effort flake extraction mode (Isaac and Harris, 1997). The authors also suggested that the specific formal features of both series could result, at least partially, from percussive activities.

3.2. Heavy-duty scrapers in the Oldowan

Looking beyond these early definitions of HDS which clearly underline a deeply rooted uncertainty as to their significance in early assemblages, let us now examine how HDS are documented at some other Oldowan sites, beginning with the oldest assemblages in Africa. Based on criteria developed by Leakey (1971), Semaw (2000)

Table 1
Average length in mm of removal negatives on HDS, and cores and of flakes from Oldowan sites (Fejej: de Lumley and Beyene, 2004 and own data; Dmanisi: de Lumley et al., 2005; Orce: own data).
Tableau 1
Longueur moyenne en mm des négatifs d'enlèvements sur les HDS, et les nucléus et des éclats des sites oldowayens (Fejej : de Lumley et Beyene, 2004 et données supplémentaires ; Dmanisi : de Lumley et al., 2005 ; Orce : données supplémentaires).

Site	HDS (average negative size/mm)	Core (average negative size/mm)	Flake (average size/mm)
Fejej	35.8	26.9	36.9
Dmanisi	11	31.8	41.7
BL	27.6	34.6	27
FN3	28.7	31.6	43.1

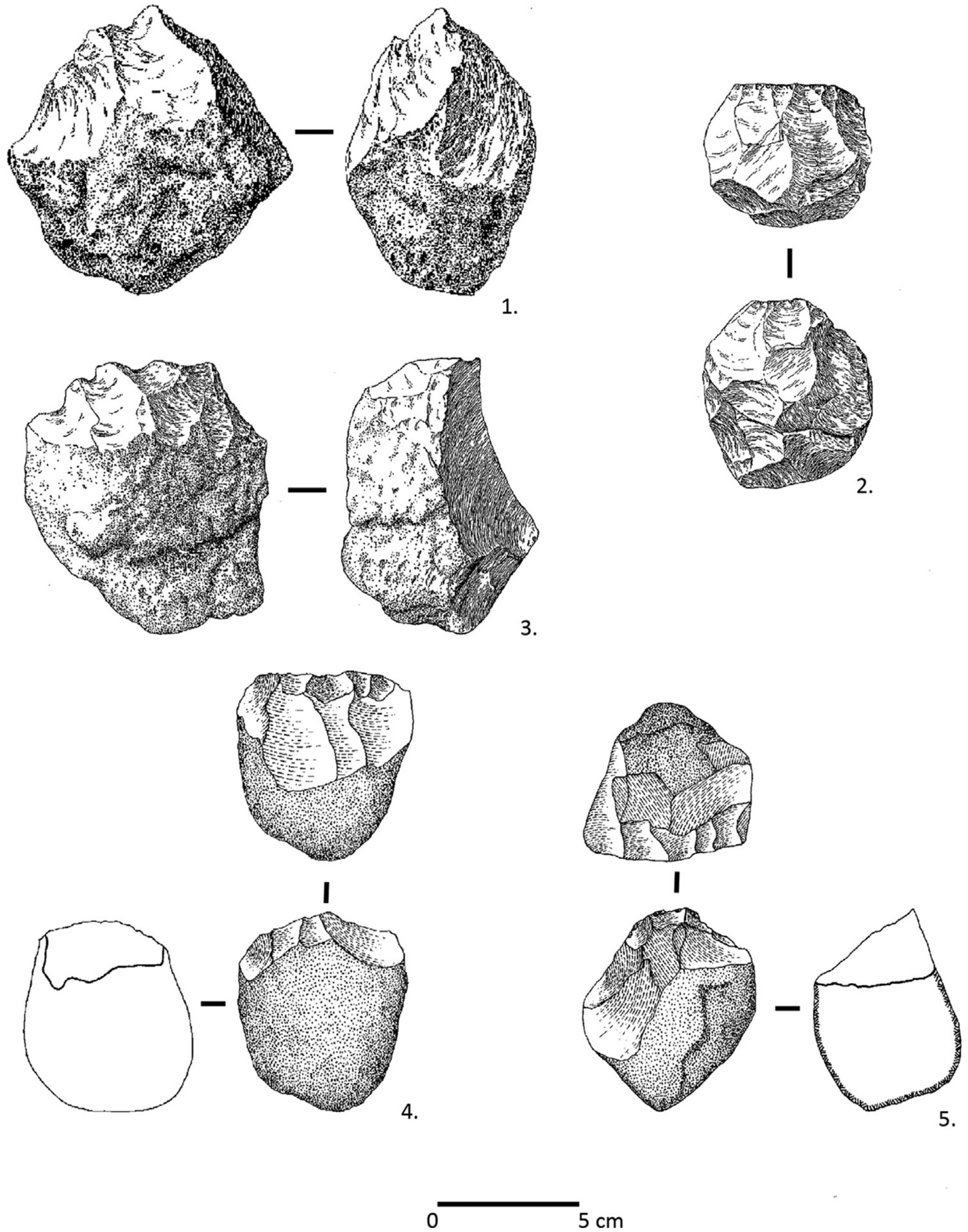


Fig. 3. Olduvai Gorge, Bed I (Leakey, 1971). 1. Heavy-duty scraper from FLK *Zinj*. on a lava cobble; 2. Heavy-duty scraper from FLK NN on an "irregular" lava flake; 3. Heavy-duty scraper from DK on a quartzite block. 4 and 5. Heavy-duty scrapers on quartz cobbles from level C1 at Fejej FJ-1a (de Lumley and Beyene, 2004).

Fig. 3. Gorge d'Olduvai, Bed 1 (Leakey, 1971). 1. *Heavy-duty scraper* de FLK *Zinj*. sur un galet de lave. 2. *Heavy-duty scraper* de FKL NN sur un éclat « irrégulier » de lave. 3. *Heavy-duty scraper* de DK sur un bloc de quartzite. 4 et 5. *Heavy-duty scrapers* sur galets de quartz du niveau C1 de Fejej FJ-1a (de Lumley et Beyene, 2004).

includes "heavy-duty core scrapers" as a distinctive category in the general tool inventory of the East Gona sites EG 10 and EG 12 (2.6–2.5 Ma, Afar Ethiopia, Table 1: 1205). Meanwhile, according to drawings by B. Isaac in Toth (1985), "core scrapers" differ from HDS because they display denticulate edges traced by adjacent, deep removals (hence, 'core'). Although they lack the convex carinated form with retouch and crush marks on abrupt edges, it is interesting to note that Toth (1985) uses the two terms interchangeably. HDS are also documented from Fejej FJ-1a, in Ethiopia (de Lumley and Beyene, 2004, Fig. 3, Nos. 4, 5) and at Dmanisi (Fig. 4), in the Republic of Georgia (Lumley et al., 2005), dating, respectively, to 1.96 and 1.81 Ma. The French term *rostro-caréné* is fittingly employed to describe the HDS morphotype by de Lumley and collaborators (*caréné* refers to the shape of the lower part of a ship's hull, the *carène*, which is flat-bottomed and has steep edges).

Our studies of the FJ-1a and Dmanisi assemblages make an important distinction between HDS, which are

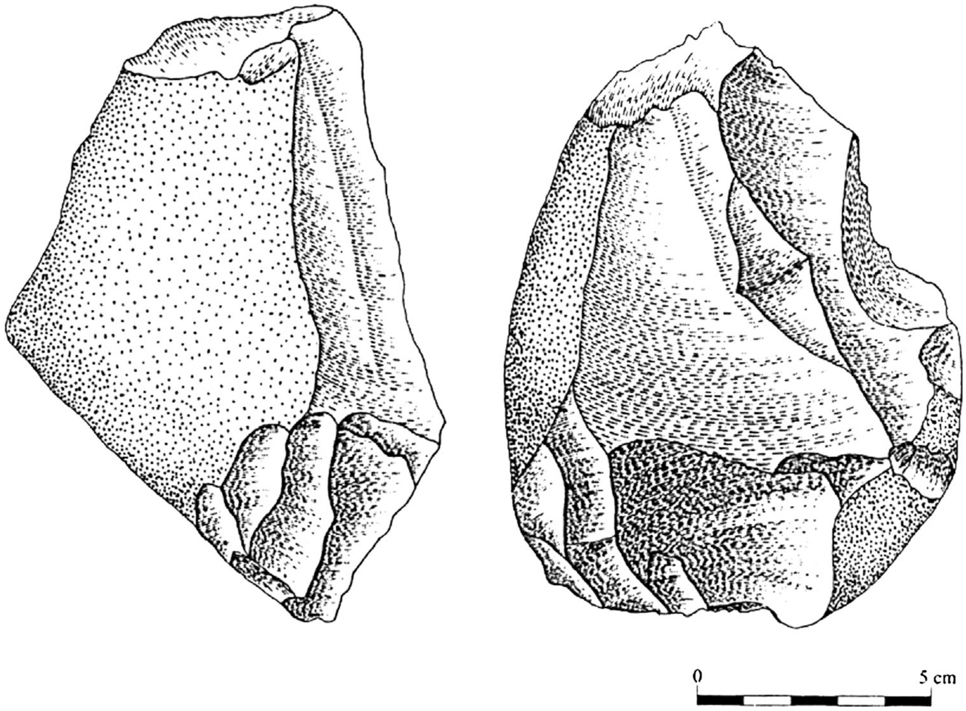


Fig. 4. Heavy-duty scraper on a tuff cobble core from an undetermined level of the Dmanisi site (Georgian Republic) (de Lumley et al., 2005).
Fig. 4. *Heavy-duty scraper* sur un nucléus en galet de tuf d'un niveau indéterminé du site de Dmanisi (république de Géorgie) (de Lumley et al., 2005).

considered to be chopper-like cobble-tools, and robust end-scrapers made on flakes, that are designated as *rabot* (French). This difference is significant because it underlines a distinction that is not based on the morphological features defining the type, but rather on the kind of blank upon which it appears (HDS on cobbles; *rabot* on regular flakes). But confusion inevitably arises when comparable morphotypes are differentially termed, as in the case with *rostro-caréné* and *rabot*. For example, in the study of the limestone heavy-duty tools from the Italian Acheulian site of Isernia la Pineta (0.65 Ma, Rufo et al., 2009), three cobble tools fitting the HDS morphotype following the descriptions provided by Leakey (1971), de Lumley and Beyene (2004) and de Lumley et al. (2005) are referred to as *rabots*. This example indicates that blank type (cobble or flake) is essential to defining HDS. It also underlines that, in spite of their origin deep within the Oldowan, HDS do share morphological similarities with robust end-scrapers, such as a frontal position on the blank, a convex worked edge, abrupt removals and edges displaying retouch and/or crushing.

3.2.1. The HDS from Fejej FJ-1a

The Oldowan assemblage from Fejej FJ-1a has yielded 6 HDS on quartz and basalt cobbles (Fig. 3, Nos. 4, 5; de Lumley and Beyene, 2004). The tools display abrupt working edges shaped by unifacial, parallel removals originating from a flat platform (fracture or cortical surface). HDS represent 10.6% of the cobble tools and only 0.2% of the lithic assemblage overall. Most of them were made on rounded cobbles that are, on average, smaller than the chopper-tools (mean HDS length = 62.3 mm). Only their abrupt, convex surfaces display continuous retouch and/or small removals regularizing the cutting edge. The affected edge is rounded and very steep, extending over about a third of the cobble's periphery (mean length of the shaped edge = 53.8 mm; mean number of removals = 2.8; mean removal length = 35.8 mm). The mean angle between the platform and the worked edge is 91°, compared with 72° for the chopper-tools (de Lumley and Beyene, 2004).

3.2.2. The HDS from Dmanisi

A total of 12 HDS were identified in our analysis of the Dmanisi assemblage (de Lumley et al., 2005). They were made on whole or broken volcanic tuff or basalt cobbles (6% of the cobble-tool assemblage that comprises a total of 206 pieces) (Fig. 4). The pieces are distinguished, once again, by abrupt, unidirectional removals originating from a flat platform and forming a carinated silhouette (French *front*). Their convex, worked surfaces are accompanied by small removals, retouch or crushing, regularizing the edge. They were made on thick, angular cobbles that are close in size to the chopper tools, but bigger than the whole cobbles. Their convex worked edges display, on average, 4.3 removals that tend to be shorter than those on other knapped items (Table 1), suggesting that the aim of the knappers could have been shaping rather than flake production; although percussive activity is not to be ruled out.

3.2.3. The HDS from Orce

The rich limestone heavy-duty toolkits from Barranco León and Fuente Nueva 3 (Orce, Andalusia) provide an excellent opportunity to identify and define HDS in the

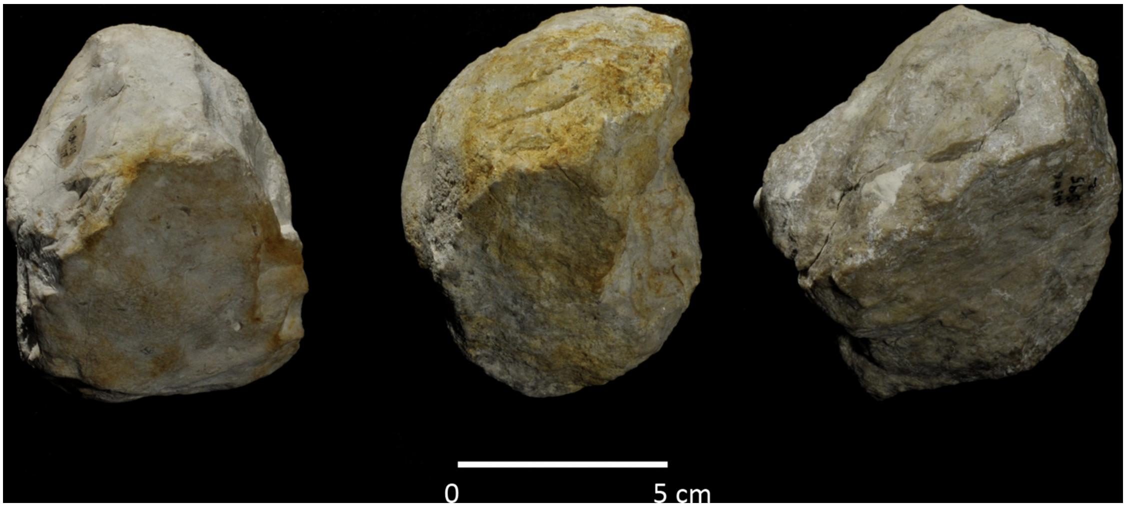


Fig. 5. Limestone heavy-duty scraper morphotypes from Orce. Barranco León (left); Fuente Nueva 3 (centre and right). Photo Jordi Mestre, IPHES.

Fig. 5. Morphotypes des *Heavy-duty scrapers* en calcaire d'Orce. Barranco León (à gauche), Fuente Nueva 3 (au centre et à droite). Photo Jordi Mestre, IPHES.

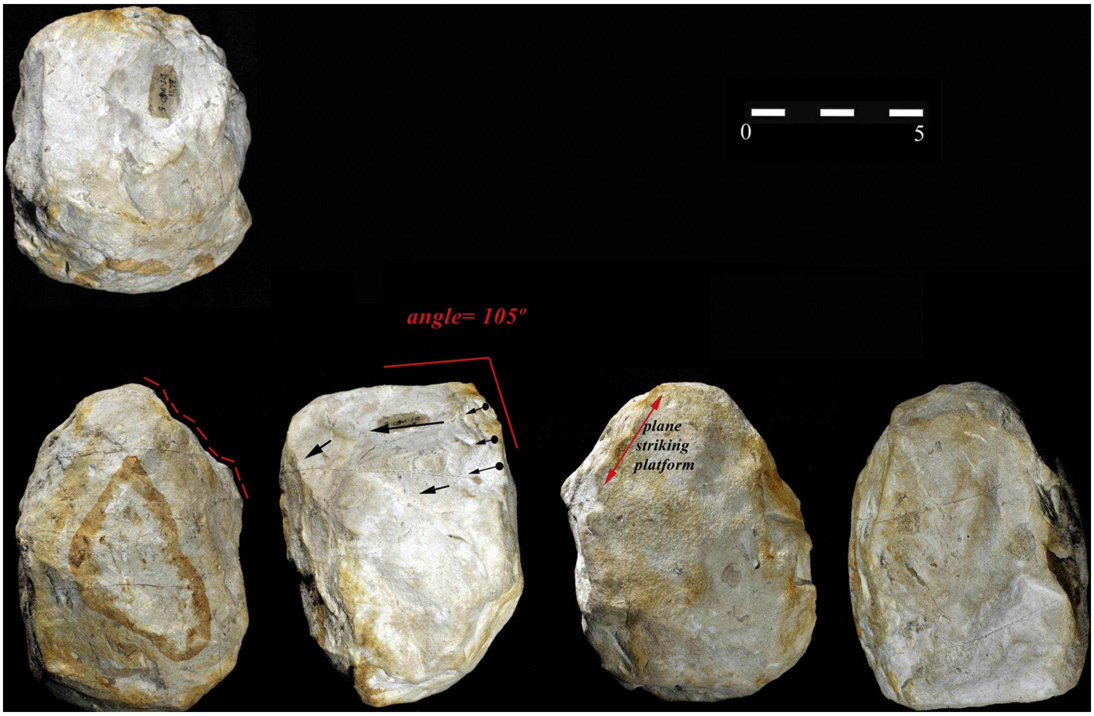


Fig. 6. Limestone heavy-duty scraper morphotype from Barranco León (Orce, Spain) (Photos by J. Mestre, IPHES).

Fig. 6. Morphotypes de *heavy-duty scraper* en calcaire de Barranco León (Orce, Espagne). Photo Jordi Mestre, IPHES.

western European Oldowan register (Barsky et al., 2015; Toro Moyano et al., 2010). At Barranco León, 7 HDR were singled out from 156 limestone items, while Fuente Nueva 3 yielded 8 HDR for 290 limestone items (all > 5 cm; Figs. 5 and 6). While the distinction cores *vs.* HDS remains difficult, these pieces, defined as *loosely configured tools* (Barsky et al., 2015), were set apart as HDS because: they present unifacial, steep removals, originating from a single, flat platform, forming a carinated edge with localized retouch/crushing. Cobbles with natural flat surfaces were selected or platforms were obtained by breakage/removals. Like at Fejej and Dmanisi, the Orce HDS are smaller than the chopper-tools (Fig. 7, combined BL + FN3 mean HDS dimensions = 86.6 × 73.7 × 64.3 mm; Fuente Nueva 3 = 98.6 × 85.0 × 68.9 mm; BL = 74.6 × 62.4 × 59.7 mm). Their low degree of transformation is illustrated by their size correlation with the rounded whole cobbles present in the assemblages (Fig. 8). The angle separating the

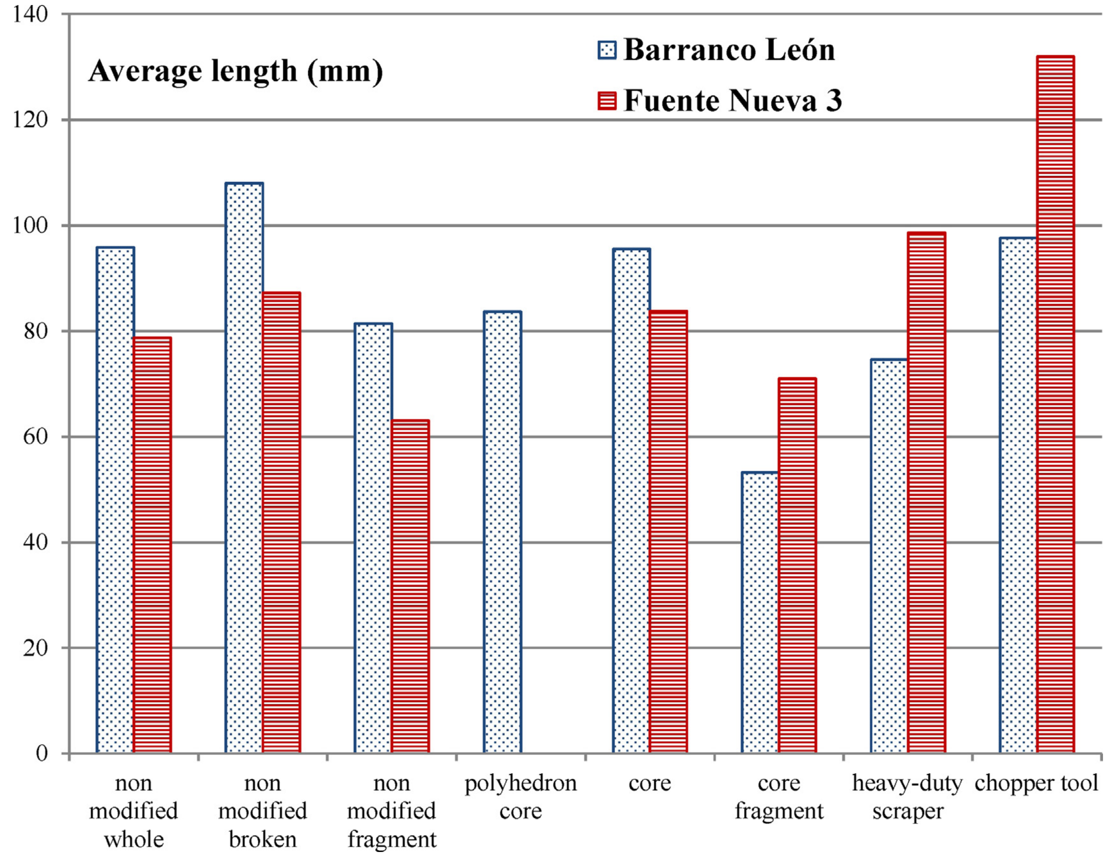


Fig. 7. Comparative mean length of the different limestone macro tool-types from Barranco León and Fuente Nueva 3. At Barranco León, heavy-duty scrapers are made on small, rounded limestone cobbles and are close in size to polyhedrons and non-modified fragments. At Fuente Nueva 3, HDS are made on limestone blocks and are larger; with a size-range closest to the chopper tools.

Fig. 7. Longueur moyenne comparée des différents types de macro outils calcaires de Barranco León et de Fuente Nueva 3. À Barranco León, les *heavy-duty scrapers* sont exécutés sur des galets calcaires petits et ronds et sont proches en taille des nucléus polyédriques et des fragments non modifiés. À Fuente Nueva 3, ils sont fabriqués sur des blocs calcaires et sont plus grands, avec une gamme dimensionnelle plus proche de celle des choppers.

worked (working) edge and the platform is considerably open (mean HDS: BL = 101°; FN3 = 103°). At BL, the carinated edges of the HDS have a homogenous size-range (around 40 mm; mean arc = 41 mm) compared with FN3 (20–125 mm; mean arc = 103 mm). The tools are slightly convex at BL (mean cord = 7 mm) and widely convex at FN3 (mean cord = 32 mm). They tend to be thicker and shorter than the chopper-tools which are flatter, and the cores, which are polyhedral. Once again, compared with knapped limestone items, the smaller mean removal sizes on the HDS could indicate a role in the assemblages other than flake production (Table 1). The extension and the constriction defining the convexity of the worked edges vary considerably, demonstrating a lack of standardization. The retouch often has divergent lateral edges and straight, steep distal ridges, a morphology that we were able to reproduce experimentally by intensive use (see below).

3.3. Heavy-duty scrapers in the Developed Oldowan and Early Acheulian

HDS are recognized in many Early Acheulian sites in Africa, although with variable denominations and/or technological interpretations (e.g., Melka Kunturé; Gallotti, 2013; Gallotti et al., 2014; Peninj, de la Torre et al., 2008; Gadeb, de la Torre, 2011). In their study of the lithic assemblages from Ubeidiya (1.6–1.4 Ma, Levant), Bar-Yosef and Goren-Inbar (1993) refined and adapted Leakey's method by integrating technological, typological and stylistic components, as well as the notion of *chaîne opératoire* (Geneste et al., 1990), to distinguish technological from stylistic attributes. In this study, HDS are classed among "core-tools" *vs.* "flaked pieces" (Isaac, 1986) and thus are categorized with chopping-tools, polyhedrons, spheroids, bifaces and discoids, and with 'modified' pieces including fragments or *heavy debitage* (Bar-Yosef and Goren-Inbar, 1993). The features used to isolate HDS are in line with those described by Leakey (1971) (Bar-Yosef and Goren-Inbar, 1993): an angle close to 90° separating the platform and a worked edge exhibiting *steep retouch and/or small removals* (Bar-Yosef and Goren-Inbar, 1993). The tools are scarce in most of the archeological horizons (Fig. 9, Nos. 2, 3). The authors do not use size-determined categories to distinguish heavy from light duty tools (50 mm limit, Leakey, 1971; 100 mm limit, Kleindiest, 1962) because the Ubeidiya assemblages do

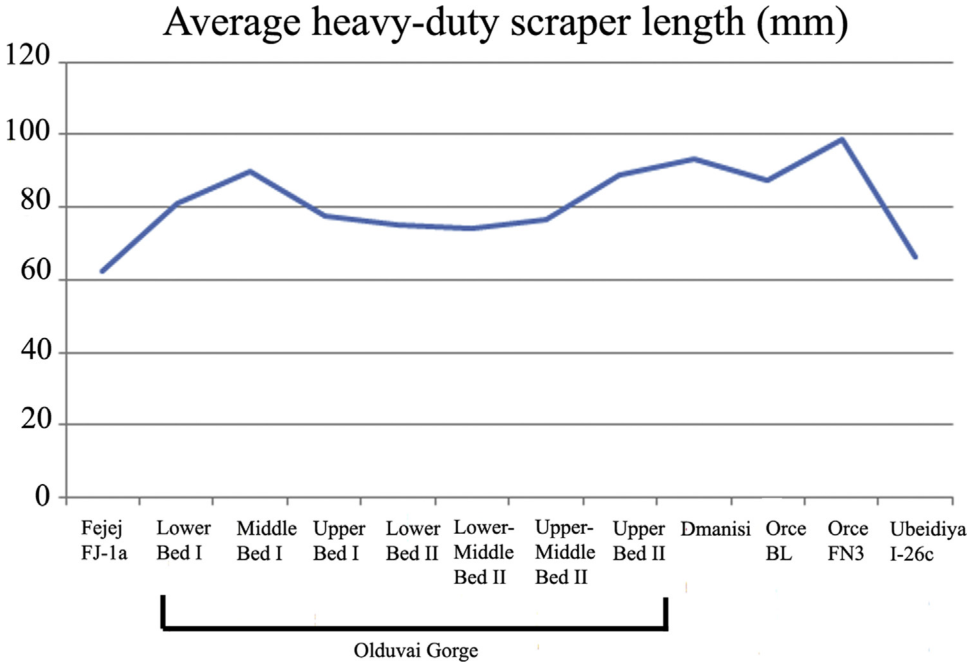


Fig. 8. Mean maximal length of heavy-duty scrapers from different Oldowan sites (Fejej FJ-1a, de Lumley and Beyene, 2004; Olduvai Gorge, Leakey, 1971; Barranco León and Fuente Nueva 3, Barsky et al., 2015; Ubeidiya (diameter), Bar-Yosef and Goren-Inbar, 1993). Most authors attribute the size range to raw material variability in each circumstance.

Fig. 8. Longueur maximale moyenne des *heavy-duty scrapers* de différents sites oldowayens (Fejej Fj-1a, de Lumley et Beyene, 2004 ; Gorge d'Olduvai, Leakey, 1971 ; Barranco León et Fuente Nueva 3, Barsky et al., 2015 ; Ubeidiya (diamètre), Bar-Yosef et Goren-Inbar, 1993). Les auteurs, pour la plupart, attribuent la gamme de taille à la variabilité du matériau brut utilisé dans chaque circonstance.

not show bimodal size distribution (Bar-Yosef and Goren-Inbar, 1993). A size threshold was, however, maintained for distinguishing between HDS and light duty scrapers (HDS > 50 mm, after Leakey, 1971) and, while both tools are classified as 'scrapers', these categories are here considered '*distinct entities*'. Techno-morphological homogeneity of the Ubeidiya HDS is deduced from their grouped size-range (70–100 mm; Bar-Yosef and Goren-Inbar, 1993: their fig. 49b). Importantly, at Ubeidiya, a site where most levels are ascribed to Developed Oldowan B, HDS were generally made on cobbles rather than on flakes (Bar-Yosef and Goren-Inbar, 1993).

At the more recent Levantine Acheulian site of Gesher-Benot Ya'aqov (0.78 Ma, Goren-Inbar et al., 2000), an analogous tool made on Large Flakes is called a "*massive scraper*" (Goren-Inbar et al., 2008; Sharon, 2009). In their study, Goren-Inbar et al. (2008) also highlight the confusion in the nomenclature pertaining to: "heavy-duty scrapers" (Leakey, 1971), citing some other terms that have been used to describe a similar morphotype, such as: "core scrapers" (Clark and Kleindienst, 2001) and "large scrapers" (Isaac, 1977). At GBY, massive scrapers are the only Large Flake tools, thus distinguishing them from other tools attributed to percussive activities. They are believed to represent a specific stage in the *chaîne operatoire* of bifacial tool production and, as such, constitute a discrete but significant part of the GBY Acheulian toolkits (Fig. 10, No. 2). Despite their scarcity in each level and the wide variety of their blank shapes, the persistence of this tool 'type' leads the authors to suggest that it could have fulfilled a specific task-related role requiring *a massive, plano-convex frontal tool with an abrupt edge* (Goren-Inbar et al., 2008). It is evident, therefore, that HDS continue to be acknowledged into the Developed Oldowan and Early Acheulian register but, are we all referring to the same tools? In fact, from the Oldowan into the Early Acheulian, while the defining features of HDS are maintained, there is a clear shift concerning the blank type: cobble or flake. Furthermore, this difference is highlighted in some cases where Early Acheulian robust scrapers are described as diverging from the 'ancestral' Oldowan morphotype (e.g., *Heavy-duty scraper-like forms* described from Peninj, Diez-Martin et al., 2014). In addition, this change lends the Acheulian 'HDS' a far wider formal diversity compared to the Oldowan ones, while also conferring them new morphologies. In fact, it implies two distinct categories of tools: the heavy-duty scraper (on a cobble) and the massive scraper (on a Large Flake, following Goren-Inbar et al., 2008).

The HDS morphotype does persist through time and is even documented in some Late Acheulian assemblages of western Europe (Fig. 11). Their morpho-technological evolution can be observed at the Caune de l'Arago cave, where a rich lithic sample demonstrates the persistence of this characteristic morphology (Barsky, 2001). The 'massive scraper' morphotype is not represented at this non-Large Flake Acheulian site, where cobble tools are common in most levels (excepting the P levels, Barsky and de Lumley, 2010). Cobbles were used for heavy-duty tools in the archeostratigraphic units G and F (Lumley et al., 2015), where a few HDS (*sic.* "*rostro-carénés*") are documented

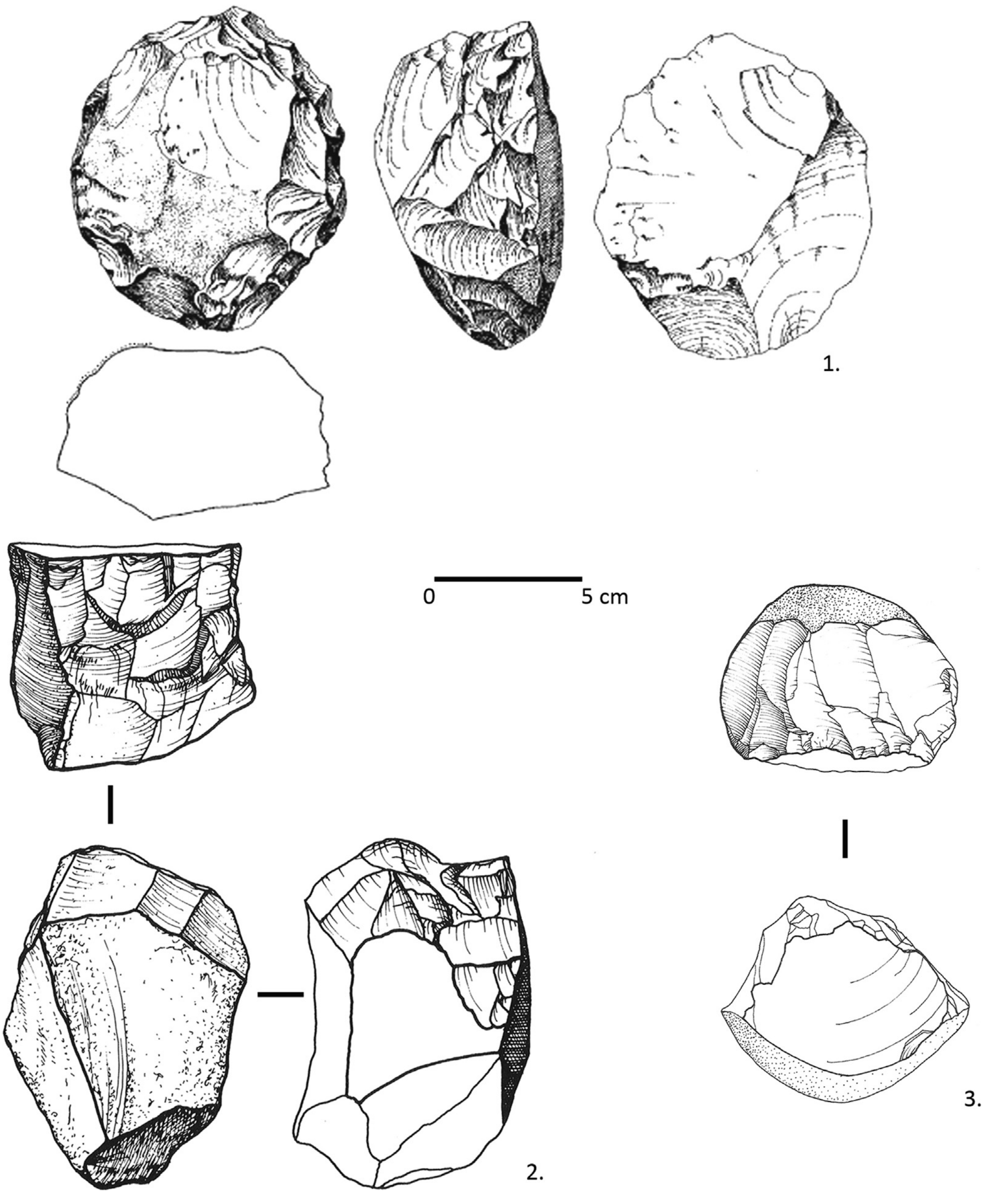


Fig. 9. Heavy-duty scrapers from the Developed Oldowan. 1. FxJj11 at Koobi Fora (Isaac and Harris, 1997) 'Karari scraper' (core) on a lava cobble. 2 and 3. Ubeidiya (Bar-Yosef and Goren-Inbar, 1993). Limestone 'heavy-duty scrapers' from layers I-15 and I-26c, respectively.

Fig. 9. *Heavy-duty scrapers* de l'Oldowayen développé. 1. FxJj11 à Koobi Fora (Isaac et Harris, 1997), « Karari scraper » (nucléus) sur un galet de lave. 2 et 3. Ubeidiya (Bar-Yosef et Goren-Inbar, 1993). *Heavy-duty scrapers* calcaires des niveaux I-15 et I-26c, respectivement.

as cobble tools with carinated, convex edges and presenting abrupt removals. Sometimes made on cores, they tend to be smaller than other chopper tools (Barsky, 2001). They are distinguished from *rabots*, which are end-scrapers made on smaller-sized blanks (flakes and cores). If we are to maintain, therefore, blank type as a defining feature of the HDS, then it should now be clear that this qualification does not entail any chrono-cultural implications. It does, however, imply that what has so often been termed 'HDS' is a technological, rather than a typological reality. We conclude that HDS in Large Flake Acheulian occurrences should be referred to as 'massive scrapers' (following Goren-Inber et al., 2008), which are longer and thinner than their Oldowan counterparts made on cobbles and which present more denticulate edges (they are, in fact, sometimes referred to as large denticulates). Also, comparable morphologies observed in later Acheulian sites, made on cores or flakes, should be referred to henceforth as *rabots*, which are smaller tools with close affinities to end-scrapers (*grattoirs*).

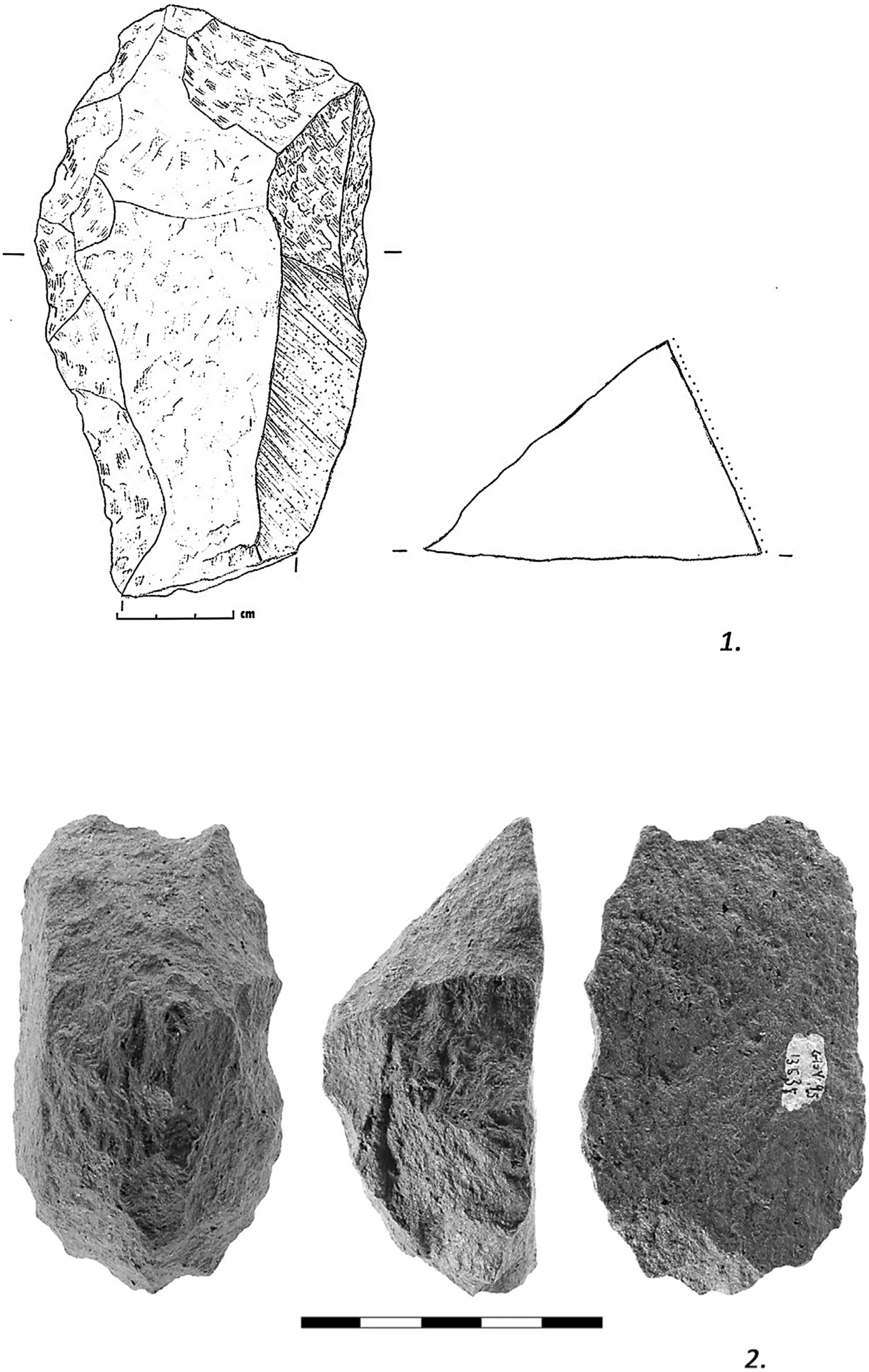


Fig. 10. Acheulian massive scrapers from Africa and the Levant. 1. TK (Thiongo Korongo) lower occupation, Bed II, Olduvai Gorge, Tanzania (Santonja et al., 2014) Acheulian tool referred to as a "heavy-duty scraper". 2. Gesher-Benot Ya'aqov (Goren-Inbar et al., 2008). Acheulian "massive scraper" on a large flake. These tools share large denticulate morphologies.

Fig. 10. Scrapers acheuléens massifs, d'Afrique et du Levant. 1. TK (Thiongo Korongo), occupation inférieure, Bed II, Gorge d'Olduvai, Tanzanie (Santonja et al., 2014), outil acheuléen rapporté à un *heavy-duty scraper*. 2. Gesher-Benot Ya'aqov (Goren-Inbar et al., 2008), « scraper massif » acheuléen sur une grande éclat. Ces outils partagent des morphologies largement denticulées.

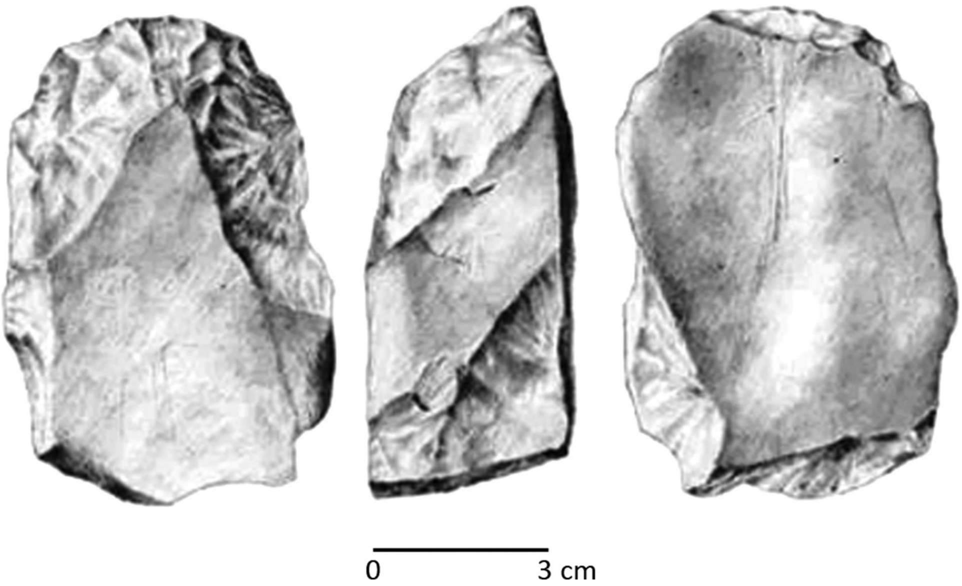


Fig. 11. Late Acheulian "heavy-duty scraper" morphotype from Western Europe. Isernia la Pineta (drawings by D. Mengoli, Rufo et al., 2009). Heavy-duty scraper morphotype referred to as a "rabot" on a limestone cobble.

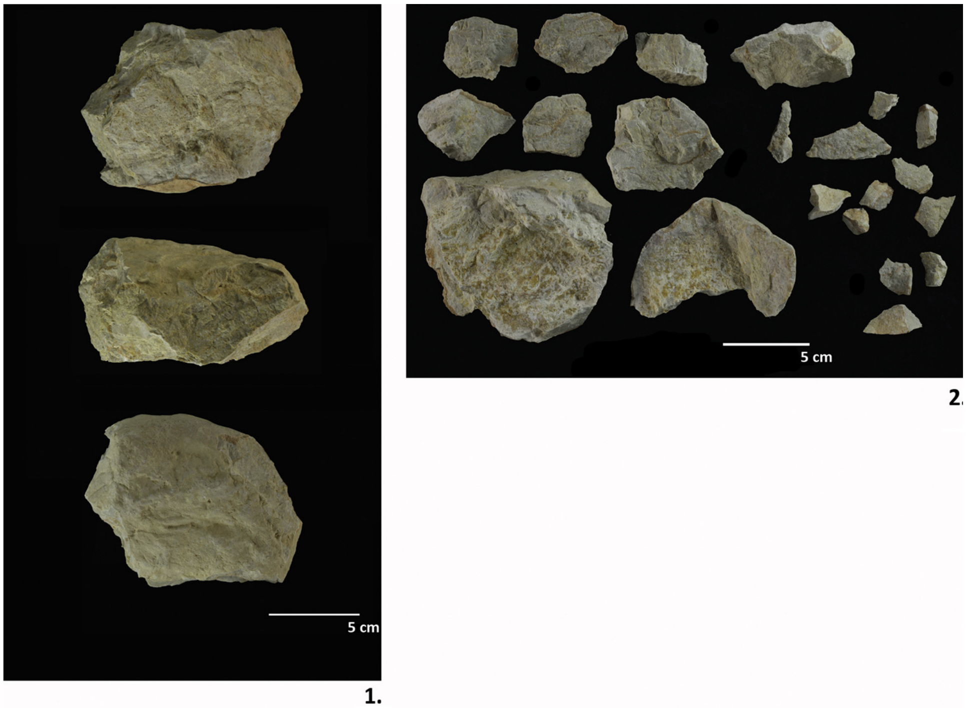
Fig. 11. Morphotype de *heavy-duty scraper* de l'Acheuléen tardif d'Europe occidentale. Isernia la Pineta (dessins de D. Mengoli, Rufo et al., 2009). Morphotype de *heavy-duty scraper* sur un galet calcaire, dénommé ici « rabot ».

3.4. Experimental results

Knapping experiments were performed to reproduce HDS morphologies using limestone cobbles from the Orce environs (Figs. 12 and 13). The aim was to observe whether or not crush marks and/or irregular retouch would result from performing the unifacial unidirectional knapping method. We also wanted to observe if delimited convex and carinated morphologies would be spontaneously reproduced by knapping. Normally, flakes were taken from the lateral edges, following a parallel pattern determined by a recurrent gesture. When a viable platform was not naturally available, the knapper strategically chose an appropriate part of the cobble to initiate knapping by way of an invasive removal (orthogonal method). The knapper chose hammerstones amongst a variety of cobbles, demonstrating a clear preference for rounded, dense and fist-sized items. The reduction process was halted once a viable HDS morphotype was obtained and reduction processes were generally short (HDS obtained after only a few blows). Knapping was terminated once a carinated form was obtained. Blows were delivered onto natural platforms (cortex, breakage planes). Forceful, precise impacts were necessary, especially for initialization of the knapping process. Extractions were performed along the periphery of the cobbles and their order and emplacement were therefore dictated by the original forms. The problematic of avoiding intentionality during knapping was resolved by carrying out only simple recurrent flake extraction and following the dictates of the natural striking platforms (cortex or fracture). The experimental HDS were photographed in order to record any subsequent changes that may affect their initial morphology during use (Fig. 14). Knapping experiments are resumed as follows:

1) ***Relative to the unifacial, unidirectional knapping process***:
   - Multiple blows were often required to successfully detach flakes;
   - Flakes were most often broken;
   - Numerous sharp-edged flakes were obtained in each case;
   - Siret accidents were frequent and their negatives provided practical guiding crests for subsequent extractions;
   - Most extractions traversed the entire distance separating the striking platform from its opposing plane surface;
   - The average flake size exceeded that of the Orce assemblages,

2) ***Relative to HDS morphology:***
   - Knapped edges present sinuous, denticulate morphology rather than regular carinated edges characteristic of HDS (*sic*. Leakey's classification of chopper or discoid, 1971);
   - The denticulate edges have fragile cornices that could easily be detached during use or rectified by friction;
   - Carinated morphologies were not automatically produced during knapping;
   - The angle between the platform and the worked edge becomes progressively more abrupt as knapping progresses into the thickness of the cobble;
   - The occurrence of overhanging negatives and stepped removal morphologies, also characteristic of HDS, was not systematic but seems to depend on the physical features of the rock;
   - Irregular breakage patterns sometimes produced 'retouch' but none of the experimental edges present crush marks.


5 cm
1.
5 cm
2.


5 cm
1.
5 cm
2.

Out of the thirteen pieces produced during our knapping experiments, only three present features close to the HDS definitions discussed above (Table 2). Two of these three, however, display semi-denticulate or denticulate edge morphologies that are not typically a feature of HDS. In sum, only one piece fits the HDS definition quite well (HDS No. 11, Table 2 and Fig. 13, Above No. 1), while lacking, however, the characteristic crush marks which are not, in fact, present on any of our experimentally knapped pieces. Overall, the experimental material displays denticulate and sharp edges that are very unlike the crushed, rounded edges of HDS documented in the archeological record. Unifacial unidirectional knapping gave large denticulate forms resembling HDS only by virtue of their contour and overall shape but not at all in their most salient features, that is to say, the well-defined, carinated convex form of the edge and the presence on that edge of retouch and/or crush marks. We therefore conclude that, at least concerning the Orce materials, these features must result from subsequent phases of use or abrasive action. It is plausible that hominins selected cores with particularly abrupt, convex edges, to perform some kind of secondary activity and that use or shaping would have completed the process of achieving the final HDS morphotype. Our experiments using HDS edges to work different materials demonstrated that abrupt edges are needed to work soft materials in order to avoid ripping them, while more oblique edges or even whole cobbles were better suited to cutting hard materials like wood or breaking bone. Working soft materials on a wooden anvil (*Quercus ilex aquafolium*) did not produce crush marks on the HDS. However, repeated pounding of soft materials like deer tendons on a limestone anvil did produce exactly the same kinds of small retouch and crush marks as those observed on HDS from Orce (Fig. 14).

4. Discussion

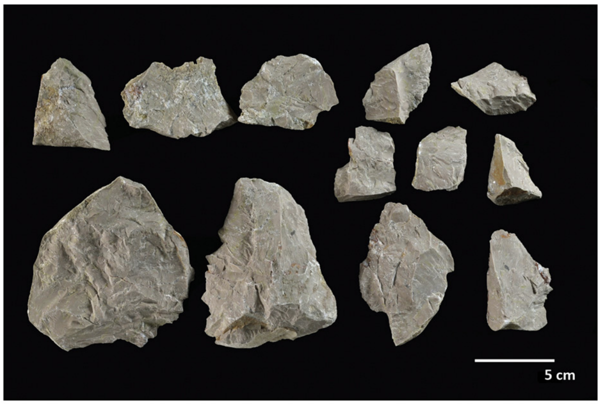
At many early sites that have provided HDS morphotypes, traces on fossil bones suggest the use of heavy-duty tools for percussion-related meat and carcass processing activities. But massive stone implements could also have been used for other purposes, such as woodworking or grinding plant fibres. Experimental research carried out by Toth (1985) argues in favour of the latter, and, while he argues that HDR morphologies ("core scrapers") are suited for heavy-duty and light-duty wood working (adzing), our experiments in wood cutting rather suggested a higher efficacy of oblique edges opposed to a weighty mass. Toth (1985) further emphasizes that sharp edges (< 80°), were suitable for cutting meat off carcasses and this view is also supported by available ethnographical evidence (Hayden, 1979). Our work shows that, at least in the case of the Orce limestone, HDS trace morphology is easily reproduced when unifacial unidirectional core forms are used as hammers to work soft materials on a stone anvil. Whether HDS morphologies were unintentionally produced from recurrent unidirectional flake production, by use or by shaping based on a pre-meditated template, is an ongoing debate that may, in future, be resolved by further experimental work. This problem of "separating" HDS from cores relates mainly to the Oldowan assemblages, because of their low degree of standardization and the absence of Large Flake supports. It is, in fact, during the Oldowan that there seems most often to be disagreement in the classification — or not — of HDS as tools. As discussed above, this is not a new issue since, following Leakey's definitions of HDS at Olduvai Gorge, other specialists have highlighted the issue (Isaac, 1986; Jelineck, 1977; de la Torre and Mora, 2005). Indeed, the fact that this matter has not been resolved after fifty years of research demonstrates that establishing strict classificatory systems, especially within the Oldowan, is not a fitting work methodology. That said, the existence of a HDS morphotype cannot be so easily dismissed given the homogeneity of the observations provided from numerous sites and the evidence presented from different assemblages over time. It should be recognized, therefore, that the HDS morphotype — no matter its technological or functional origin — maintains its place as one of the oldest morphotypes known in the world.

Certainly, as Toth (1985) and others have maintained, many of the Oldowan core tool forms are likely knapping by-products, and there is no clear-cut way to differentiate 'tools' from 'cores' in Oldowan occurrences. However, as demonstrated at Orce (Barsky et al., 2015), it now seems clear that Oldowan 'tools' constitute simply repeated morphologies that will vary from site to site in accordance to the size, quality and shape of the raw materials used. We argue that the fact that the repetition over time of objects fitting within a specific formal range is clearly task-related. This is the case of HDS: the flat, convex surface with an abrupt, nosed extremity obviously corresponds with some — yet to be determined — activity that has persisted over time. A step towards resolving this complex issue is to accept the distinctiveness of the HDS morphotype that we can recognize as *a repeated norm in the archaeological record* (Hovers, 2012). This study contributes to understanding technological transformations in the Oldowan and Acheulian Techno-Complexes through the archeometrical and formal recognition of the emergence of the HDS morphotype. The specific configuration of this tool is most intriguing and raises questions about the kinds of activities responsible for the intense stigma observed on their

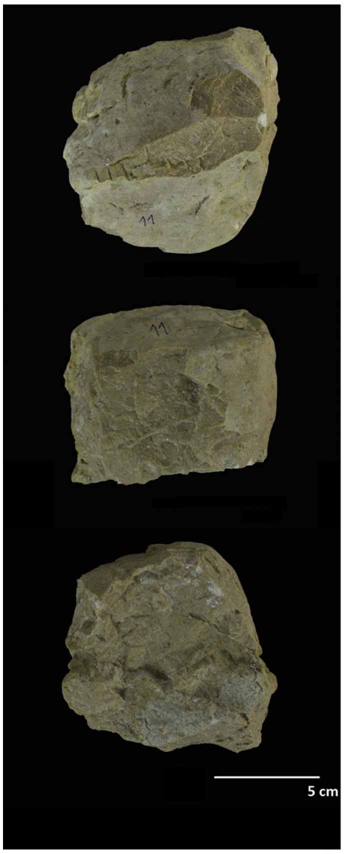
Fig. 12. Experimentally knapped Orce limestone. (Above: 1. core and 2. flakes) Knapping experiment No. 1 (124 × 101 × 66 mm. Angle worked edge = 100°). Poor quality, fissured limestone cobble with oblong shape. The platform is a fracture surface provoked during knapping. Stepped morphology of the worked edge resulted from knapping and breakage. Short knapping sequence. Products are large and small flakes, as well as fragments. (Below 1. core and 2. flakes) Knapping experiment No. 7 (112 × 87 × 73 mm. Angle worked edge = 90°). Thick rounded cobble of good quality limestone. A single cortical platform was knapped by a few, unidirectional removals until an abrupt surface was obtained.

Fig. 12. Calcaire d'Orce, débité expérimentalement. (En haut : 1. nucléus et 2. éclats). Expérience de débitage nº 1 (124 × 101 × 66 mm. Angle du bord travaillé : 100°). Galet de calcaire de qualité médiocre, fissuré de forme oblongue. La plate-forme est une surface de fracture provoquée durant le débitage et de casse. La morphologie en escalier du bord travaillé résulte d'accidents de débitage et de casse. Séquence de débitage court : éclats et fragments grands et petits. En bas, 1. nucléus et 2. Éclats. Expérience de débitage nº 7 (112 × 87 × 73 mm. Angle du bord travaillé : 90°) Galet calcaire épais et arrondi, de bonne qualité. Une plate-forme unique a été débitée par quelques extractions unidirectionelles jusqu'à obtention d'une morphologie abrupte.

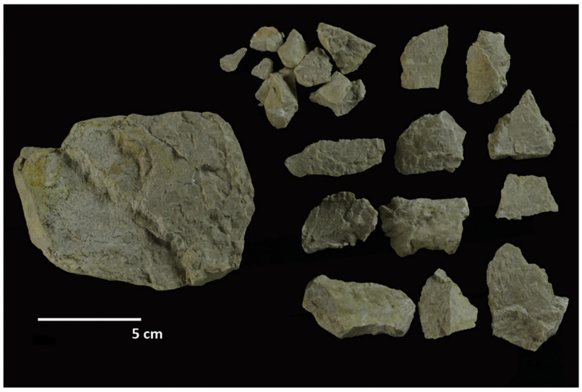
1.



2.



1.



2.

edges. Oldowan stone toolkits do not include truly standardized tool types that only become ubiquitous from the onset of the Acheulian (i.e. retouched flakes and LCT's). Yet in the Oldowan, formal attributes, such as those characterizing HDS, could have been found to present advantages for performing a specific task. If the need to perform that task persisted over time, so too would the morphotype be repeatedly manufactured and thus developed into a truly configured tool type. It is useful to retain the observation by Isaac and Harris (1997) who regarded the HDS morphotype simply as reflective of "[. . .] fossilized stone-working habits rather than as 'imposed designs' . . . indicative of "repeated, regular use of convenient procedures" (Isaac and Harris, 1997). The repetition of the HDS morphotype over time from the dawn of human technologies is an empirical reality that, as we have seen, could be task-related. This constancy could explain how and why HDS were to become intentionally manufactured objects present in the majority of Acheulian toolkits.

Concluding from our data, discussions and observations, it is appropriate here to qualify "heavy-duty scrapers" as follows:

Heavy-duty scrapers are tools made on rounded cobbles that appear during the Oldowan. They present a sub-triangular or rounded section provided by a flat surface that served as a striking platform. This platform is formed by a cortical surface, a fracture or a previous removal negative. The carinated morphology of the worked edge results from recurrent, parallel, short, abrupt, removals that are generally smaller than those observed on the cores or chopper tools from

Fig. 13. (Above: 1. core and 2. flakes) Knapping experiment No. 11 (95 × 93 × 63 mm. Angle worked edge = 96°). Thick, square limestone cobble of mediocre quality limestone. A fracture occurring during knapping served as a striking platform for a series of medium to small-sized flakes and broken flakes (orthogonal knapping). Frequent breakage. (Below: 1. core and 2. flakes): knapping experiment No. 13 (140 × 98 × 79 mm. Angle worked edge = 85°). Large, oval-shaped cobble of mediocre limestone. Knapping performed from a cortical platform produced deep removal negatives determining an oblique-angled, denticulate edge. Flakes and broken flakes are large to medium-sized.

Fig. 13. (En haut : 1, nucléus et 2, éclats. Expérience de débitage n° 11 (95 × 93 × 63 mm. Angle du bord travaillé : 96°). Galet calcaire épais et carré, de qualité médiocre. Une fracture de débitage a servi de plate-forme pour une série d'éclats de taille petite à moyenne et d'éclats cassés (débitage orthogonal). Fractures fréquentes. (En bas : 1. nucléus et 2. éclats) : Expérience de débitage n° 13 (140 × 98 × 79 mm. Angle du bord travaillé : 85°). Grand galet calcaire forme ovale et de qualité médiocre. Le débitage effectué à partir d'une plate-forme corticale a produit des négatifs d'extraction profonds, déterminant un bord denticulé, à angle oblique. Les éclats et les éclats cassés sont de taille moyenne à grande.

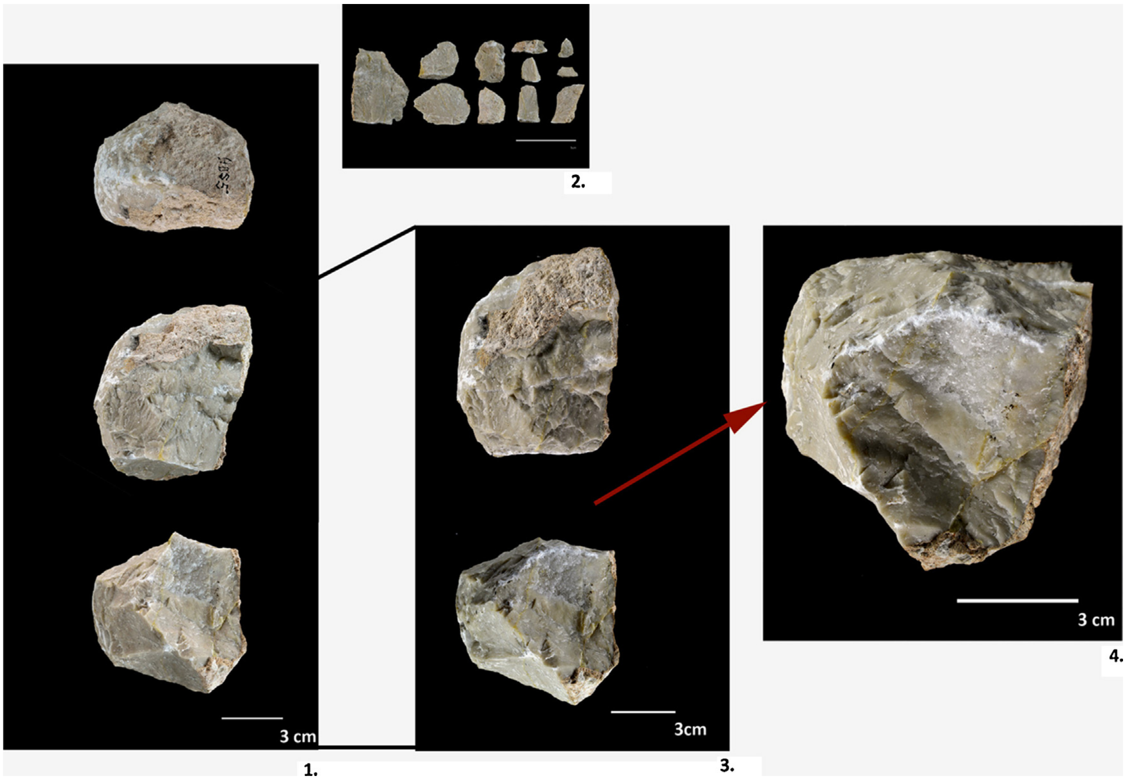


Fig. 14. Knapping experiment No. 5 (94 × 68 × 64 mm. Angle worked edge = 110°). 1 and 2. Small broken cobble. Concave platform prepared by a removal on a thick triangular cobble fragment (orthogonal knapping method). Denticulate edge obtained. Large and medium-sized flakes were produced. 3 and 4. Details of the piece after it was used to work dried deer tendons on a stone anvil showing the effacing of the denticulated edge and localized crush marks.

Fig. 14. Expérience de débitage n° 5 (94 × 68 × 64 mm. Angle du bord travaillé: 110°). 1 et 2. Petit galet cassé. Plate-forme concave préparée par extraction sur un épais fragment triangulaire de galet (méthode de débitage orthogonal). Bord denticulé obtenu. Des éclats de taille moyenne à grande ont été produits. 3 et 4. Détails de la pièce après son utilisation pour travailler des tendons de cerf séchés sur une enclume de pierre montrant l'effacement du bord denticulé et les marques de broyage localisées.

Table 2
Recapitulative of data pertaining to the heavy-duty scraper morphotype for the experimental material.
Tableau 2
Récapitulatif des données relatives au morphotype de *heavy-duty scraper* pour le matériel expérimental.

Exp. No.	Striking platform	Angle	Convexity	Denticulation	Irregular retouch/crush marks	Crush marks	Carinated	Overall HDS morphology
1	Fracture	Abrupt (100°)	Semi-convex	Denticulate	Stepped crush marks from breakage	No	Yes	Yes
2	Cortex	Abrupt (95°)	Convex	Denticulate	No	No	Yes	No
3	Removal	Abrupt (97°)	Convex	Denticulate	No	No	No	No
4	Removal	Abrupt (95°)	Convex	Denticulate	Slight	No	Yes	No
5	Removal	Abrupt (110°)	Convex	Denticulate	Slight	No	Yes	No
6	Cortex	Abrupt (92°)	Convex	Semi-denticulate	Slight	No	Yes	Proximate
7	Cortex	Abrupt (90°)	Convex	Semi-denticulate	No	No	Yes	Proximate
8	Cortex	Oblique (80°)	Rectilinear	Denticulate	No	No	No	No
9	Cortex	Abrupt (91°)	Convex	Denticulate	No	No	No	No
10	Cortex	Abrupt (94°)	Convex	Semi-denticulate	Stepped crush marks from breakage	No	Yes	Yes
11	Removal	Abrupt (96°)	Convex	Non-denticulate	Stepped crush marks from breakage	No	Yes	Yes
12	Cortex	Abrupt (104°)	Slightly convex	Non-denticulate	No	No	Yes	No
13	Cortex	Oblique (85°)	Convex	Denticulate	No	No	No	No

the same assemblages. Their edges present steep, irregular retouch or trimming and often also crush marks uniquely on the convex upper surface. The angle separating the platform and the worked surface is $\geq 90°$. Heavy-duty scrapers are generally scarce relative to other cobble tools in an assemblage. The heavy-duty scraper morphotype persists into the Developed Oldowan and is exchanged during the Large Flake Acheulian by massive scrapers made on Large Flakes. During the Late Acheulian, analogous morphotypes encountered on cores and regular flakes are duly referred to as rabots, a tool type whose overall morphology blends into the group of end-scrapers.

While numerous issues relating to the intentionality of the HDS morphotype and its eventual functionality in early and later stone toolkits remain to be resolved, this characterization will be useful to identify heavy-duty scrapers in stone-tool assemblages and to distinguish them from massive scrapers and rabots, thus avoiding confusion in the classification of this ancient tool type in future.

Acknowledgements

The authors are grateful for funding from the Junta de Andalusia: 'Primeras ocupaciones humanas del Pleistoceno inferior de la Cuenca de Guadix–Baza (Granada, España)', B090678SV18BC (2009–2011), and 'Presencia humana y context paleoecologico en la cuenca continental de Guadix-Baza. Estudio e interpretación a partir de los depósitos Plio-Pleistocénicos de Orce (Granada, España)', B120489SV18BC (2012–2015). We are also thankful for support from the 'Ministerio de Economía y Competitividad' (MINECO): '*Study of the Early Pleistocene faunal and human dispersals in the Mediterranean basin*' CGL2016-80975-P (2017–2019). We extend our gratitude to the talented photographers Jordi Mestre and Sioba Grande Domínguez (IPHES). We also thank Ignacio de la Torre for comments and corrections that have significantly improved our manuscript.

References

Allaby, M., 1999. A Dictionary of Zoology (Accessed on: November 13, 2012, available at: http://www.encyclopedia.com/doc/1O8-morphotype.html).
Barsky, D., 2001. Le débitage des industries lithiques de la Caune de l'Arago (Pyrénées-Orientales, France) : leur place dans l'évolution des industries du Paléolithique inférieur en Europe méditerranéenne. Perpignan University, France (Unpublished PhD dissertation).
Barsky, D., 2009. An overview of some African and Eurasian Oldowan sites: evaluation of Hominin cognition levels, technological advancement and adaptive skills. In: Hovers, E., Braun, D. (Eds.), Interdisciplinary Approaches to the Oldowan. Springer, Netherlands.
Barsky, D., de Lumley, H., 2010. Early European Mode 2 and the stone industry from the Caune de l'Arago's archeostratigraphical levels 'P'. Quat. Int. 223-224, 71–86.
Barsky, D., Vergès, J.M., Sala, R., Menéndez, L., Toro-Moyano, I., 2015. Limestone percussion tools from the late Early Pleistocene sites of Barranco León and Fuente Nueva 3 (Orce Spain). Philos. Trans. Royal Soc. B 370, 20140352, http://dx.doi.org/10.1098/rstb.2014.0352.
Bar-Yosef, O., Goren-Inbar, N., 1993. The Lithic Assemblage of Ubeidiya. A Lower Paleolithic site in the Jordan Valley. Institute of Archaeology, Hebrew University of Jerusalem, Jerusalem.
Braun, D.R., Tactikos, J.C., Ferraro, J.V., Shira, L.A., Harris, J.W.K., 2008. Oldowan reduction sequences: methodological considerations.J. Archaeol. Sci. 35, 2153–2163.
Carbonell, E., Guilbaud, M., Mora, R., 1983. Utilización de la lógica analítica para el studio de los tecnocomplejos a cantos tallados. Cah. Noir 1, 3–79.
Carbonell, E., Márquez, B., Mosquera, M., Ollé, A., Rodríguez, X.P., Sala, R., Vaquero, M., Vergès, J.M., 1995. Atapuerca Trinchera Galería (Spain): Strategies and operational methods of lithic industry. Cah. Noir 7, 41–83.
Carbonell, E., Sala, R., Barsky, D., Celiberti, V., 2009. From homogeneity to multiplicity: a new approach to the study of archaic stone tools. In: Hovers, E., Braun, D. (Eds.), Interdisciplinary Approaches to the Oldowan. Springer, Netherlands, pp. 25–38.
Carbonell, E., Barsky, D., Sala, R., Celiberti, V., 2016. Structural continuity and technological change in Lower Pleistocene toolkits. Quat. Int. 393, 6–18.
Clark, J.D., Kleindienst, M.R., 2001. The Stone Age cultural sequence: terminology, typology and raw material. In: Clark, J.D. (Ed.), Kalambo Falls Prehistoric Site. Cambridge University Press, Cambridge, pp. 34–65.
Collina-Girard, J., 1986. Grille descriptive et évolution des industries archaïques, le modèle catalán. Bull. Soc. Prehist. Fr. 83 (11–12), 383–403 (études et travaux).
Diez-Martin, F., Sánchez Yustus, P., Gómez de la Rúa, D., Gómez González, J.Á., de Luque, L., Barba, R., 2014. Early Acheulean technology at Es2-Lepolosi (ancient MHS-Bayasi) in Peninj (Lake Natron Tanzania). Quat. Int. 322–323, 209–236.

Gallotti, R., 2013. An older origin for the Acheulian at Melka Kunturé (Upper Awash Ethiopia): techno-economic behaviours at Garba IVD. J. Hum. Evol. 65, 594–620.
Gallotti, R., Raynal, J.P., Geraads, D., Mussi, M., 2014. Garba XIII (Melka Kunture, Upper Awash Ethiopia): a new Acheulean site of the late Lower Pleistocene. Quat. Int. 343, 17–27.
Geneste, J.M., Boëda, E., Meignen, L., 1990. Identification des chaînes opératoires et complexité technique. Paleorient 2, 43–80.
Goldman-Neuman, T., Hovers, E., 2012. Raw material selectivity in Late Pliocene Oldowan sites in the Makaamitalu Basin, Hadar, Ethiopia. J. Hum. Evol. 62, 353–366.
Goren-Inbar, N., Feibel, C.S., Verosub, K.L., Melamed, Y., Kislev, M.E., Tchernov, E., Saragusti, I., 2000. Pleistocene milestones on the out-of-Africa corridor at Gesher Benot Ya'aqov, Israel. Science 289, 944–974.
Goren-Inbar, N., Sharon, G., Alperson-Afil, I., Laschiver, 2008. The Acheulian massive scrapers of Gesher-Benot Ya'aqov – product of the *biface chaîne opératoire*. J. Hum. Evol. 55, 702–712.
Harris, J.W.K., 1978. The Karari Industry: its place in East African Prehistory. University of California, Berkeley (PhD dissertation).
Hayden, B., 1979. Australian Institute of Aboriginal Studies, Canberra. Humanities Press Inc, New Jersey.
Hovers, E., 2012. Invention, reinvention and innovation: makings of Oldowan lithic technology. In: Elias, S. (Ed.), Origins of human innovation and creativity, 16. Elsevier B.V, pp. 51–68 (Developments in Quaternary Science).
Isaac, G.L., 1977. Olorgesailie: Archaeological Studies of a Middle Pleistocene Lake Basin, Kenya. The University of Chicago Press, Chicago.
Isaac, G.L., 1984. The archaeology of human origins: studies of the lower Pleistocene in East Africa 1971–1981. Adv. World Archaeol. 3, 1–87.
Isaac, G.L., 1986. Foundation stones: early artifacts as indicators of activities and abilities. In: Bailey, G.N., Callow, P. (Eds.), Stone Age Prehistory. Cambridge University Press, Cambridge, pp. 221–241.
Isaac, G.L., Harris, J.W.K., 1997. The stone artifact assemblages: a comparative study. In: Isaac, G.L. (Ed.), Koobi Fora Research Project, 5. Clarendon Press, Oxford, pp. 262–299 (Plio-Pleistocene Archaeology).
Jelineck, A.J., 1977. The Lower Paleolithic: current evidence and interpretations. Annu. Rev. Anthropol. 6, 11–32.
Kleindiest, M.R., 1962. Components of east African Acheulian assemblages: an analytic approach. Musée royal de l'Afrique centrale, Tervuren, Belgium, pp. 81–105.
Laplace, G., 1972. La typologie analytique et structurale : base rationelle d'étude des industries lithiques et osseuses. Banques de données archéologiques, 932. Colloques nationeaux du CNRS, pp. 91–143.
Laplace, G., 1974. De la dynamique de l'analyse structurale ou la typologie analytique. Rev. Sci. Prehist. 29 (1), 1974.
Leakey, M.D., 1936. Stone Age Africa. In: An outline of prehistory in Africa. Oxford University Press, London, UK.
Leakey, M.D., 1971. Olduvai Gorge, excavations in Bed I and Bed II, 1960–1963, 3. Cambridge University Press, Cambridge, UK.
de Lumley, H., Beyene, Y., 2004. Les sites préhistoriques de la région de Fejej, Sud-Omo, Éthiopie dans leur contexte stratigraphique et paléontologique. Association pour la diffusion de la pensé française (ADPF), Paris (Éditions Recherche sur les civilisations).
Lumley, H.de, Nioradzé, M., Barsky, D., Cauche, D., Celiberti, V., Notter, O., Zvania, D., Lordkipanidzé, D., 2005. Les industries lithiques préoldowayennes du début du Pléistocène inférieur du site de Dmanissi en Géorgie. L'Anthropologie 109, 1–182.
Lumley, H.de, Fontaneil, C., Grégoire, S., Batalla, G., Caumon, G., Celiberti, V., Chevalier, T., Deguillaume, S., Fournier, A., Lumley, M.A.de, Magniez, P., Moigne, A.M., Notter, O., Perrenoud, C., Pois, V., Pollet, G., Testu, A., 2015. Caune de l'Arago Tome VI, Tautavel-en-Roussillon, Pyrénées-Orientales, France : individualisation des unités archéostratigraphiques. CNRS Éditions, Paris.
McDougall, I., Brown, F.H., 2006. Precise $^{40}Ar/^{39}Ar$ geochronology for the upper Koobi Fora Formation, Turkana Basin, northern Kenya. J. Geol. Soc. 163, 205–220.
Movius Jr., H.L., 1943. The Stone Age of Burma. In: de Terra, H., Movius Jr., H.L. (Eds.), Research of Early Man in Burma. , pp. 341–393 (Also available in: Trans. Am. Philos. Soc., 32(3)).
Rufo, M.A., Minelli, A., Peretto, C., 2009. The limestone industry of the Paleolithic site of Isernia la Pineta: an interpretative model of behavioural strategies. Anthropologie 113, 78–95.
Santonja, M., Panera, J., Rubio-Jara, S., Pérez-González, A., Uribelarrea, D., Domínguez-Rodrigo, M., Abulla, Audax, Z.P.M., Baquedano, E., 2014. Technological strategies and the economy of raw materials in the TK (Thiogo Korongo) lower occupation, Bed II, Olduvai Gorge, Tanzania. Quat. Int. 322–323, 181–208.
Semaw, S., 2000. The world's oldest stone artefacts from Gona, Ethiopia: their implications for understanding stone technology and patterns of human evolution between 2.6-1.5 million years ago. J. Archaeol. Sci. 27, 1197–1214.
Sharon, G., 2009. Acheulian Giant Core technology. A worldwide perspective. Curr. Anthropol. 50 (3), 335–367.
Shea, J., 2013. Lithic Modes A-I: A new framework for describing global-scale variation in stone tool technology illustrated with evidence from the east Mediterranean Levant. J. Archaeol. Method Theory 20 (1), 151–186.
Soressi, M., Geneste, J.M., 2011. Special Issue: reduction sequence, *chaîne opératoire*, and other methods: The epistemologies of different approaches to lithic analysis. Paleoanthropology 2011, 334–350.
Tavoso, A., 1978. Le Paléolithique inférieur et moyen du Haut-Languedoc. In: Gisements des terrasses alluviales du Tarn, du Dadou, de l'Agout du Sor et du Fresquel. Université de Provence, France (Études Quaternaires 5).
Toth, N., 1985. The Oldowan reassessed: a close look at early stone artifacts. J. Archaeol. Sci. 12, 101–120.
de la Torre, I., Mora, R., 2005. Technological strategies in the Lower Pleistocene at Olduvai Beds I & II. ERUAL, Liège, Belgium, pp. 112.
de la Torre, I., Mora, R., Martínez-Moreno, J., 2008. The Early Acheulian in Peninj (Lake Natron, Tanzania). J. Anthropol. Archaeol. 27, 244–264.
de la Torre, I., Mora, R., 2009. A technological analysis of non-knapped stone tools in Olduvai Beds I & II. In: Mourre, V., Jarry, M. (Eds.), Stressing the relevance of percussion activities in the African Lower Pleistocene, 3. Les Eyzies: Paleo, pp. 13–34 (Entre le marteau et l'enclume. Table Ronde sur la percussion directe au percuteur dur et la diversité de ses modalités d'application).
de la Torre, I., 2011. The Early Stone Age lithic assemblage of Gadeb (Ethiopia) and the Developed Oldowan/early Acheulian in East Africa. J. Hum. Evol. 60 (6), 768–812.
Toro Moyano, I., Lumley, H.de, Barrier, P., Barsky, D., Cauche, D., Celiberti, V., Grégoire, S., Lebègue, F., Mestour, B., Moncel, M.H., 2010. Les industries lithiques archaïques du Barranco León et de Fuente Nueva 3, Orce, basin du Guadix-Baza, Andalousie. In: Monography. CNRS Éditions.