Supplementary Material C, Figs S4, and S5

Techno-economic analysis: method

The study of the artefacts is founded on the techno-economic approach following the *chaîne opératoire* concept (Leroi-Gourhan 1964, 1971; Lemonnier 1976, 1986; Pelegrin 1985; Geneste 1989, 1991; Perlès 1991; Inizan et al. 1999). We examined all of the technical sequences involved in lithic production in order to decipher the related skills and competencies.

The first step in *chaîne opératoire* reconstruction is the particle size distribution of the lithic industry, which allows to evaluate the integrity of the collected series (Schick 1986; Lenoble 2005; Bertran et al. 2012; Maurin et al. 2017). Before the remains are buried, natural processes such as runoff have the ability to displace particles according to their size and therefore to truncate the initial assemblage. The sorting of a lithic series, whether natural and/or anthropogenic, can be demonstrated by determining the numeral particle size composition of knapping products and by comparing it with experimental or archaeological data (protocol in Bertran et al. 2012). The width of each quartzite artefact was measured using a caliper. The width is the largest dimension of the object taken in the plane orthogonal to its elongation axis. In addition, experimental knapping was carried out on quartzite cobbles collected in current or fossil beaches, i.e. 19 productions for a total of 1350 items measured (Fig. S4). All elements with a width larger than 5 mm were measured using a caliper.

The analysis of unmodified items (pebbles and cobbles) recovered at ThI-L1 was conceived as an integral part of the techno-economic analysis. Pebbles and cobbles were classified in terms of natural shape and size to appraise the range of available shapes and volumes. We recorded length, width, thickness, and weight of each unmodified specimen. According to the Wentworth (1922) grain scale classification, pebbles are comprised between 4 and 63 mm, and cobbles between 64 and 256 mm. Pebble and cobble morphology in frontal and lateral views has been recorded for specimens with a length ≥ 3 cm. This choice is based on the technological analysis of the hammerstones and cores from ThI-L1 which suggests that natural elements with a minimum length of approximately 3 cm were used as blanks. Four morphological types have been defined in frontal view (ovoid, subcircular, subquadrangular, and subtriangular) and four in lateral view (bi-convex, plano-convex, concavo-convex, and flat; Fig. S5a, b). Roundness/angularity was also recorded, because it may have been an important selection criterion given that the natural angles between surfaces facilitate the initial lithic production phases and play a role in the type of activity performed (Inizan et al. 1999; Goldman-Neuman and Hovers 2011; Gallotti and Mussi 2017).

All artefacts were measured in three dimensions and weighed.

We classified cores according to 1) technique; 2) the number of flaking surfaces; 3) the direction of flaking; 4) the presence/absence of distinct striking platform(s); 5) the features of the striking platform (cortical, rectified, prepared); 6) the angle between the striking platform and the flaking surface; and 7) the angle(s) between flaking surfaces (Gallotti, 2013; Gallotti et al., 2020). Considering these features, core analysis allows us to identify exploitation modalities and volume management, to understand how some geometrical and topological properties of the blanks were exploited by knappers, i.e. convexity(es), flat surface(s), angles between surfaces, adjacency/opposition of flat/convex/concave surfaces. Regarding the striking platform, we distinguished among three types: cortical, if it corresponds to the natural surface of the blank; rectified, when created by few removals to obtain a suitable flaking angle; prepared, when it is created by removals that allow the recurrence of the products and/or the predetermination of the shape, dimensions and/or specific technical aspects of the products. We counted the number of the negative scars on each core. Length, width, and thickness were measured orienting the core according to the technological axis of the flaking surface(s). In the case of discoid and multifacial multidirectional irregular cores, we measured the core along the longest axis.

The flake analysis takes into account the dimensions (length, width, and thickness measured according to the flaking axis), the number and direction of negative scars on the dorsal face, the type of butt, the flaking angle, the shape and cross-section, the correspondence between morphological and flaking axis, the presence of overshot/hinged removals, the presence of retouch, the location and type of retouch, and possible correspondence among shapes, sizes and technical objective comparing them to the negatives visible on the LCTs and cores (Gallotti 2013; Gallotti et al. 2020). We also classified flakes according to the presence of cortex on the dorsal face and on the striking platform: even if some of us previously classified quartzite flakes with criteria of Tavoso (1969), we followed Toth (1982) and recorded the amount of cortex present on the dorsal face (25%, 50%, 75%, 100%).

Large flakes and LCTs have been defined as being longer or wider than 10 cm (e.g., Kleindienst 1962; Sharon 2010; de la Torre 2011; Beyene et al. 2013). LCTs are intended here as shaped (handaxes, picks, and cleavers) or retouched tools (massive scrapers, *sensu* de la Torre et al. 2008) with a length or width > 10 cm. We use the term "shaping" to indicate "a sequence of knapping operations carried out for the purpose of manufacturing a single artefact by sculpting the raw material in accordance with the desired form" (Inizan et al. 1999: 43). When repeated on a certain number of specimens that all tend towards the same morphology, this process reveals an actual shaping strategy addressed to manufacture specific tool-type(s). The terms "handaxe" and "biface" are not used here as synonyms. Handaxe is a LCTs with a cutting edge around its perimeter (or part of it), more or less pointed. Biface is intended here as a LCT whose morphology "results from the simultaneous arrangement of two convexities, so that one is the image of the other according to a bifacial plane of equilibrium [...] From the intersection of these two convexities arises a silhouette "smoothed out" by retouching, which is distributed in relation to a bilateral plane of balance" («résulte de l'aménagement simultané de deux convexités, de manière à ce que l'une soit à l'image de l'autre en fonction d'un plan d'équilibre bifacial […] De l'intersection de ces deux convexités naît une silhouette «lissée» par retouche, qui se distribue par rapport à un plan d'équilibre bilatéral»; Roche and Texier 1991: 102). Cleavers (*sensu* Tixier 1956) are LCTs obtained either by flaking only, or by flaking followed by shaping. The cutting edge must be left unretouched, i.e. it is the outcome of the flaking of the blank. LCTs with a transversal bit achieved by shaping or by retouch are not cleavers but beveled handaxes (Inizan et al. 1999). Picks designate elongated pointed artefacts, where shaping gives particular emphasis to the tip (Keindienst 1962) which is quite distinct both with respect to the lateral edges and with respect to the overall morphology of the tool. We distinguished picks with a trihedral tip when they have only the tip area with a shaped trihedral cross-section. Trihedral and rhomboidal picks designate pointed LCTs that are both elongated and robust with a trihedral or rhomboidal cross-section involving not only the tip, but the entire tool volume (Inizan et al. 1999).

The analysis of LCTs considers the blank type, the location, extent, and chronology of shaping, the number of negative scars, the presence of patterns anticipated or predetermined by blank selection/production, the presence of planned bifacial and bilateral equilibrium, the overall morphology, and the tip shape. The LCTs have been measured in their three dimensions (length, width, and thickness) according to the morphological axis (Fig. S5c). Angles of the cutting edge(s) have been measured according to the scheme in Fig. S5d. The direction of blow was recorded for the flakes on which LCTs were manufactured and in relation to the LCT longitudinal axis (Sharon 2011; Fig. S5e). Large flakes have been also measured according to their morphological axis because conceived as LCTs blanks.

Artefact assemblage also yielded cobbles bearing percussion marks. We recorded the shape, dimensions, and weight. Following the methodology adopted by Raynal and Sbihi-Alaoui (2016), we identified the position of percussion damages by distinguishing between traces located on the extremity(ies), edge(s) and/or face(s) of the cobble.

Figure S4. Photographic overview of the 19 knapping experiments on Casablanca quartzites (a: beveled handaxe; b-d: bifacial partial cores; e-g: discoid cores; h: pick; i-m: pointed handaxes; n-s: unifacial unidirectional cores).

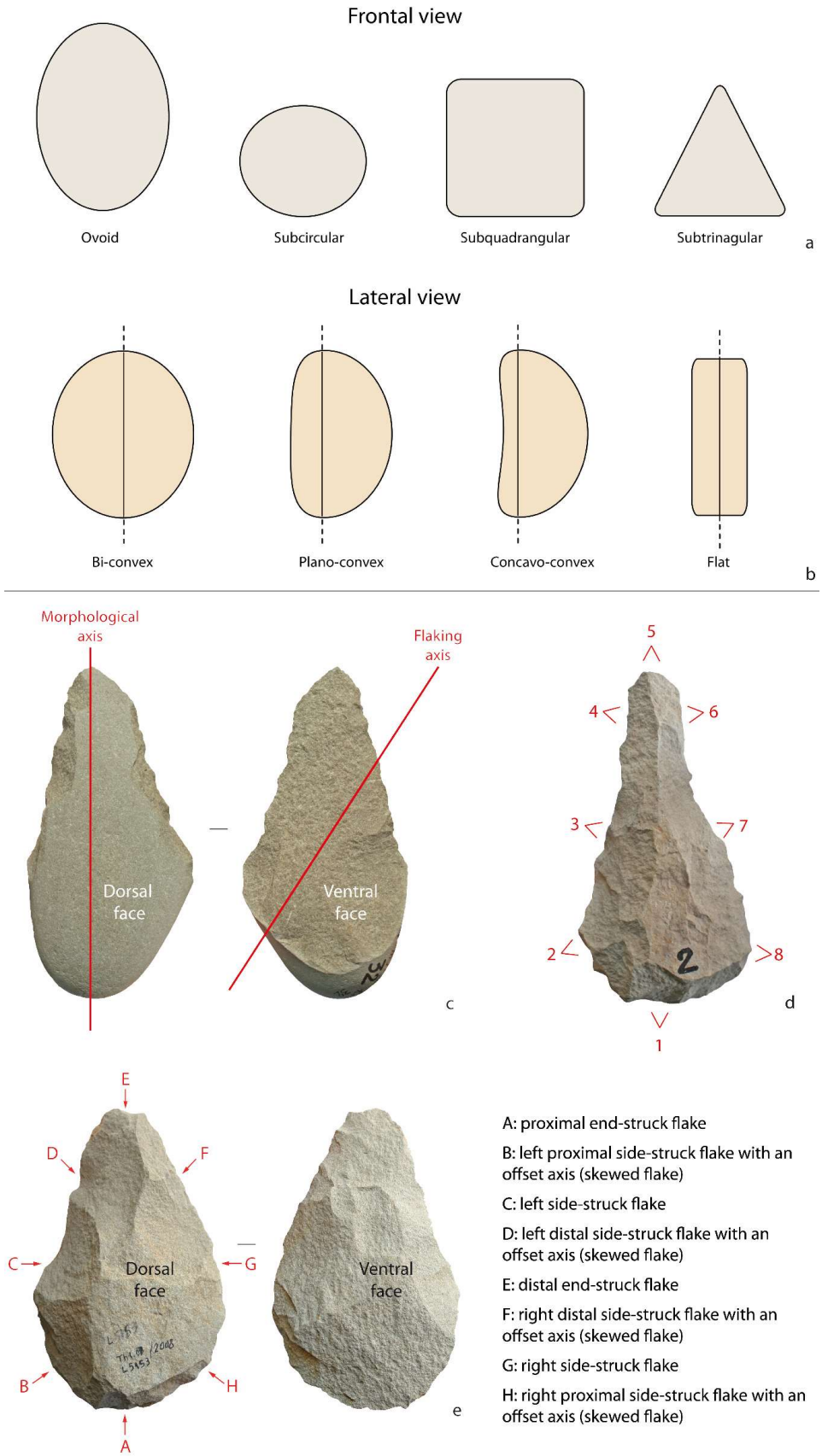

Figure S5. Conventions in lithic assemblage analysis from ThI-L1. a: cobble/pebble shapes in frontal view; b: cobble/pebble shapes in lateral view; c: morphological and flaking axes of a LCT on entame flake blank; d: location of the cutting edge angle measurements; e: blow directions of a large flake used as LCT blank and relative terminology.

References

Bertran P, Lenoble A, Todisco D, et al (2012) Particle size distribution of lithic assemblages and taphonomy of Palaeolithic sites. J Archaeol Sci 39: 3148-3166. https://doi.org/10.1016/j.jas.2012.04.055.

Beyene Y, Katoh S, WoldeGabriel G, et al (2013) The characteristics and chronology of the earliest Acheulean at Konso, Ethiopia. Proc Natl Acad Sci 110: 1584-1591. https://doi.org/10.1073/pnas.1221285110.

de la Torre I (2011) The Early Stone Age lithic assemblages of Gadeb (Ethiopia) and the developed Oldowan/early Acheulean in East Africa. J Hum Evol 60: 768-812. https://doi.org/10.1016/j.jhevol.2011.01.009.

de la Torre I, Mora R, Martínez-Moreno J (2008) The early Acheulean in Peninj (Lake Natron, Tanzania). J Anthropol Archaeol 27: 244–264. https://doi.org/10.1016/j.jaa.2007.12.001.

Gallotti R (2013) An older origin for the Acheulean at Melka Kunture (Upper Awash, Ethiopia). Techno-economic behaviours at Garba IVD. J Hum Evol 65: 594-620. https://doi.org/10.1016/j.jhevol.2013.07.001.

Gallotti R, Mohib A, Fernandes P, et al (2020) Dedicated core-on-anvil production of bladelet-like flakes in the Acheulean at Thomas Quarry I - L1 (Casablanca, Morocco). Sci Rep 10: 9225. https://doi.org/10.1038/s41598-020-65903-3.

Gallotti R, Mussi M (2017) Two Acheuleans, two humankinds: From 1.5 to 0.85 Ma at Melka Kunture (Upper Awash, Ethiopian highlands). J Anthropol Sci 95: 1-46. https://doi: 10.4436/JASS.95001.

Geneste JM (1989) Economie des ressources lithiques dans le Mousterien du sud-ouest de la France. In: Otte M (ed) L'Homme de Néanderthal, volume 6: La Subsistance, ERAUL, Liege, p. 75-97.

Geneste JM (1991) Systèmes techniques de production lithique: Variations techno-économiques dans les processus de réalisation des outillages paléolithiques. Techniques et Culture 17-18: 1-35.

Goldman-Neuman T, Hovers E (2012) Raw material selectivity in Late Pliocene Oldowan sites in the Makaamitalu Basin, Hadar, Ethiopia. J Hum Evol 62: 353-66. https://doi:10.1016/j.jhevol.2011.05.006.

Inizan ML, Reduron-Ballinger M, Roche H, et al (1999) Technology and terminology of knapped stone (Préhistoire de la Pierre taillée 5), CREP, Nanterre.

Kleindienst MR (1962) Component of the East African Acheulian assemblage: an analytic approach. In: Mortelmans G, Nenquin J (eds) Actes du IV Congrès Panafricain de Préhistoire et de l'Etude du Quaternaire, Leopoldville, 1959, Belgie Annalen, Musée Royal de l'Afrique Centrale, Tervuren, p. 81–108.

Lemonnier P (1976) La description des chaînes opératoires. Contribution à l'analyse des systèmes techniques. Technique et Culture 1: 100-151.

Lemonnier P (1986) The study of material culture today: toward an anthropology of technical systems. J Anthropol Archaeol 5: 147-186. https://doi.org/10.1016/0278-4165(86)90012-7.

Lenoble A (2005) Ruissellement et formations des sites préhistoriques : référentiel actualiste et exemples d'application au fossile, British Archaeological Report International Series 1363, Oxford.

Leroi-Gourhan A (1964) Le geste et la parole. Technique et langage, Albin Michel, Paris.

Leroi-Gourhan A (1971) Evolution et technique. L'homme et la matière, Albin Michel, Paris.

Maurin T, Bertran P, Delagnes A, et al (2017) Early hominin landscape use in the Lower Omo Valley, Ethiopia: Insights from the taphonomical analysis of Oldowan occurrences in the Shungura Formation (Member F). J Hum Evol 111: 33-53. https://doi.org/10.1016/j.jhevol.2017.06.009.

Pelegrin J (1985) Réflexions sur le comportement technique. In: Otte M (ed) La signification culturelle des industries lithiques Studia Praehistorica Belgica 4, BAR International Series 239, Liege, p. 72-91.

Perlés C (1991) Économie des matières première set économie du débitage : deux conceptions opposées ?. In: Beyries S, Meignen L, Texier PJ (eds), 25 and d'études technologiques en Préhistoire : bilan et perspectives, Proceedings XI rencontres d'archéologie et d'histoire d'Antibes, October 18-20, 1990, APDCA, Juan-les-Pins, p. 35-45.

Raynal J-P, Sbihi-Alaoui F-Z (2016) Le macro-outillage de percussion. In: Raynal J-P, Mohib A (eds) Préhistoire de Casablanca. I - La grotte des Rhinocéros (fouilles 1991 et 1996), Institut National des Sciences de l'Archéologie et du Patrimoine, VESAM VI, Rabat, p.175-181.

Roche H, Texier P-J (1991) La notion de complexité dans un ensemble lithique. Application aux séries acheuléennes d'Isenya (Kenya). In: Beyries S, Meignen L, Texier PJ (eds) 25 ans d'études technologiques en Préhistoire : bilan et perspectives, Proceedings XIème rencontres internationales d'Archéologie et d'Histoire d'Antibes, APDCA, Juan-les-Pins, p. 99-108.

Schick KD (1986) Stone Age Sites in the Making: Experiments in the Formation and Transformation of Archaeological Occurrences, British Archaeological Report International Series 319, Oxford 313.

Sharon G (2010) Large Flake Acheulian. Quat Int 223: 226-233. https://doi.org/10.1016/j.quaint.2009.11.023.

Sharon G (2011) Flakes Crossing the Straits? Entame Flakes and Northern Africa–Iberia Contact During the Acheulean. Afr Archaeol Rev 28: 125–140. https://doi.org/10.1007/s10437-011-9087-3.

Tavoso A (1969) Etude des terrasses alluviales du Fresquel (Aude) et des industries préhistoriques associées. Impr. Leconte, Marseille.

Tixier J (1956) Le hachereau dans l'Acheuléen nord-africain. Notes typologiques, Proceedings of the XV session of the Congrès préhistorique de France, July 15-22, Poitiers-Angoulême, pp. 914-923.

Toth N (1982) The Stone Technologies of Early Hominids at Koobi Fora, Kenya; An Experimental Approach. Ph.D. Dissertation, University of California.

Wentworth CK (1922) A scale of grade and class terms for clastic sediments. The Journal of Geology 30: 377–392.