Active percussion tools from the Oldowan site of Barranco León (Orce, Andalusia, Spain): The fundamental role of pounding activities in hominin lifeways

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Abstract

Dated to 1.4 Mya, the Barranco León site (Orce, Andalusia, Spain) is currently the oldest and richest late Lower Pleistocene stone tool assemblage discovered so far in Europe. Archeological and paleontological remains are found clearly associated in lacustrine deposits traversed by a small channel. This paper provides new data about the lithic assemblage from level D, focusing on the abundant active percussion implements that form a part of the highly divers set of limestone macro-tools unique to this assemblage. Morpho-technological and experimental analysis of these tools allows us to hypothesize about the kinds of activities that might have been carried out by hominins at this site. Experimental work allows us to define percussive trace morphologies and to identify new types of percussion tools in the collection, beyond those of classical, ellipsoidal morphology. Analysis of the stone surfaces used for active percussion demonstrates that, while some of the tools could have been used for stone knapping, other hammer morphologies are not well adapted for this kind of activity. The morphology of the tools and the type of percussion damage displayed on their active surfaces provide criteria with which to widen the activity range of the hominins that used them. This study of the percussion instruments from Barranco León contributes essential data with which to buttress the growing interest in the macro component of Oldowan stone toolkits African and Eurasian sites and their possible uses.

Keywords: Manuport; Barranco León; Late lower pleistocene; Oldowan; Experimental archeology

1 Introduction

Percussion implements form a part of the basic toolkit in Prehistoric stone tool assemblages in the most varied chronologies. These tools, though they do not always play a prominent role in the industries, provide essential clues for understanding what kinds of activities were performed by hominins at prehistoric archeological sites. In the framework of the Oldowan techno-complex, where they are often found in abundance (Chavaillon, 1979), the so-called 'macro tool' assemblages provide us with an assortment of study materials from which to obtain information about hominin activity. Beyond butchery, an activity deduced mainly from macro traces on bones (Dominguez-Rodrigo and Alcalá, 2016), and sparse evidence for woodworking (Keeley and Toth, 1981), little is known about the kinds of activities that were carried out by Oldowan hominins. In fact, from the range of possible or probable activities, there is no reason to exclude the likelihood that actions such as working plant materials, digging, chopping wood, modifying animal skins and soft tissues, were within the range of cognitive and technical skills of these hominins.

Percussion tools have been identified in earliest African Oldowan sites: Lomekwi 3 (3.3 Mya, Harmand et al., 2015); Kada Gona EG 10 and EG 12 and Ounda Gona OGS 7 sites (2.5–2.6 Mya, Semaw, 2000; Semaw et al., 1997, 2003, 2009); Lokalalei 2C (2.34 Mya, Roche et al., 1999; Delagnes and Roche, 2005); Fejej FJ-1a (1.96 Mya, de Lumley and Beyene, 2004; Barsky et al., 2011); Olduvai Gorge Bed I sites (1.8 Mya, Leakey, 1971; de Torre and Mora, 2009; Diez-Martin et al., 2010), Koobi Fora KBS member sites FxJj 1, FxJj 3, FxJj 10 (1.95 Ma, McDougall and Brown, 2006; Isaac and Isaac, 1997) and Melka Kunture Gombore I*B* (1.7 Mya, Chavaillon, 1979) and Gombore I*γ* (1.3–1.1 Mya, Chavaillon, 2004). They are also present in Eurasian Oldowan assemblages: Dmanisi (1.81 Mya, Gabunia, et al., 2000; Vekua and Lordkipanidze, 2010; de Lumley et al., 2005); Pont-de-Lavaud (1.1 Mya, Despriée and Gageonnet, 2003; Despriée et al., 2006; Lombera et al., 2016); Le Vallonnet (1.2 Mya, de Lumley et al., 1988; Michel et al., 2017), and Fuente Nueva 3, located only a few kilometers away from Barranco León (heretofore: BL; 1.2 and 1.4 Mya, Agustí et al., 1987, 1996, 2007; Duval et al., 2011, 2012a, 2012b; Barsky et al., 2010, 2014, 2015, Toro-Moyano et al., 2009). Manuports are also reported from Bois-de-Riquet, level US2 (1.2 Mya, Crochet et al., 2009; Bourguignon et al., 2016a, 2016b). While some of these sites have yielded relatively few percussion tools, we underline that BL provides, contrastingly, an exceptionally rich macro-tool assemblage whose descriptive and experimental analysis, provided here, will certainly serve as a database for future comparisons at all of these occurrences.

If, in the past, some typological approaches treated percussion tools indiscriminately within the category "*utilized material*" (Leakey, 1971; Isaac and Isaac, 1997), such methodologies do not efface the important distinction between the different roles of active (hammerstone) and passive (anvil) percussion tools, respectively*, …as transmitters or receptors of a striking force with the aim of transforming another object or material* (de la Torre and Mora, 2005). One of the first to emphasize the important role played by percussion tools in ancient stone industries was J. Chavaillon (1979), who recognized that they were too often marginalized in descriptive studies. After describing how these tools and the traces they bear can be indicative of precise activities. By finally categorizing them into *whole and fractured*, Chavaillon (1979) pointed out that the integrity of the active percussion instruments was in relation to their use.

More recently, in their re-analysis of the Olduvai Gorge Bed I stone toolkits, de la Torre and Mora (2005) provide meticulous descriptions of the percussion tools, highlighting active percussion instruments and their role as hammerstones. In this study, the authors interpret these tools as having been used for knapping activities. Their descriptions include an interpretative work of the role of active percussion in producing different kinds of traces, such as *fracture angles* and even sub-spheroid-type morphologies.

In addition, to this growing interest in percussive activities in the Oldowan context (de la Torre and Hirata, 2015), moving beyond typological constraints has led to the development of new methodologies for distinguishing between traces on stone resulting from natural causes and those provoked by anthropic intervention (Caruana et al., 2014). Considering the significance of the methodological breakthroughs made in the study of percussion tools and their relationship to different kinds of activities, most recently providing a new focus on the Orce stone toolkits (Barsky et al., 2015), a more detailed study of these macro toolkits is most timely. The traces preserved on the limestone macro tools from BL, although sometimes difficult to discern on altered surfaces, provide an exceptional database of their variability at a macroscopic level. This analysis of active percussion tools from BL attaches importance to the morphology of the cobbles both before and after their use as hammerstones. In some cases, different work processes other than stone knapping activities and butchery have been brought to light thanks to comparative experimental work performed on various materials (e.g. tendons, wood).

2 The Barranco León site

During the late Lower Pleistocene, hominins left traces of their presence at the Orce sites (Guadix-Baza region, Andalusia, Spain). At the time, the Guadix sub-basin was traversed by a hydrological system descending from Sierra Nevada and Sierra de Cazorla. Different river systems and their affluents flowed into a lake that existed in the eastern Baza sector of the basin, from the Upper Miocene until towards the end of the Middle Pleistocene. The Orce archeological sites are located in the northeastern boundary of the Baza sector, whose depositional sequence is characterized by Pliocene and Pleistocene alluvial and lacustrine sediments assigned to the Baza formation (Oms et al., 2000a, 2010; Sala Ramos, 2014). The BL site is situated on the left bank of a ravine originating from the Sierra de Umbria, in a section providing an excellent record of paleoenvironmental conditions on the ancient lake margin. The archeostratigraphical sequence exposed at BL is included into the *Upper Member* series of lacustrine and palustrine deposits (Oms et al., 2000b, 2011), consisting of around 20 m of clays, carbonated silts, limestones, sands and conglomerates (Agustí et al., 2015). This sequence encloses the site's archeological unit D, about 20–35 cm thick, that has provided abundant archeo-paleontological materials, including a hominin deciduous tooth (Toro-Moyano et al., 2013). The lithic artifacts presented in this paper are included in this level. Natural dynamics observed from micro-morphological analysis of level D reveal that the deposits are characterized by a shallow lacustrine sequence: it is an unstable system with variations in the base level, produced by the lake's lateral migration. This system is highly diagnostic of lake-margin micro-environments, which also record some fluvial inputs and local immersive events (Rodriguez Rivas, 2013).

Level BL-D contains macro- and micro-vertebrate fossil associations typical for this period of the Early Pleistocene (Abbazzi, 2010; Agustí and Madurell, 2003; Alberdi, 2010; Furió-Bruno, 2003; Martínez-Navarro et al., 2010; Lacombat, 2010; Madurell-Malapeira et al., 2011; Toro-Moyano et al., 2013; Blain et al., 2011, 2016; Medin et al., 2017). Paleoecological and paleoclimatical studies of BL's level D indicate a warmer and more humid climate than presently recorded in the Guadix-Baza Basin (Blain et al., 2011). Recently, BL level D has been subdivided into sublevels D1 and D2, both with a similar sandy sedimentary matrix, but are linked to two different depositional events (Agustí et al., 2015). The baseline of level D1 has yielded most of the macro tools, made from angular limestone cobbles of various shapes and sizes. These cobbles are linked to high-energy currents of the paleo-channel traversing the site. Contrastingly, level D2 corresponds to an *in situ* formation whose sedimentary matrix contains less gravels.

Apart from differences in tool frequencies, the two sublevels have yielded a similar stone industry made from flint (cores and small flakes) and limestone (passive and active percussion macro tools, cores and flakes). While there are obvious difficulties in identifying the anthropic intervention on the *in situ* limestone materials, ongoing studies focusing on this raw material are pointing towards selectivity processes. The latter are brought to light in the qualitative, morphological and volumetric features of cobbles displaying removals and/or percussion marks, thanks to new methodologies presented here. While it is certainly impossible to quantify with exactitude the number of cobbles that might have been used as hammerstones in this kind of accumulation, the relationships established between cobble volumetric features and the types and situation of the traces they bear do point towards systematic repetitions, which can only be attributed to hominin interventions. Finally, qualitative selectivity processes brought to light thanks to new petrographic data presented here concerning limestone variability at Orce lend credence to establishing hominin selective processes in some cases.

3 Materials and methods

After new revision of the materials, we present here a synthesis of the flint and limestone tools available for study from the first excavations in 1995 up to 2014 (1.847 pieces) (Table 1). One of the main features of this Oldowan assemblage is the wide range of limestone cobble morphologies it represents, and whose origins are to be found, for the most part, directly within the site's deposits. This poses the particularly complex problematic of distinguishing those cobbles which have been used and/or only summarily modified by hominins. As a first step, we have proposed two main categories (Barsky et al., 2015): 1) cobbles without percussion marks (naturals and possible manuports) and 2) cobbles with percussion marks (hammerstones, anvils). In addition, there are large limestone cores and multi-functional tools, flakes and loosely configured tools. The assemblage also includes small flint flakes and fragments and abundant small-sized waste (<2 cm).

Table 1 Number and type of lithic items of different raw materials (1995–2014).

alt-text: Table 1

	Limestone	Flint	Calcarenite	Total
Cobbles with percussion marks[a]	56	–	2	58
Cobbles without percussion marks	104	–	–	104
Cores and core fragments	54	40	–	94
Flakes	56	352	–	408
Debris (>5 cm)	36	0	–	36
Debris and flake fragments (<5 cm)	209	938	–	1147
TOTALS	**515**	**1.330**	**2**	**1.847**

[a] Including active (N = 48) and passive (N = 10) percussion instruments.

There are clear differences in the use of the two main raw materials: flint and limestone. While the former was reserved for producing small flakes from cores (there is not a single flint macro tool with active percussion marks), the latter presents a far wider range of uses, namely: cores and flakes, some large tool production and percussive activities. This study focuses specifically on the limestone active percussion tools (see de Torre and Mora, 2009–2010 for definitions. Also, *macro tools*; Barsky et al., 2015), which have been isolated from the collection based on criteria elaborated by our experimental program. Thus, a total of 48 limestone tools were retained as displaying clear traces of active percussion out of the 1.847 pieces comprising the BL collection. Since the active percussion tools have been discriminated on the basis of observations made of the traces obtained on the experimental limestone materials, it is vital to outline here the experimental protocol that we used. This will be followed by a synthetic description of the methodology we have designed specifically for the analysis of macro tools and the percussive traces they present. This methodology is applicable for both experimental and archeological collections and its use on other collections should permit interesting inter-site comparisons. Finally, we will present results obtained from both the experimental and archeological active percussion tools, with special emphasis on their main morphological characteristics.

3.1 Experimental protocol

The experimental protocol involves numerous experimental sessions aimed at exploring different gestures and their applications for working a variety of materials susceptible to have been available to Orce hominins. The experiments described here include: freehand stone knapping using the same methods as those observed on the archeological materials (unidirectional recurrent, orthogonal), butchery using experimental tools (breaking cow long bones), meat processing, working dry tendons and chopping and processing wood. These experiments have been fundamental for identifying and defining percussive trace morphologies on Orce limestone.

The limestone used in the experiments was collected near to the BL site and we were careful to select cobbles and blocks with identical morphologies and petrographic features as those in the archeological sample. The main raw material used in the experiments is a silicified, compact limestone that was also identified as the predominant type in the archeological sample.

Experimental cobble morphologies:

- 10 ellipsoidal cobbles with curved extremities.
- 2 large blocks fractured by throwing onto a passive hammerstone (anvil) (Fr.: *percussion lancée sur percuteur dormant*) gave four fragments presenting potential dihedral percussive protuberances.
- 4 cobbles of irregular morphology presenting at least one trihedral-pyramidal extremity.

Each of the above morphologies was used to perform all of the tested functional experiments:

(1) stone knapping with direct hammer;

(2) bone breakage of cow forelegs (with and without anvil);

(3) wood crushing;

(4) meat and tendons processing.

In total, 23 experiments were carried out involving both tool production (N = 2) and tool use (N = 21). The aim of the experiments was to explore more adequately the kinds of materials and gestures we might recognize on the limestone archeological materials from BL, and, more generally, to permit a more precise characterization of the kinds of accidents that can occur on limestone hammers during different knapping and use episodes. Taking into account the different morphologies of BL's cobbles, we tested three different types of percussive surface areas (Fig. 1).

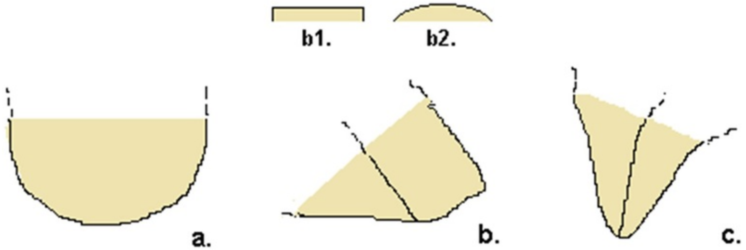

Fig. 1 Different morphology of active percussion surfaces: curved (a.); dihedral (b.); rectilinear (b1); convex (b2); trihedral-pyramidal (c.).

alt-text: Fig. 1

3.2 Methodology for the study of archeological and experimental macro tools

Once isolated on the basis of the experimental work outlined above, items displaying traces of active percussion were studied in accordance to their technological and volumetric characteristics, as well as to the position of the traces of percussion in relation to these formal aspects (Barsky et al., 2015):

- **Phase 1. Recognition of active percussion tools**

While it is not always easy to discriminate between natural and anthropically induced traces of percussion on cobble surfaces, the localized concentration and the marked visibility of the traces, largely contribute to minimizing ambiguities regarding this distinction. In the case of BL, the geomatics approach proposed by Caruana et al. (2014) was not necessary in order to achieve this aim satisfactorily. In all cases, traces that are easily discernible macroscopically were found to be concentrated on different areas of the items, and pieces were considered of anthropic origin when a systematic disposition was evidenced after the study of the highlighted attributes and comparisons with the traces produced on the experimental hammers.

- **Phase 2. Raw materials determination**

The active percussion tools where grouped into *Groups of Raw Material* (GRM) in accordance to their type, and then further classified into *Units of Raw Material* (URM) in accordance to their dominant macroscopic petrographic characteristics (Roebroeks, 1988; Vaquero, 2008), such as: granulometry, color and texture of the cortex, color of the matrix, presence/absence of crystallization planes, trace elements (iron oxide), fracture planes and inclusions (e.g. bioclasts).

- **Phase 3. Positioning of the tools**

We focus here on establishing the relationship between morphological/volumetric data obtained from the cobbles, and the type and situation of the traces they present. Cobble surfaces with the greatest concentration of damage patterns are placed in the distal position within the *Numerical System* (Barsky et al., 2015) and integrated into a concentric scheme (Fig. 2). This allows for homogeneity in mapping out dispersion patterns of traces observed along the surface or on multiple surfaces of each cobble.

- **Phase 4. Morphological analysis and trace description**

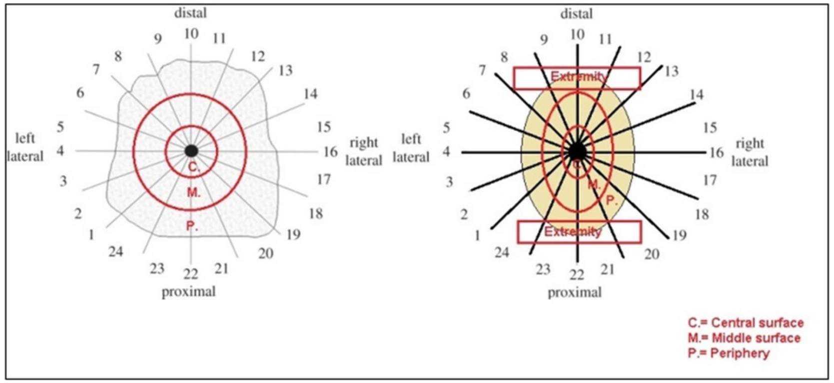

Fig. 2 Radial Numeric System for attribute location integrated by a concentric system for determination of concentration or dispersion on object surfaces (modified after Barsky et al., 2015).

alt-text: Fig. 2

The cobble (tool blank) is qualified in accordance to the following criteria:

- (a.) Type (cobble, block, slab).
- (b.) Morphology (ellipsoidal, parallelepiped, polyhedral, cubic, etc.).
- (c.) Morphology of the surface used for active percussion (flat, rounded, pointed, angular).
- (d.) Origin of percussion surface(s):
  - Natural (cortex, breakage plane) or
  - Anthropically generated (anthropic fracture, removals negative(s), and previous percussion damage).
- (e.) Determination and description of the percussion damage.

- (f.) Indicating possible opportunistic exploitation of percussion damage (secondary use), for example, the formation of crush marks on accidental removal negative crests.

4 Results

4.1 The experimental results

The experimental activity has been specifically geared towards synchronizing the use patterns of the experimental and archeological materials by strict usage of limestone cobbles of comparable morphologies and size ranges. Prior to their use therefore, the experimental cobbles had the same morphologies of potential active surfaces as the archeological ones did (curves, dihedral protuberances, trihedral-pyramidal tips), thus allowing to objectively evaluate the functionality/non-functionality of these instruments when they were used for different purposes (Tabl. 2). Consequently, we were able to record the type and position of the percussion damage caused by each type of activity we tested (Supplementary material 1).

- **Ellipsoidal cobbles with rounded surfaces**

This cobble morphology was found to be well-suited for effectively performing all of the activities tested; except for wood chopping, since a rounded surface only served to crush the outer plane of the wood (bark). These cobbles only displayed clear percussion marks when they were used for stone knapping. Concerning the latter, we tested damage on hammers used to knap 10 silicified limestone cores. Flakes were produced by free-hand methods identical to those observed in the archeological assemblage. During knapping, accidental removals occurred frequently on the hammers (in 2/6 cases, damage provoked on the hammers was so pronounced that the knapper opted to abandon them). Their inadequacy was due in part to the intensity of the blows required to knap flakes and/or to internal imperfections within the limestone itself; rather than to the number of blows delivered (Fig. 3).

- **Cobbles presenting dihedral protrusions**

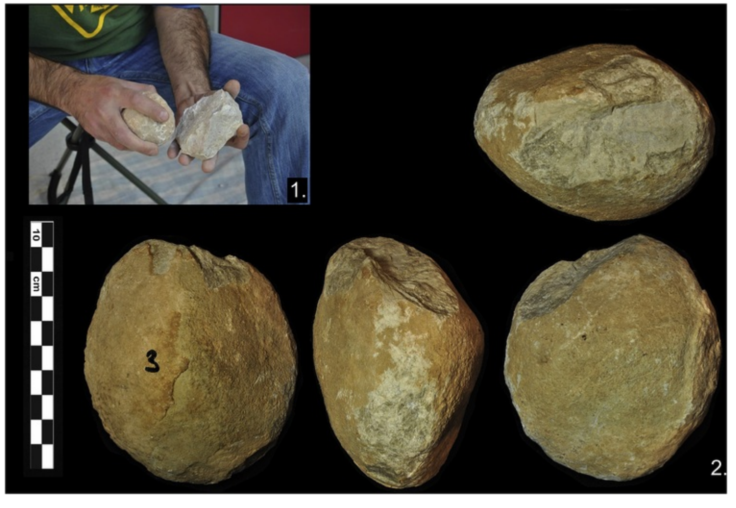

Fig. 3 Percussion damage patterns produced: (3.1) Experimental stone knapping using cobbles with rounded active percussive surfaces; (3.2) Experimental ellipsoidal cobble with opposite accidental removal negatives on its extremity generating a crest, as well as on its periphery damage like cupola and surface scarring.

alt-text: Fig. 3

Large-sized cobbles presenting dihedral protrusions, seemingly provoked by percussion, were observed in the archeological sample. They display crush marks and accidental removals on their (active) edges. Our aim was to test if the removals observed on these dihedrals were due to accidental breakage during active percussion or if they were intentionally provoked to obtain flakes. Accordingly, we chose similarly large cobbles to use in the experimental activities. The dihedrals on the experimental cobbles presented angles measuring between 67° and 89° (except one of 52°); in agreement with the range of the archeological pieces.

These cobbles proved to be inapt for stone knapping, because their active edge did not allow to effectively deliver the kinds of blows required for flake production. Furthermore, this type of active edge was poorly suited for processing meat and tendons, since it cut into the fibers instead of producing the desired crushing of the materials to soften them. However, breaking fresh bone on a stone anvil did finally reproduce identical use-wear morphologies as on the archeological dihedrals (Fig. 4.1.1; 4.1.2 and 4.1.3) when contact was made between the active and dormant percussion tools (Fig. 4.1). In addition, this morphology-action relation is clearly viable since bones were easily broken by the dihedral edge (Fig. 4.1b). These large-sized tools were also proven functional for wood cutting (*Salix* *alba,* Linneo (Prefer to use the right name Linnaeus, 1753.), 1753, Fig. 4.2). Results show accidental removal negatives (Fig. 4.2.1, detail a.) and retouch-like crush marks along the dihedral edge, as well as depletion of the cutting edge (Fig. 4.2.1 detail b) (see Fig. 5) .

- **Cobbles presenting trihedral-pyramidal apexes**

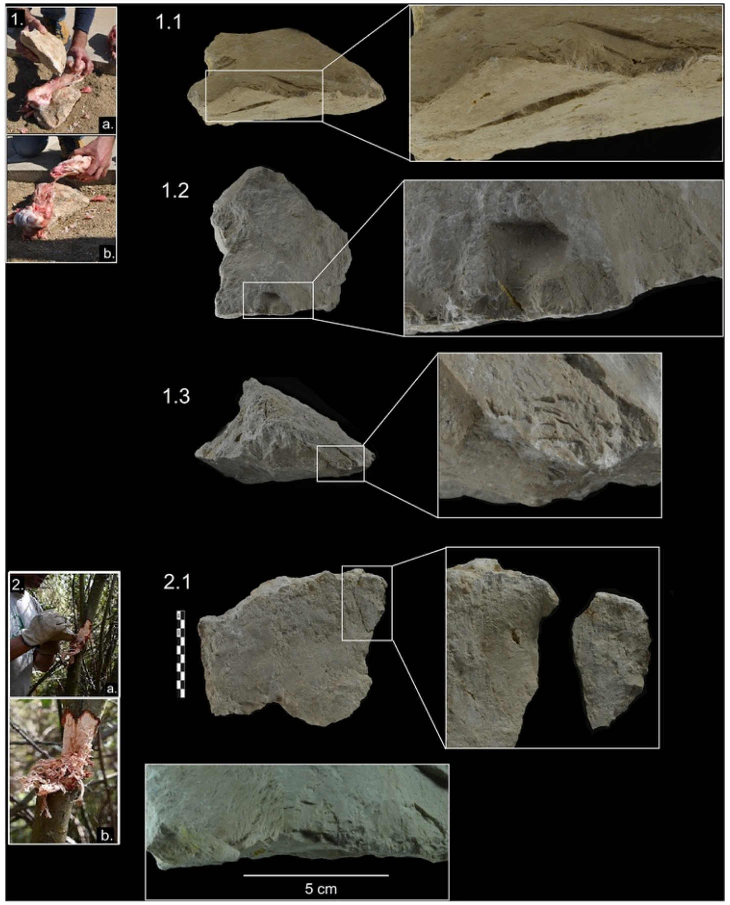

Fig. 4 Experiments performed using cobbles with dihedral active percussion areas. 4.1a) Breakage of fresh bone on a stone anvil; (4.1b.) Functionality of the dihedral tool to break bones; (4.1.1.) Negatives of the accidental removals on opposite surfaces; (4.1.2) Accidental removals along the dihedral edge consequence of the hit with the anvil; (4.1.3) Crush marks on the dihedral edge consequence resulting from the blow with the anvil; 4.2a) Wood (bark) chopping; (4.2b) Functionality of the tool to chop wood; (4.2.1) Negatives of the accidental removals, retouch-like crush marks and wearing of the cutting edge.

alt-text: Fig. 4

Fig. 5 Experimental stone knapping using cobbles with trihedral-pyramidal apexes. Pyramidal extremity (with slightly rounded termination), (5.1) proved initially to be suitable for flake extraction, but the percussion zone was easily damaged; (5.2a) High concentration pitting with cupola; (5.2b) Breakage of the point with accidental removals.

alt-text: Fig. 5

Instruments with an active angular apex were not found to be particularly functional for the activities we tested. Stone knapping with this kind of tool did produce some flakes, but the percussion surface turned out to be brittle, resulting in high concentration pitting, crushing and accidental removals. (The citation “Fig. 5” should be inserts here. This paragraph shall be positioned before figure 5.)This morphotype was not well-adapted for activities such as wood chopping, because lacking a sharp cutting angle. It were also found to be ineffective for working tendons since the pointed morphology simply destroys the fibers.

4.2 Functionality or non-functionality of the different cobble morphologies

As our experiments progressed, we established the range of morphologies and percussion marks produced on limestone when performing different percussive gestures on various types of materials. Furthermore, we were able to evaluate the functionality or non-functionality of cobble shapes and sizes in accordance to the characteristics of their active surface morphologies, thus giving us a basis with which to hypothesize about their possible or probable uses for specific tasks (Tabl. 2). Importantly, each of the different morphologies identified for the active area, hammering with the driving force of applied percussion, was found to be directly related to the effect it will produce on the worked material: smash, divide-cut, pierce, slice, scratch, carve, etc. The morpho-types correspond, therefore, to a pre-determined surface area of potential that will or will not be useful to perform different, shape-specific tasks (Table 2).

Table 2 Functionality of the different shapes of the active percussion area and type of percussion damage generated for each of the experimental activities tested: (F) functional (NF) non-functional.

alt-text: Table 2

Experimental activity	Shape of active percussion area	Functionality	N° of experiments	Type of percussion damage
Stone knapping	**Curved**	**F**	6	cupola; accidental removal negative; facetted breakage (on crests)
	Dihedral	NF	1	–
	Trihedral-pyramidal	NF	1	–
Bone breaking	**Curved**	**F**	2	not evident
	Dihedral	**F**	3	accidental removals after contact with stone anvil
	Trihedral-pyramidal	NF	1	–
Wood chopping	Curved	NF	1	–
	Dihedral	**F**	2	crush marks, accidental removals and polish
	Trihedral-pyramidal	NF	1	–
Soft animal tissue processing (meat and tendons)	**Curved**	**F**	1	not evident
	Dihedral	NF	1	–

	Trihedral-pyramidal	NF	1	–
Total functional experiments:			21	

4.3 The active percussion tools from Barranco León. Results from the archeological material

All of the archeological pieces presenting percussion marks possibly or evidently due to percussion were re-examined to the light of the results from the experimental sample. This allowed to clearly identify 48 percussion instruments that show different cobble-blank morphologies and display the array of percussion zone types described above (Supplementary material 2).

4.3.1 Raw materials and volumetric features

With the exception of two rounded calcarenite cobbles with rolled cortical surfaces, all of the pieces in our sample are in limestone from the immediate vicinity of the BL site. In addition to the three types of limestone initially identified at BL (silicified, marly and oolithic, Toro-Moyano et al., 2010), we now recognize 5 raw material units (RMU) and 1 unit of calcarenite, based on new microscopic observations (Fig. 6). In fact, discriminating between these different qualities of limestone available to Orce hominins both in and around the sites has proven to be highly significant since it is revelatory of selective processes demonstrated here by the clear dominance of silicified compact limestone (URMC1: 45,8%) in our archeological sample (Fig. 7).

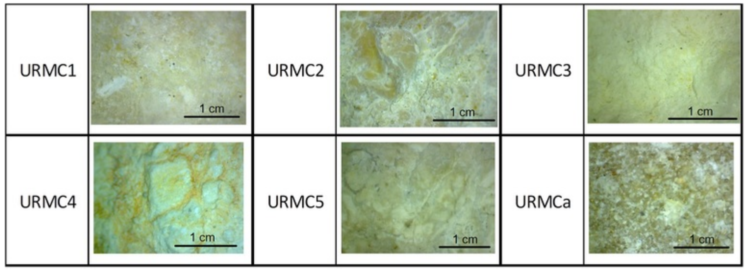

Fig. 6 (RMUC1) Silicified compact limestone of organogenic origin, with a massive structure and a conchoidal, splinter-like breakage pattern; (RMUC2) Silicified limestone with polyhedral structure, whose matrix is non-homogeneous and compact, with and irregular breakage, determined by its polyhedral structure; (RMUC3) Marly powdery limestone with a crumbly appearance due to a tender exterior; (RMUC4) Marly silicified limestone with mixt silicates. The latter is more silicified than URMC3 and has a more compact cortical surface; (URMC5) Relatively compact, Oolithic limestone, made up of concentric clusters or ovoid aggregates.; (URMCa calcarenite.

alt-text: Fig. 6

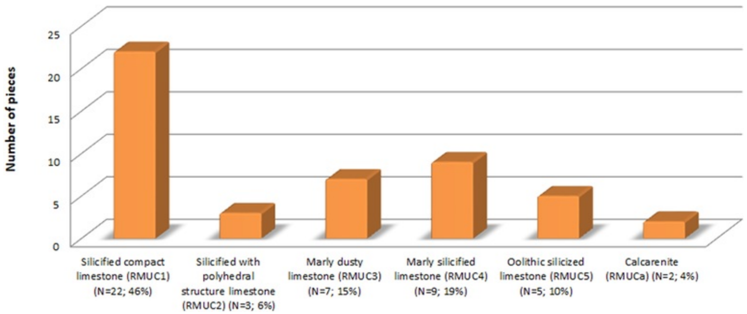

Fig. 7 Distribution of Barranco León limestone active percussion tools in accordance to each Raw Material Unit.

alt-text: Fig. 7

The active percussion tools in the BL assemblage present an average size of 96 × 79 × 59 mm and an average weight of 640 g. Five pieces are, however, isolated from the rest of the group by virtue of their greater weight and size (Fig. 8). They present a mean length of 180 × 139 × 101 mm and an average weight of 2.244 g. Selected cobbles are whole or broken, and there are also some lightly rolled pieces (blocks) and, rarely, slabs.

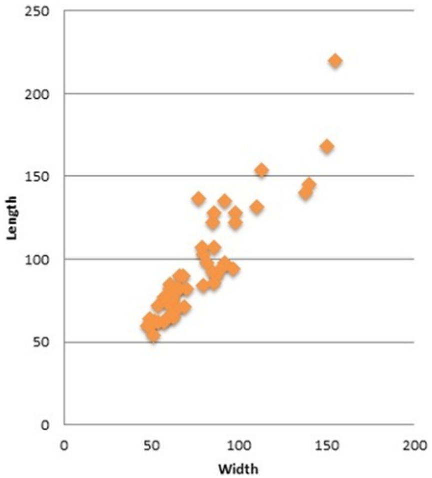

Fig. 8 Dimensions of the Barranco León active percussion tools (length and width).

alt-text: Fig. 8

From the morphological point of view, the archeological hammerstones frequently have an oval shape (N = 25; 52%), followed by multi-surface cubic shapes (N = 13; 27%) and pieces of shorter, prismatic and irregular morphologies (N = 10; 21%). It is noteworthy that some of the active percussion tools were initially cores that were selected to be re-used as hammers (Fig. 9). This distinctive phenomenon is considered as an additional link in the chains of technical operations observed at BL (Fr. *chaînes opératoires*). This, highly significant occurrence, indicates a re-selection process (Toro-Moyano et al., 2011; Barsky et al., 2014), that, as suggested by our experimental work, must have been grounded in discriminatory processes in relation to morphological and volumetric criteria. Hominins might have favored some core forms for secondary use as hammers over naturally available cobbles because they presented useful curved surfaces or, in some cases, exploitable orthogonal-dihedral angles from previous exploitation events that are not always naturally present on the natural cobbles (Fig. 9).

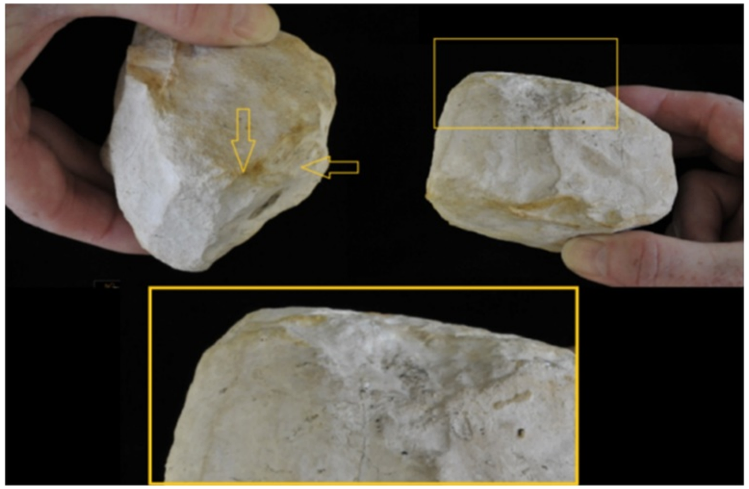

Fig. 9 Multifunctional limestone tool from Barranco León. Bipolar-on-anvil reduced core with secondary percussion marks on an angle separating a cortical surface from abrupt removal negatives.

alt-text: Fig. 9

4.3.2 Damage patterns on the Barranco León active percussion tools

A total of 77 areas with percussion marks were identified on the 48 tools analyzed. The fact that the number of surfaces used exceeds the number of pieces is indicative of either: multiple use episodes on single items with changes in gripping during the activity or; re-use of the tools in separate moments with selection of different active zones. We have identified a very wide variety of damage patterns, that is, scars due to impact with another object (passive), on the active percussion tools from BL, including (in order of frequency): accidental removal negatives, surface scarring, high concentration pitting with cupola, crush marks, facetted breakage, bipolar breakage impacts and striations (Fig. 10).

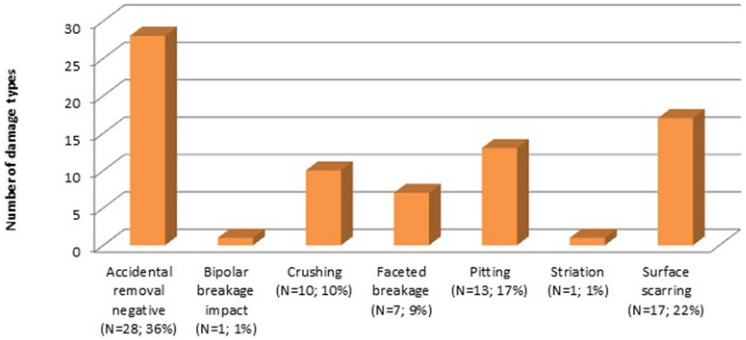

Fig. 10 Number and percentage of the different damage types identified on the active percussion tools from Barranco León.

alt-text: Fig. 10

Accidental removal negatives (Fig. 11, (a.)), are the most commonly found damage pattern in the sample. They are observed on cobble extremities, as well as on fracture plane intersections and on the angles of blocks and fragments. In lesser frequency, crush marks and ***facetted breakage*** (Fig. 11, (c)), are observed in similar situations. The damage category of high concentration pitting **with *cupola*** (Fig. 11, (b.)), apparently resulting from a gesture involving multiple blows on a single area, is typically observed on flat, rounded cobble surfaces. This damage pattern was identified solely on the ellipsoidal cobbles, generally on the extremities. However, similar pitting is also observed on the lateral edges of a few of the hammers, indicating changes in gripping. **Surface scarring** (Fig. 11, (d.)), is visible on a variety of cobble forms: along the periphery of the blocks and on cobble and slab extremities. Following the definition given by Diez-Martin et al. (2010), this type of damage is produced when cobbles, *due to intense impact, lose mass in the form of thin percussion positives.* Other kinds of damage encountered include **bipolar breakage impacts** (Fig. 11, (e.)), located generally on cobble extremities, and striations, observed on slab peripheries.

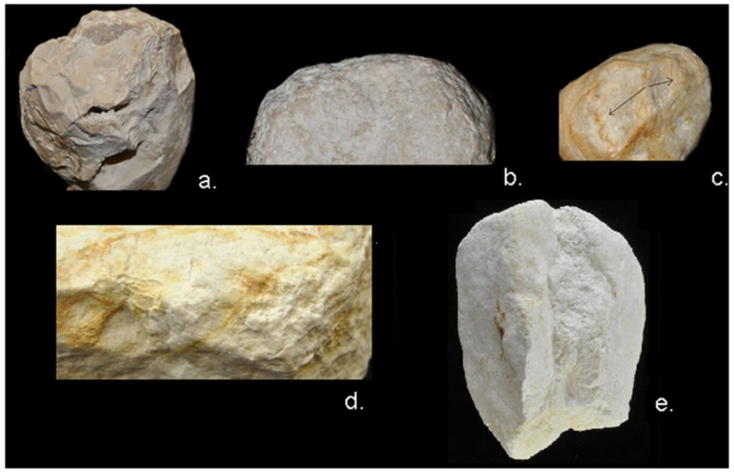

Fig. 11 Damage patterns on active percussion tools from Barranco León. (a.) Fracture angle produced by accidental removal negatives; (b.) High concentration pitting with cupola; (c.) Facetted breakage; (d) Surface scarring; (e.) Bipolar breakage impacts.

alt-text: Fig. 11

4.3.3 Correlation of surface damage patterns and cobble morphologies for the active percussion tools from Barranco León

Our unique methodology for seeking out patterns in the position of the percussion traces in relation to the morphological characteristics of the percussion tools, applied to the Orce archeological materials (Barsky et al., 2015), provides interesting results in our sample. Specifically, the high concentration with respect to the dispersion of the traces is remarkable as it is indicative of a choice made by hominins using the tools as to the preferred area(s) for hammering and, by extension, the respective situation of the prehensile area and opposite-active zone. Sometimes, different categories of percussion marks overlap or superimpose in the same area. In this case, traces can be linked, depending on the case, to intensive use of one area of a tool, or even to excessively forceful blows.

On cobbles with elliptical morphology (Fig. 12), the traces are concentrated on the rounded extremities, and, in some cases, may extend along their periphery (Figs. 12.7 and Fig. 13.3). In 10 cases, hammerstones display traces translating the secondary exploitation of fracture angles (following the definition by de la Torre and Mora, 2005: crests generated by accidental removal negatives), opportunistically used to perform percussion activities (Fig. 13.1; 13.2; 13.3). This is clearly evidenced by facetted breakage (Fig. 12.3) and micro-removals or irregular retouch present along the crest lines (Fig. 12.2).

Fig. 12 Ellipsoidal hammers from Barranco León. All in limestone except num. 4 in calcarenite. They have been positioned with the damaged extremity used for percussion activity in the distal position. 1–5) Ellipsoidal hammers with accidental removals on one extremity; 6) Ellipsoidal hammer with surface scarring on one extremity; 7) Ellipsoidal hammer with two isolated accidental removals on the extremity sides, and cupola percussion marks on the curved extremity and as well along the lateral plan surface; 8) Ellipsoidal hammer with cupola percussion marks on the extremity and surface scarring on the periphery, close to the opposite extremity.

alt-text: Fig. 12

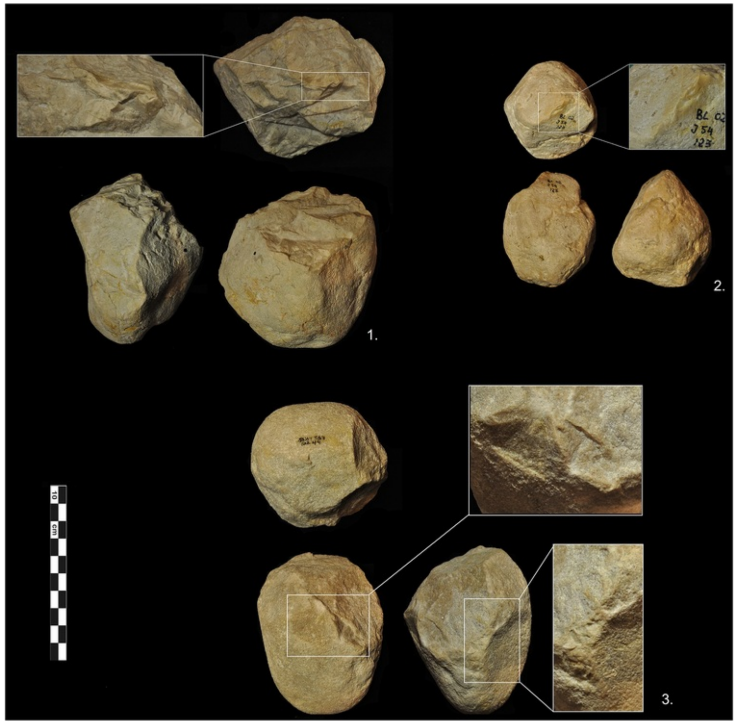

Fig. 13 Ellipsoidal limestone hammers with crests generated by accidental removal negatives. 1) Ellipsoidal hammers (chopping tools like) with crush marks on crest produced by opposite accidental removal negatives; 2) Ellipsoidal limestone hammer with polish and micro-removals on the crest generated by an accidental removal; 3) Ellipsoidal calcarenite hammers with splitting of accidental removals on crest and high concentration pitting and small crush masks on a crest. Localized traces on crests indicate opportunistic use.

alt-text: Fig. 13

Active percussion marks are observed on fractured cobbles and fragments of limestone with a compact structure and presenting at least one dihedral active edge (Fig. 14). These include accidental removals on opposite plane surfaces (Fig. 14.1 (centre detail) and Fig. 14.2 (lateral right detail). Accidental removals are visible along the angle (Figs. 14.1–14.2) as well as crush marks (Fig. 14.1). In this specific case, two large irregular blocks, the traces are situated along the edge created by the junction between a fracture plane and a neocortical surface. The hominins plainly chose to use this convex dihedral edge for percussion.

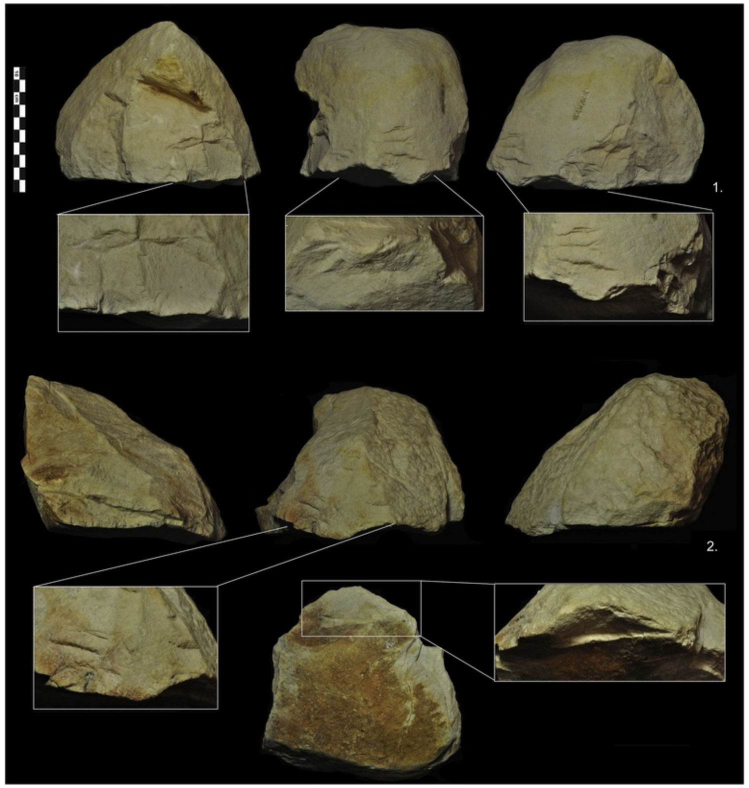

Fig. 14 Limestone active percussion tools from Barranco León with sharp dihedral edges probably used to break fresh bone on an anvil. 1) Large irregular block with percussion damage situated along the edge created by the junction between a fracture plane and a neocortical surface. In detail from left to right: accidental removals; accidental removals on opposite plane surfaces; overlapped accidental removals and crush marks. 2) Large irregular block with percussion damage situated along the edge created by the junction between a plane (the fracture plane is anthropically produced) and a neocortical surface. In detail: overlapped accidenta removals on opposite plane surfaces.

alt-text: Fig. 14

Some irregularly shaped pieces with protruding trihedral or even quadrilateral angles equally display crush marks, although these morphologies do not appear to have been very intensely exploited at this site (Fig. 15).

Fig. 15 Polyhedral active percussion tool with crush marks on a pyramidal extremity.

alt-text: Fig. 15

5 Discussion

Recently, studies GIS analysis and 3D modeling have been used to explore the spatial distribution of percussion traces on hammerstones used by chimpanzees (*Pan troglodytes*) both in to the wild (Benito-Calvo et al., 2015) and in captivity (Arroyo et al., 2016), allowing to compare them with pounding tools found in archeological contexts. The active percussion tools used by the free primates of Bossou (Guinea-Conakry) present percussive marks "… *concentrated in central areas covering a large portion of the working surfaces, with the presence of off-centre percussive traces*". Meanwhile, those used by captive primates (Kumamoto Sanctuary, Japan) demonstrate that different impact mechanisms have generated "*impacts and small cropped areas located on the peripheral areas of the active surfaces*". In comparison, therefore, with our data from the hominin site of BL we make the following observations:

1) The active percussion tools from BL present different zones with clear concentrations of percussion marks, while those produced by chimpanzees tend to show a more dispersed damage pattern.

2) The chimpanzee-induced traces are concentrated on cobble peripheries, while those of BL tend to be situated on cobble extremities.

3) Active percussion tools from BL show a relatively higher degree of modification than on the primate tools: they present very visible traces that, in many cases, significantly modify the initial morphology of the percussion zone (for example: accidental removals)

4) In the case of nut-cracking, the preferred working surface used by chimpanzees tends to be flat, while curved or dihedral extremities were clearly preferred by BL hominins.

We note that these important differences in tool morphology are linked both to the quality of the raw material used and its reactive mechanisms during impact, and to the type of activity carried out.

Following, we provide a brief review of the descriptions of active percussion tools from other Oldowan sites in order to evidence similarities and differences with the active percussion tools from Barranco León.

- ***Earliest African late Lower Pleistocene sites:***

- At Lomekwi 3 (3.3 Ma, Kenya, McDougall and Brown, 2008, 2012) by Harmand et al. (2015), a total of seven basalt and phonolites cobbles are interpreted as hand-held active percussion tools. They show impact marks associated with fractured surfaces. Some cores with series of continuous, small scars along the platform edges could reflect indicate that they were used for heavy-duty tasks.
- Semaw et al. (2009) observe late Pliocene lithic assemblage variability, indicating that ellipsoidal hammerstones have not been found at the East Gona EG10 and EG 12 sites, nor at the Ounda Gona OGS 7 sites (2.6 Ma, Ethiopia, McDougall et al., 1992, Semaw et al., 1997, 2003). However, a few trachyte and rhyolite cores do "*… show pitting/pounding marks on cortical butts, probably a result of use as hammerstones or possible use for pounding activities related to processing of animal carcasses such as for breaking bones for marrows* (Semaw et al., 2009).
- Ellipsoidal trachyte hammerstones (N = 13) were recognized by Delagnes and Roche (2005) at Lokalalei 2C (2.34 Ma, Kenya, Roche et al., 1999). Some of these are reported to be of angular morphology (N = 5). Most of them (12/18 pieces) present clear impact damage and battering marks concentrated on one or two protruding areas. In most cases, the percussion zone is situated at one or both of the extremities of the cobble, but in a few cases (N = 3), the impact scars have a more central location.
- At Fejej FJ-1a (1.96 Ma, Ethiopia, de Lumley and Beyene, 2004), a total of 183 whole cobbles and hammerstones were identified. A relationship is noted between cobble shape and subsequent use: for percussion instruments, Fejej hominins selected thick cobbles with oval sections, while flat cobbles with oval sections were preferred for shaping chopper-like tools. Like at BL, the FJ-1a tools present scars and/or accidentally detached flake negatives attributed to percussion, often situated on cobble extremities or on the edges of fractured cobble surfaces. Like at BL, the assemblage has yielded cores with secondary percussion damage (multi-purpose tools).
- In Olduvai Gorge Bed I sites (1.8 Ma, Tanzania, Leakey, 1971) as indicated by Diez-Martin et al. (2010) for the FLK North site, hominins were performing both percussive and battering activities. Among the ellipsoidal hamerstones documented, there are seven basalt nodules with evident percussion damage. The variability of percussion marks and negative scars described are on acute and irregular edges of matrixes presenting dihedral angles. Such percussors with exploited dihedral angles, also found at BL, are defined as "*hammerstones with battered edges*" (Diez-Martin et al., 2010). Additionally, de la Torre and Mora (2005) have defined these items as "*hammerstones with fracture angles"*. The former author considers that "*… negative scars produced on one edge of the nodule form a dihedral angle"* and that "*… this ridge shows intense alteration produced by percussion, sometimes clearly blunted by the intensity of load application";* while the latter authors consider that this damage pattern could have been spontaneously produced during the course of hammering. At BL, hominins either took advantage of acute edges naturally present on some cobbles, or intentionally provoked fracture plane intersections (Fig. 13). In other cases, they opportunistically exploited crests formed by accidental removals provoked by pounding activities (Fig. 12).
- A few hammerstones and manuports are documented at three KBS member sites of Koobi Fora (1.95 Ma, Kenya, Isaac and Isaac 1997). At FxJj 1, two unmodified pieces bigger than 4 cm were identified amongst an assemblage of basalt pebbles. One of these was interpreted as archeological. At FxJj 3, an ellipsoidal hammerstone with damage on its extremities was found, as well as two possible manuports coming from the surface, along the eroding outcrop of the KBS Tuff. Other non-modified rounded cobbles are documented from the FxJj 10 site, where another ellipsoidal hammer was reported.
- At Melka Kunturé (1.7 Ma, Ethiopia, Chavaillon, 1979), Chavaillon (2004) indicates that, at Gombore BI (Oldowan, *sensu lato*) and Gombore Iγ (later Oldowan), there are a large number of hammerstones and broken cobbles. In the Gombore Iγ site, 349 battered cobbles and broken cobbles are reported, while at Gombore BI, there are a total of 413 pieces described either as active hammerstones or as pitted hammerstones, as well as 1.858 battered cobbles. Beyond this quantitative indication, that underlines the importance of such tools in these lithic assemblages, no detailed morphological description is available yet.

- ***Earliest Eurasian Oldowan sites:***

- The presence of 60 percussors is documented from the Dmanisi site (1.81 Ma, Georgia) by Lumley et al. (2005). This number was subsequently reduced to only 41 by Mgeladze et al. (2011). The hammers are mainly in tuff, andesite, and basalt but there are also some items in granite and quartzite. The whole cobbles show traces of percussion on their extremities, as well as on lateral peripheries. The fractured cobbles and/or those with isolated accidental, removals are also considered to have been used for active percussion. In some cases these hammers show traces of their subsequent use as anvils or nuclei.

A single percussion tool on a quartz cobble has been published from the Pont-de-Lavaud site (1 Ma, Centre France, Despriée et al., 2006; Lombera et al., 2016) and is described as offering "*… a good manual grip and the arrangement of the battering marks, clustered in the lateral and distal part of the pebble, indicate its function as a freehand hammerstone. It also bears some crushing marks and pits in the proximal edge, indicating a second active zone, also possibly linked to freehand percussion."* However, a recent revision of a part of this important assemblage (by ST) has now brought to light the presence of more hammerstones in this assemblage (N = 7). These pieces present the same characteristics of evident damage caused by active percussion outlined above: pitting, surface scarring, accidental removals and double faceted breakage. They present a range of dimensions and have ellipsoidal and elongated ovaloid morphologies.

- In the stratigraphical unit 2 (archeological level within a basalt interstice) of the Bois-de-Riquet site (1.3–1.1 Mya, Lézignan-la-Cèbe, Hérault, France, Bourguignon et al., 2016a, 2016b), 10 non-modified basalt spherical cobbles were discovered (Bourguignon et al., 2016b). While they do not present marked percussion damage (after comparing with cobbles affected by marine erosion from 25 km from the site), some of the cobbles show microscopic percussion marks on their extremities. These items have been identified as probable manuports by virtue of their size and shape differences when compared with the naturally occurring, angular elements of the infill. Their formal attributes and their high density are suggestive of hominin raw material selection processes. (**Change this paragraph in this way:** In the stratigraphical unit 2 (archeological level within a basalt interstice) of the Bois-de-Riquet site (1.3–1.1 Mya, Lézignan-la-Cèbe, Hérault, France, Bourguignon et al., 2016a, 2016b), around 20 non-modified basalt spherical cobbles were discovered (Bourguignon et al., 2016b). Some of them present marked percussion damage, and show microscopic percussion marks on their extremities. Some cobbles are broken at an extremity, which indicate percussion activities. These items have been identified as probable pounding tools by virtue of their size and shape differences when compared with the naturally occurring, angular elements of the infill. Moreover, it has been established that they come from another lava flow than the site. Their formal attributes and their high density are suggestive of hominin raw material selection processes.)

- At the Le Vallonnet cave site (Alpes-Maritimes, south of France, Yokoyama, et al., 1988, de Lumley et al., 1988; Cauche, 2009, Terradillos-Bernal and Moncel, 2004), newly dated to 1.2 Ma (Michel et al., 2017), the assemblage includes numerous limestone macro-tools believed to have been used for active percussion. These often occur as cobbles with isolated accidental removal negatives interpreted as due to violent strikes (de Lumley et al., 2009). A refit of a hammerstone and a flake was effectuated (de Lumley et al., 1988). Unfortunately, the limestone material is strongly altered, impeding clear visibility of other types of percussion marks that could potentially be documented. Some limestone cores also show traces indicating that they were used as hammers.

Given its spatial and temporal proximity with BL, we provide more ample comparisons with the Fuente Nueva 3 site, situated at Orce only some 4 km away from BL (1.3–1.2 Mya, Oms et al., 1996; Martínez-Navarro et al., 1997; Álvarez et al., 2015; Toro-Moyano et al., 2010, 2013). Intense and frequent percussive activities are clearly evidenced at both of the Orce archeological sites (Barsky et al., 2015). At FN3, 14/36 whole cobbles present percussion marks, as do 42/84 non-flaked broken cobbles and 26/65 non-flaked fragments (Barsky et al., 2015). The qualities of the limestone at FN3 differs from BL, with a higher overall incidence of densely compacted and fine quality silicified limestone. Unlike at BL, FN 3 hominins frequently exploited limestone blocks, in addition to cobbles. In spite of the presence of a few ellipsoidal hammers at FN3 (N = 4), this, relative scarcity of convex extremities resulted in a more frequent use of abrupt edges and intersecting plane surfaces for active percussion tasks (fracture planes are very common on the lateral and transversal extremities of the macro tools). Like at BL, the FN3 cores sometimes show traces demonstrating their secondary use as hammerstones. Quality and morphology of the selected cobbles in the two sites have a strong link to the different site environmental contexts. We must keep in mind that two sites are situated in the same area but are related to slightly different situations: BL is actually traversed by a paleo-channel flowing to the lake margin, while FN3 was accumulated in a lakeside, swampy environment. At BL, therefore, rounded cobbles were brought directly into the site by the currents of the paleo-channel, while at FN3 the exact source of the rounded cobbles has not yet been localized.

Through time, active percussion tools continue to be commonly represented in most later, Acheulian occurrences and beyond. While a detailed examination of this issue is beyond the scope of the present manuscript, a useful example for comparison is provided by the Acheulean site Gesher Benot Ya'aqov (0.79 Mya Goren-Inbar and Belitzky, 1989; Goren-Inbar et al., 2000; Feibel, 2004), where detailed behavioral observations concerning the use of limestone for percussive activity is provided by Alperson-Afil and Goren-Inbar (2016). While the use of basalt is also deocumented at this site, limestone appears to have played a more fundamental role for percussion. Tools include hammerstones, hammerstones with fracture angles, chopping tools and multifunctional cores. As at BL, a qualitative selection of the calcareous raw material is noted, as well as dimensional and morphological selective criterion. At GBY, different functions have been recognized for the pounding tools in relation to their morphology (Alperson-Afil and Goren-Inbar, 2016). In fact, tools for knapping and battering have been recognized. The hypothesis fracture angle percussors might have been used for bone cracking is proposed. Our experiments show that curved surfaces such as dihedral are efficient for this purpose. Moreover, at BL the overlapping of traces of percussion on removal negatives shows that cores were sometimes re-used as hammers, while at GBY, the limestone operative scheme seems to indicate the transformation of percussion items into core-tools. At BL, FN3 and GBY, limestone is evidenced as a preferred material for percussive activities. That are, fortunately registered on this rock type's tender surface, which tends to register percussion by intensive scarring or accidental removals. As we have already underlined, the localized concentration of these marks in relation to the size and shape of the cobbles contributes to discerning anthropic from natural damage. In all cases, such accidental morphological alterations seem to have been opportunistically used by hominins, lending functional continuity to these objects.

6 Conclusions

This synthesis allows us to recognize and present the tools used for active percussion from the site of BL. Some 1.4 Mya, hominins at this site used raw materials differentially, managing two different operating chains: flint for the production of small, sharp instruments, and limestone, mainly intended for percussive activities. New data presented here demonstrates other selective processes at play in the behavioral repertoire of the Orce hominins, who were discriminating between different qualitative factors within the same limestone raw material. In addition, we show that hominins at BL oriented their preferences towards a fine quality compact limestone (RMU1) for their active percussion tools, while the powdery and marly qualities were less commonly used for this purpose.

Interesting selective processes have also been evidenced from the analysis of the morphological features of the cobbles used as active hammers. Although we observe a dominance of rounded cobbles amongst the hammers, some irregular, polyhedral forms were also used. Our work shows that the attention paid by hominins to cobble morphology concerned not only overall size and shape, which should be suitable for manipulation, but also the characteristics of the active percussion zones. In our sample, the latter areas are preferentially curved, or sometimes dihedral or trihedral.

This study equally deepens what we know about the multi-functionality (Toro Moyano et al., 2011) and re-use (Barsky et al., 2014) of some of lithic items from BL. For active percussion, the practice of multiple functions of the same object is confirmed, since, in some cases, cores on cobbles that preserve their original ellipsoidal morphology show crush marks that are clearly posterior to their knapping phases. We also evidence that percussion marks are sometimes concentrated on distinct areas of a single piece, thus attesting to changes the manipulation of the tools within the different chains of action performed. In such cases, however, it is impossible to know whether these episodes belong to a single phase of use or to different moments of re-use of the same tool.

Experimental work has allowed us to better comprehend the Orce calcareous materials and their mechanical response to percussion activity. Our data shows, for example, that the curved surface areas of the limestone cobbles used at BL are efficient both for stone knapping and for breaking large herbivore bones. In addition, our findings reveal that hominins at Orce were certainly using protruding dihedral angles on cobbles (provoked or natural) and fracture angles (de la Torre and Mora, 2005) to perform other kinds of percussive activities. It appears that, at BL, the intensity of active percussion activities was such that there was even opportunistic use of protruding ridges, for example those formed by negatives generated by accidental removals. Signs of percussion on ‘ridge lines’ reveals that even ‘damaged’ tools were opportunistically used; rather than abandoned due to functional loss.

Percussive traces associated with stone knapping is most evident. However, bone breakage, already attested at the site (Toro-Moyano et al., 2013), was shown to leave traces on the hammerstones used for butchery mainly when they accidentally came into contact with supporting stone anvils. Remarkably, the experimental hammerstones used in this manner generated traces compatible with those of the archeological sample (Barsky et al., 2018). Obviously, more evident traces (e.g. accidental removal negatives) might have been provoked on the archeological materials since they were likely used to work much larger bones than the cow forelegs used in our experiments (Mammoth, Rhino). Tools used for meat and tendon processing activities did not show any diagnostic traces. However, repeated percussion of an abrupt-angled edge to work soft materials on a stone anvil did induce crush marks typically observed on ‘heavy-duty scraper’ morphotypes, mainly due to occasional contact between the hammer and anvil (Barsky et al., 2018).

Finally, diagnostic macro traces for wood chopping were identified on dihedrals of large percussion tools. These are characterized by blunting of the edges and flat, invasive retouch. Wood processing may also be linked to other structural categories (retouch and micro breakage on edges) but this remains to be confirmed by further experiments. In any case, it appears evident that, given the very large, heavy tools in the archeological sample that display irregular morphology with dihedral angles we may conclude that these items were not useful for core exploitation due to the irregularity of their active surfaces and their difficult manipulation.

Even though the traces related to percussion activity are not specifically diagnostic with respect to the kinds of materials that were being worked, it was, in most cases, possible to establish a relationship between the morphology of the active percussion area and its efficacy or not for performing a given kind of activity. In addition, morphological and dimensional features of the cobbles also gave indications of the kinds of gestures most likely to have been used when performing each kind of task. Thus, protruding angles were poorly suited for flake production but rather may have been used for breaking bone. Functional for chopping wood, such protruding angles in the archeological sample do not present the same traces as those obtained in the experiments. Ellipsoidal cobbles are useful for knapping, butchery and processing animal soft tissue, but not for chopping wood. Trihedral-pyramidal angles can be useful to produce flakes, but only have a limited use range. Our experiments also showed that a trihedral-pyramidal apex does not perform as well as a curved surface when delivering blows to another body (for the same activity). Such forms are easily broken and display different percussion damage types. In any case, although we are continuing to work on hypothesis as to the possible uses of these pointed morphologies, the percussion damage recognized on the archeological materials clearly indicates their use for some kind of pounding activity.

In any case, it has now become clear that, from the early Oldowan, a range of percussive activities played a fundamental role in hominin lifeways. The data provided by the exceptional collection of macro tools from the BL site at Orce (Spain) and the associated experimental work presented here, provides a glimpse towards the functional aspects that these tools could, potentially, reveal to us.

The possibility that hominins were carrying out other activities than stone knapping, meat cutting and bone breakage (i.e. working skins, processing tendons, chopping wood), has never before clearly evidenced for the Oldowan but it is now suggested by the exceptional macro tool collection from Barranco León and the experimental work carried out here. We propose that the study of percussion tools and their possible uses during the Oldowan, is a theme that needs to be more fully explored in relation with to the environmental contexts in which the hominins were living. The remarkable collection of percussion tools from BL highlights the variability of percussive activities carried out by hominins at Orce, and serves as a comparative database for determining early hominin behaviors and lifestyles at other African and Eurasian Oldowan sites.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jas.2018.06.004.

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Appendix A. Supplementary data

The following are the supplementary data related to this article:

Multimedia Component 1

Supplementary material 2

alt-text: Supplementary material 2

Multimedia Component 2

Supplementary material 1

alt-text: Supplementary material 1

Highlights

- Barranco León is the best European collection of Oldowan percussive tools.
- First detailed study with data of Oldowan active percussive tools from Barranco León.
- Experimental research reveals possible percussive activities of Oldowan hominins.
- Unique methodology provides a template for studying ancient percussive technologies.
- Archeological and experimental data reveals possible Oldowan hominin activity.

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