The function of small tools in Europe during the Middle Pleistocene: The case of Marathousa 1 (Megalopolis, Greece)

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Abstract:

Small flake industries are a commonly identified component of Lower Paleolithic archaeological assemblages in Eurasia. Utilized as blanks for tools, at many sites, their functions are often poorly understood. Here we present a preliminary traceological analysis of lithics from Marathousa 1 (MAR-1; Megalopolis, Greece). MAR-1 dates to *ca*. 400-500 ka BP and is one of the oldest open-air sites in South-Eastern Europe. It has yielded a lithic assemblage made almost exclusively of small-sized flakes found in direct association with diverse megafauna including elephants, hippo and deer.

For this preliminary study, a total of 223 artifacts were sampled for a taphonomical analysis and 13 for a functional analysis. The lithic artifacts from MAR-1 are exceptionally well-preserved and are only slightly affected by chemical alterations. They are therefore ideal for a techno-morpho-functional analysis. Use-wear traces confirm on-site butchery. Our results also confirm that plants were worked at the site, whereas technological traces, rarely observed on lithics from this age, can also be seen on a number of specimens. Whereas both retouched and unretouched tools contribute significantly to the MAR-1 toolkit, shapes are varied, and at this phase of the study do not appear morphologically or technologically standardized. However, backing (natural or retouched) opposite to a sharp edge can be observed on numerous specimens. When compared to the sparse functional data available on small tools from Lower Paleolithic Europe and the Levant, small flake tools include a wide variety of techno-functional types. To fully begin to understand this diversity, lithic toolkits must be considered in relation to the rest of the assemblage and the accompanying contextual

Journal of Lithic Studies (2022) vol. 9, nr. 1, 29 p. DOI: https://doi.org/10.2218/jls.5553

Published by the School of History, Classics and Archaeology, University of Edinburgh
ISSN: 2055-0472. URL: http://journals.ed.ac.uk/lithicstudies/

data, including information from technological, archaeozoological, and palaeoenvironmental datasets.

Keywords: Lower Palaeolithic; Middle Pleistocene; Greece; small tools; taphonomy; use-wear analysis; techno-morpho-functional analysis

1. Introduction and background

Small flakes constitute important blanks in many lithic assemblages of the Lower Paleolithic (Rocca *et al.* 2016). Even though they are present both in Africa and Eurasia from ≥1 Ma to 300 ka (Burdukiewicz & Ronen 2003; Derevianko 2006; Lemorini 2018), small tools are still inadequately understood. No definition is commonly accepted: “Small is indefinite physical measure” (Burdukiewicz & Ronen 2003: 235). The use of the term “small flake” demonstrates that this category of blank type for tool use was defined in opposition to larger, more conspicuous tool types, which have long been prioritized in the analyses of Lower Paleolithic lithic assemblages. However, a tool cannot be reduced to its dimensions alone. Small tool classification is based on typological (denticulates, notches, scrapers, backed pieces) and dimensional criteria (*ca*., 20-40 mm; Burdukiewicz & Ronen 2003; Rocca 2013: 236-251), while raw material, technological, functional and environmental data are rarely included in the discussion, constituting a barrier for the understanding of ancient industries. The concept of small essentially obscures variability in aspects other than size, and small tools do not constitute a straightforward entity solely on the grounds of size. Often, they do not seem to reflect raw material constraints, and at some sites they appear to have been deliberately produced even when larger blanks were available (Burdukiewicz & Ronen 2003; Zaidner 2013). Furthermore, small tools derive from a variety of production methods (alternate, multidirectional, discoid) and blank types (cores, tools, flakes, chunks and debris; Tourloukis *et al.* 2018b). They can be dominant (or not) in lithic assemblages, and associated (or not) with larger tools. They may or may not be associated with megafauna (Venditti 2019: 150-154 and references therein). In short, a reliance on small tools is not context-or region-specific. Although the origin of such assemblage diversity is still debated, it is proposed to be related to the age of assemblages, to the unique preservation of sites, or to specialized activities or durations.

To further our understanding of how small lithics were utilized, techno-morpho-functional (Boëda 1997: 92-110; Lepot 1993: 25-40) and traceological analysis (Semenov 1964) are necessary. Conducting a combined approach allows us to further assess the *chaîne opératoire* from the production of tool to their use and curation through the analysis of their final morphology before discard (Guibert-Cardin *et al.* in press). It provides the opportunity to elucidate whether tools were multifunctional or produced for a specific activity, whether they were complementary or functionally redundant to larger tools, or whether they were hafted or handheld. To investigate these questions, well-preserved, well-dated sites with multidisciplinary approaches are essential.

Here we report the preliminary results from a traceological study of lithics from Marathousa 1 (MAR-1; Megalopolis, Greece). The site is well-dated, in a fine-grained matrix and has a robust stratigraphic sequence. In general, Lower Paleolithic sites with stratified, secure contexts or absolute dating are rare in the Balkans and South-East Europe, and MAR-1 is currently the only Middle Pleistocene site of this region with archaeological and faunal remains from a stratified and dated context. Moreover, it is the only known butchery site in the Southern Balkans (Panagopoulou *et al.* 2018; Tourloukis & Harvati 2018). The unique lithic assemblage and context of MAR-1 provide a rare opportunity to document hominin behaviors in this region. The MAR-1 lithics are almost exclusively composed of small tools, which provide the opportunity to investigate small tool functions in a reliable framework and to compare functional results with other data obtained on the site, such as archaeozoological, technological and palaeoenvironmental data. Technological studies on MAR-1 provide numerous data on technological behaviors but questions remain about tool use and site function: for example, it has yet to be investigated if both unretouched and retouched flakes exhibit use-wear traces; what are the patterns in the morphology of used tool edges; and whether the tools were hafted or hand-held. Before studying the functional aspects of the lithics, a taphonomical analysis was conducted to document Post-Depositional Surface Modifications (hereafter PDSM) and identify the nature of post-depositional processes. Functional results were then compared with use-wear data obtained from Lower Palaeolithic small lithic tools from Europe and the Levant.

2. Marathousa 1

2.1. General settings and background of previous research

MAR-1 was discovered in 2013, during a systematic target-oriented surface survey in the framework of the ERC project “Palaeoanthropology at the Gates of Europe” (PaGE*;* Harvati 2016; Harvati *et al*. 2018; Harvati & Tourloukis 2013; Panagopoulou *et al.* 2015; ; Thompson *et al*. 2018). The aim of this project was to locate and identify Pleistocene archaeological remains from undisturbed, primary contexts (see *e.g.*, Harvati *et al.* 2018; Harvati & Tourloukis 2013; Tourloukis *et al.* 2015; Thompson *et al.* 2018). MAR-1 is located in the Megalopolis Basin, southern Greece, which periodically hosted an ancient lake (Figure 1a). The basin sequence is divided into six formations and the site is situated in the Middle Pleistocene Marathousa Member of the Choremi Formation (Karkanas *et al.* 2018). The deposits of the Marathousa Member are composed of lacustrine clays, silts and sands, alternating with lignite layers. The latter accumulated in warm and humid conditions, while the detrital units accumulated in cold and dry periods, representing successive interglacial-glacial cycles. MAR-1 is located between two lignite seams (IIb and III), and the archaeological remains are preserved in a fine-grained matrix at the contact of sedimentary units UA3-UA4 (Area A) and UB4-UB5 (Area B; Figure 1b).

The excavation is divided into two areas, A and B, separated by 60 m, to investigate the spatial distribution of the remains and extent of the site. These two areas are correlated on the grounds of stratigraphical, lithological, sedimentological, geochemical and micromorphological data (Karkanas *et al.* 2018). In general, the layers are thicker in Area B and more compressed in Area A, indicating that Area A was closer to the lake shore. Lithic and faunal remains are embedded in a mudflow and were subjected to minor post-depositional reworking (Giusti *et al.* 2018; Konidaris *et al.* 2018; Tourloukis *et al*. 2018b).

Palaeobotanical and faunal remains are numerous and provide valuable information to reconstruct the palaeoenvironment. The exceptionally preserved materials are composed of carpological remains, pollen, wood, phytoliths, diatoms, mollusks, ostracods and insects, indicating that hominin activities took place in a warming climate, in a wooded landscape with open areas near a lake (Field *et al.* 2018). In particular, it appears that animal and plant resources and freshwater were available to hominins in close vicinity to the site (Bludau *et al*. 2021). Cut marks and percussion marks on faunal remains attest to on-site butchering activities (Konidaris *et al.* 2018), but no direct evidence for plant use has been identified so far.

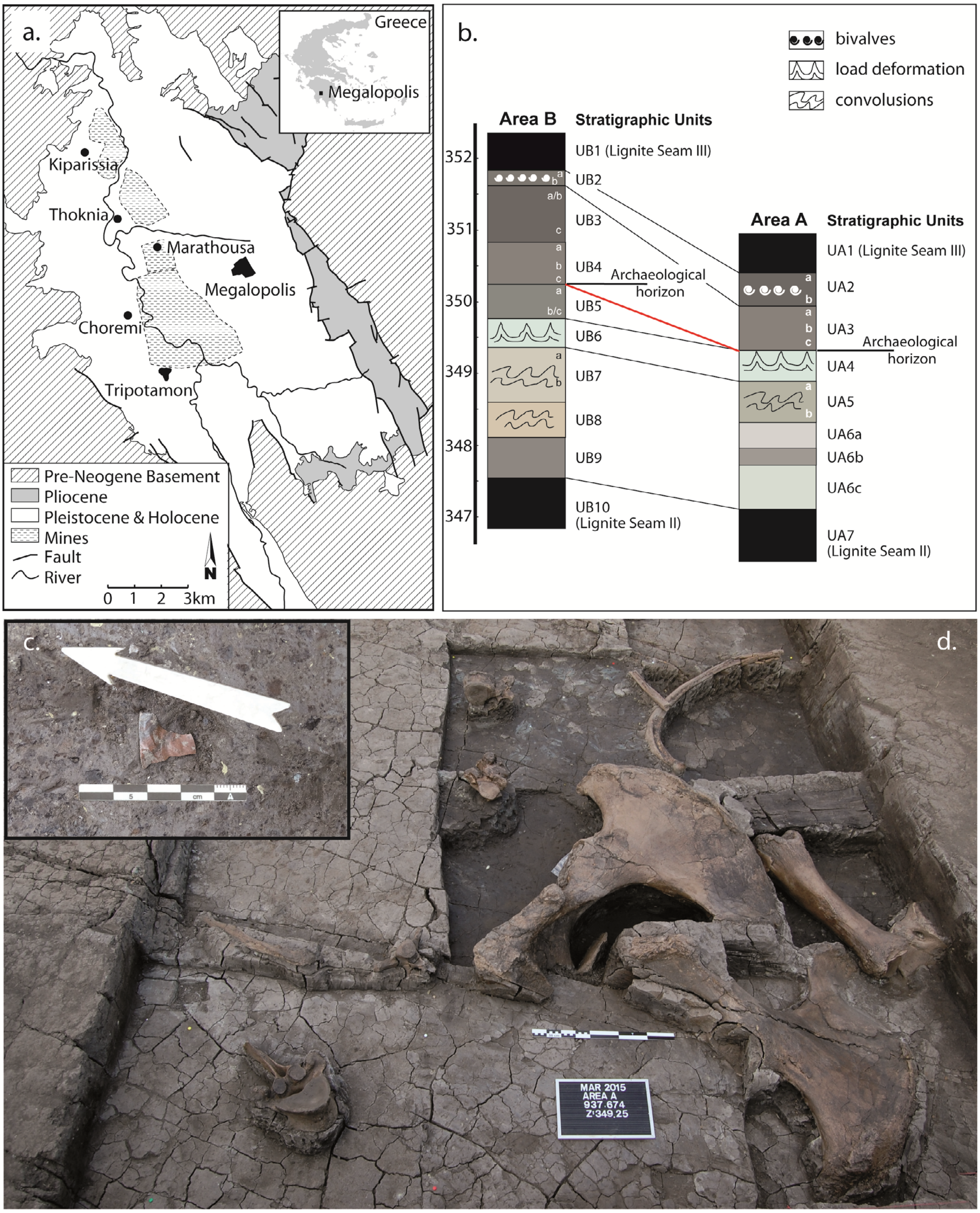

Figure 1. a. Location of Marathousa 1 (modified from van Vugt *et al.* 2000), b. stratigraphic column of Area A and B, Marathousa 1 (modified from Karkanas *et al.* 2018), c. Radiolarite flake recovered from the mudflow of UB4c, d. panoramic view of Area A during 2015 field campaign, showing the distribution of the elephant remains. The tibia to the right of the pelvis bears cut-marks (Konidaris *et al.* 2018).

The site was investigated with multiple dating methods in order to obtain a reliable chrono-stratigraphic framework. Electron Spin Resonance (ESR) on teeth and mollusks from UA2, UA3c/UA4 and UB4c/UB5 provided dates of 488 ± 37, 512 ± 34 and 503 ± 12 ka respectively (Blackwell *et al.* 2018). Post-infrared Infrared Stimulated Luminescence (post-IR IRSL) on sediment samples from UB2, UB5, UB7, UA3 and UA5 provided age determinations between 480 ± 39 and 380 ± 48 ka (Jacobs *et al.* 2018). A study based on magnetostratigraphy and lithostratigraphic correlations produced two age-models, of which the one preferred by the authors assigns the MAR-1 sequence to Marine Isotope Stage 12 (*ca.* 480-420 ka; Tourloukis *et al.* 2018a). Sedimentological, biochronological and palaeoenvironmental data are in broad agreement with these results (Doukas *et al.* 2018; Field *et al.* 2018; Karkanas *et al.* 2018). In summary, the archaeological remains are chronologically bracketed between *ca.* 500-400 ka BP, rendering MAR-1 the oldest-known archaeological site in Greece and one of the oldest open-air sites in South-Eastern Europe (Panagopoulou *et al.* 2018).

Area A exhibits numerous elephant bones from a largely complete single individual (*Palaeoloxodon antiquus*) with anthropogenic cut-marks and a low density of lithic finds (Konidaris *et al.* 2018; Figure 1c and d). Faunal remains include other large mammals (hippos, cervids, bovids, carnivore), small mammals and birds in both areas (Doukas *et al.* 2018; Konidaris *et al.* 2018; Michailidis *et al.* 2018). Area B has yielded a higher density of lithics, with a more diverse toolkit than Area A, but also additional elephant remains and bones with cut-marks and other anthropogenic marks. The data suggest that hominins exploited an elephant carcass in Area A near the lakeshore, whereas, in Area B they exploited a larger variety of mammals, including additional elephant individuals, and most likely conducted a broader range of activities (Tourloukis *et al.* 2018b).

2.2. The lithic assemblage

The lithic assemblage from MAR-1 is currently composed of 2058 artifacts (Table 1 and Table 2) from the 2013-2019 field seasons (water screening and lithic analysis are ongoing). The raw materials are predominantly radiolarite, and to a lesser degree flint, limestone and quartz, collected in close proximity to the site (Tourloukis *et al.* 2018b). Radiolarite is by far the most common raw material but is generally of low quality. Indeed, cleavage plane fractures occur frequently and explain to some extent the high frequency of small blanks. Radiolarite, and to a lesser degree flint, are present near the site in the form of small pebbles, cobbles and isolated nodules for the flint. Radiolarite plaquettes were also occasionally utilized as blanks but are reduced in the same manner as those that derive from pebbles, indicating a preference for a specific type of reduction sequence that is not significantly influenced by raw material type or form (Tourloukis *et al.* 2018b).

Table 1. Assemblage composition classified by size

	> 1.5 mm	**< 1.5 mm**	**Total**
Lithic type	Cores, tools, flakes and debris	Chips and debris	
N	411	1,647	2,058
%	20%	80%	100%

Table 2. Assemblage composition classified by areas

	Area A	**Area B**	**Total**
N	97	1,961	2,058
%	5%	95%	100%

The lithic assemblage is composed of exhausted cores (minimally prepared and heavily reduced), flakes (mainly between 15 and 25mm in length and width) and tools (mainly backed pieces but also notches, composite tools, retouched pieces, denticulates, scrapers, core-tools and pointed and convergent pieces). The largest and most elongated specimens selected as blanks for tool manufacture have an average length of 28 mm. Blank types are varied: flakes, flake fragments, debris, cores and core fragments. The aim of the debitage is to produce thick (*i.e.*, durable) blanks with one or more sharp edges. When retouch is present, it typically sets up a working edge or a backing. Thus, the question arises whether this shaping is purposeful to facilitate prehension or hafting.

In terms of hominin socio-economic behaviors, it appears that tools were produced, used and maintained on-site from locally available raw materials. This appears to have been a response to immediate needs, such as meat procurement and carcass processing. The low to medium density of lithic remains suggest that the site was occupied by a small group during short durations, possibly as a seasonal persistent place preserved as a remnant of the larger landscape in close proximity to the lake shore.

3. Materials and methods

The objective of this preliminary study is to assess the potential for use-wear analysis on a sample of lithics from the Middle Pleistocene remains of MAR-1. The study focuses on a sample of 250 lithic artifacts coming from Areas A (N=6) and B (N=244), excavated in 2013-2019. The sample is representative of the whole assemblage in terms of size class (it includes almost half of the category with lithics >1.5 cm as well as small part of the chips), main artifacts classes (cores, tools, flakes, chunks and debris) and reduction sequence (all stages represented in the assemblage have been studied). The sample for this study is detailed in Table 3. The analysis was carried out in two stages: a taphonomic analysis of the flint and radiolarite artifacts to determine the nature of post-depositional processes; and then a functional analysis of the 250 artefacts in the sample. This last part of the work is in progress and 13 pieces have been analysed so far and are presented here (Figure 2).

The pieces were manipulated with gloves and were not cleaned before the analysis, so as not to impede future residue analysis, which explains why a greasy thin film is sometimes visible on the photographs. In that respect, functional determinations were only made when several stigmas were associated, consistent and diagnostic. Once the artifacts are washed, functional interpretations may be more precise.

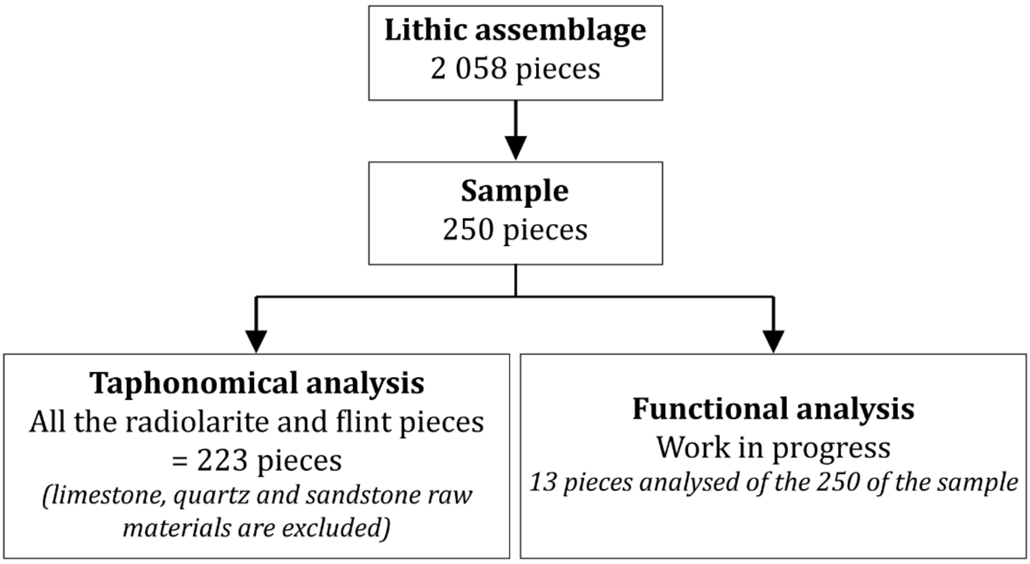

Figure 2. Details of sampling and stages of analysis.

Table 3. Sample details by lithic and raw material types.

Lithic type	Radiolarite	Flint	Limestone	Quartz	Sandstone	Total
Unretouched blanks	**148**	**21**	**15**	**10**	**1**	**195**
Cores and core fragments	7	0	5	2	0	14
Flakes >15 mm	96	12	8	4	1	121
Chips <15 mm	38	7	0	3	0	48
Debris	7	2	2	1	0	12
Retouched blanks	**47**	**7**	**1**	**0**	**0**	**55**
Backed pieces	9	2	1	0	0	12
Notched pieces	10	2	0	0	0	12
Denticulates	7	0	0	0	0	7
Scrapers	6	1	0	0	0	7
Core tools	7	0	0	0	0	7
Retouched pieces	4	1	0	0	0	5
Composite tools	3	1	0	0	0	4
Pointed pieces	1	0	0	0	0	1
Total	**195**	**28**	**16**	**10**	**1**	**250**

3.1. Taphonomical study

Our taphonomical study was founded on the methodological approach developed by petroarchaeologists (Fernandes 2012: 119-165; Fernandes & Raynal 2006). The aim of this methodology is to identify the post-depositional processes within the archaeological site and their intensity level (whether chemical or mechanical processes are in the majority) on the lithic specimens. We only conducted the taphonomic analysis on the radiolarite and flint raw material because PDSM on the other raw materials (limestone, quartz and sandstone) present very different aspects and it would have been necessary to adapt our criteria of observation each time.

The PDSM were documented for all the radiolarite and flint pieces of the sample (N=223) in order to determine the nature of the post-depositional processes and to evaluate the integrity of the archaeological materials.

The following descriptive criteria are taken into account:

Patina gradient: corresponds to the patina intensity. Absent; slight (white coat); medium (well-developed but original color visible); high (original color hardly observable); complete (original color cannot be observed).

Damage marks gradient: corresponds to the intensity of impact on edges, arrises and surfaces. Absent; very slight (<10% of the piece); slight (10 to 25%); medium (25 to 50%); high (>50%).

Damage marks: scars; crushing; impact points on surface.

Dissolution: present; absent.

Soil sheen: slight; very slight; more developed.

Other: absent; bright spots; rounding; striations; recent damage.

Alteration gradient: determined in relation to the gradient of PDSM identified above. No alteration; slight; medium; high.

Main type of alteration: for each piece, assessment of whether the alterations are mainly of chemical or mechanical origin.

3.2. Techno-morpho-functional analysis

Small lithics present significant morphological variability (backed flakes, unretouched and retouched flakes, retouched cores) which partly explains why they can be more properly considered as a type of blank than as a unique tool type (Aureli *et al.* 2016). Therefore, considering this variability, we combined a techno-morpho-functional analysis with use-wear analysis. The techno-morpho-functional approach, conceived by M. Lepot (1993: 25-40) and E. Boëda (1997: 92-110; 2001; 2013: 47-52) is occasionally combined with use-wear analysis to better characterize lithic assemblages from the Lower and Middle Paleolithic (Bonilauri 2010: 114-369; Claud 2008: 213-469; Guibert-Cardin *et al.* 2021; Guibert-Cardin 2022; 131-316).

First, the functional analysis of lithics was conducted at both low and high magnifications to identify active parts and modes of tool use. The functional observations were made using a stereomicroscope (Leica Wild M10) with a range of magnification from 8x to 80x, and a microscope (Olympus BHM) with a range of magnification from 100x to 200x with a Leica camera. Macroscopic photography was taken with a Dinolite from 10x to 200x. Use-wear traces were compared to traces that are documented in a reference collection based on experiments, which is available at the laboratory *Cultures-Environnements. Préhistoire, Antiquité, Moyen Âge* (CEPAM; Nice, France). Additional experiments are ongoing, with replicas of small radiolarite flakes such as those of the MAR-1 assemblage, for plant and meat processing. This work was recently initiated with a butchery experiment at the University of Tübingen, conducted on an elephant foot with small flakes made of radiolarite from Megalopolis (Starkovich *et al.* 2021).

Lastly, a diacritical analysis on the chronology of each removal in the formation of tools with use-wear traces was conducted. The cutting edge was described, taking into account length, edge angle, as well as morphology in plan view, cross-section and profile view. In particular, we seek to understand the relationships that exist between the production of blanks for tools, morphology, retouch and use.

4. Results

4.1. Taphonomy

The 223 pieces analyzed for the taphonomical study are exceptionally well preserved considering the age of the assemblage. The two major PDSM observed are soil sheen and damage marks (Figure 3c). Soil sheen is a chemical or mechanical alteration that produces a glossy appearance on the surface of lithics. It may also be due to a dissolution of the silica or to micro-movements in the sediment (Levi Sala 1986; Mansur-Franchomme 1986: 128-133). This alteration potentially obliterates functional polishes, when the latter are poorly developed or when the sheen is strong. In general, the pieces have a very slight to slightly developed soil sheen that did not prevent the identification of functional polishes. Striations of random orientations are often associated with soil sheen (Figure 3d).

Damage marks, in particular scars, are even more challenging for use-wear analyses, because they may conceal or remove part of a specimen's edge that potentially bears functional traces (Figure 3e). Here, damage marks are almost all scars, with the exception of one piece that also shows pits on the surface. Only 36 pieces exhibit medium or high frequencies of scars, while the others have only a few to no scars visible. Therefore, due to the limited impact of PDSM on the surface of the lithics the potential for conducting a functional analysis is high.

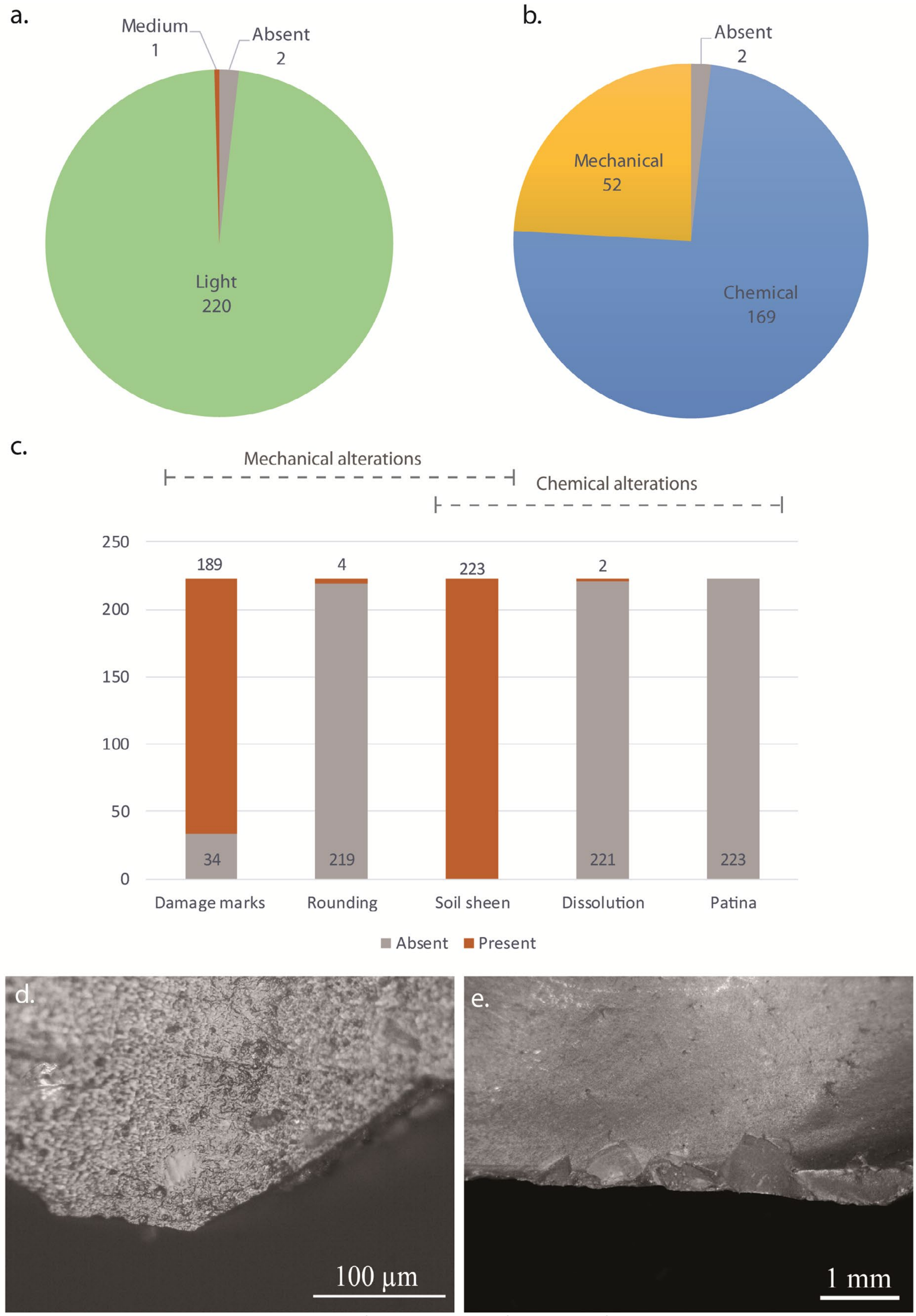

Figure 3. Graphs representing the number of radiolarite and flint pieces from MAR-1 included in this study, a. according to their degree of alteration; b. according to the main type of alteration; c. according to each type of surface alteration (a piece can exhibit several types of alteration); d. soil sheen, random striations and flat polish near edge (MAR1 1171) and e. small overlapping taphonomical scars (MAR1 1140).

The other PDSM are occasional: four pieces bear rounding on their edges and arises, two have recent edge damage and two show dissolution on their surfaces. Recent damage is easy to identify because soil sheen is totally absent. Dissolution does not affect the edges with potential use-wear traces, but instead develops locally on faces within a pit or a fissure. Finally, rounding is poorly developed and affects very few pieces, so it does not constitute a major obstacle for the use-wear analysis.

In summary, the overwhelming majority of the pieces examined exhibit slight alterations, providing the opportunity to conduct use-wear analysis at both low and high magnifications for macro and micro-traces (Figure 3a). PDSM are mainly of chemical origin (N=169 pieces out of the total N=223) (Figure 3b), however some mechanical alterations attest to slight movement of the lithics after deposition. This observation reinforces the interpretation of minor reworking of the find layers (lithic and faunal assemblages) according to Giusti *et al*. (2018).

4.2. Use-wear traces

For this analysis, 13 lithics were analyzed for use-wear with a stereomicroscope and a metallographic microscope (Figure 4). Five in total show use wear traces: two backed knifes, one pointed tool with a convergent edge and two unretouched flakes; whereas, one notched piece exhibits technological traces. The remaining seven lithics do not exhibit use-wear traces. However, this does not necessarily imply that the latter were not utilized. Instead, perhaps the material processed was too soft or the activity was too brief for use wear traces to develop. Another possible explanation is that use-wear traces were too fragile and degraded because of PDSM, since polishes do not all have the same resistance to alterations (Plisson 1983; 1985: 100-147).

The precise description of the use-wear traces of each specimen and photos of experimental use-wear traces can be consulted in the supplementary materials.

The first flake studied (MAR1 1.2) is one of the largest lithics of the assemblage (Figure 5). This specimen is a flint flake with backing present on the right lateral edge that is possibly the result of an accidental siret fracture or an intentional fracture using the dorsal surface as the striking platform. The opposite edge is unretouched and bears functional traces related to the working of a hard material in a longitudinal motion. The scars are bifacial and often oblique to the edge and striations are parallel to the working edge, indicating a longitudinal motion. The material processed is hard because crushing is present and scars are large, sometimes overlapping with hinge or feather terminations and cone initiation (Figure 5b). Smooth spots of polish confirm this interpretation (Figure 5c).

The radiolarite flake, MAR1 620 is a backed knife (Figure 5). The back is created by abrupt retouch and is opposite an unretouched edge bearing use-wear traces. The latter are poorly developed and are related to the work of a hard material in a longitudinal motion, possibly during a butchering activity. Spots of polish and rounding are only present on the highest areas of the microtopography indicating the working of a hard material (Figure 5a). The stigmata are similar to use-wear traces evident from butchery activities when a tool accidentally strikes bone (Figure 7b). Traces are insufficiently developed to securely determine the type of processed material. Striations are oblique to the edge indicating a longitudinal motion.

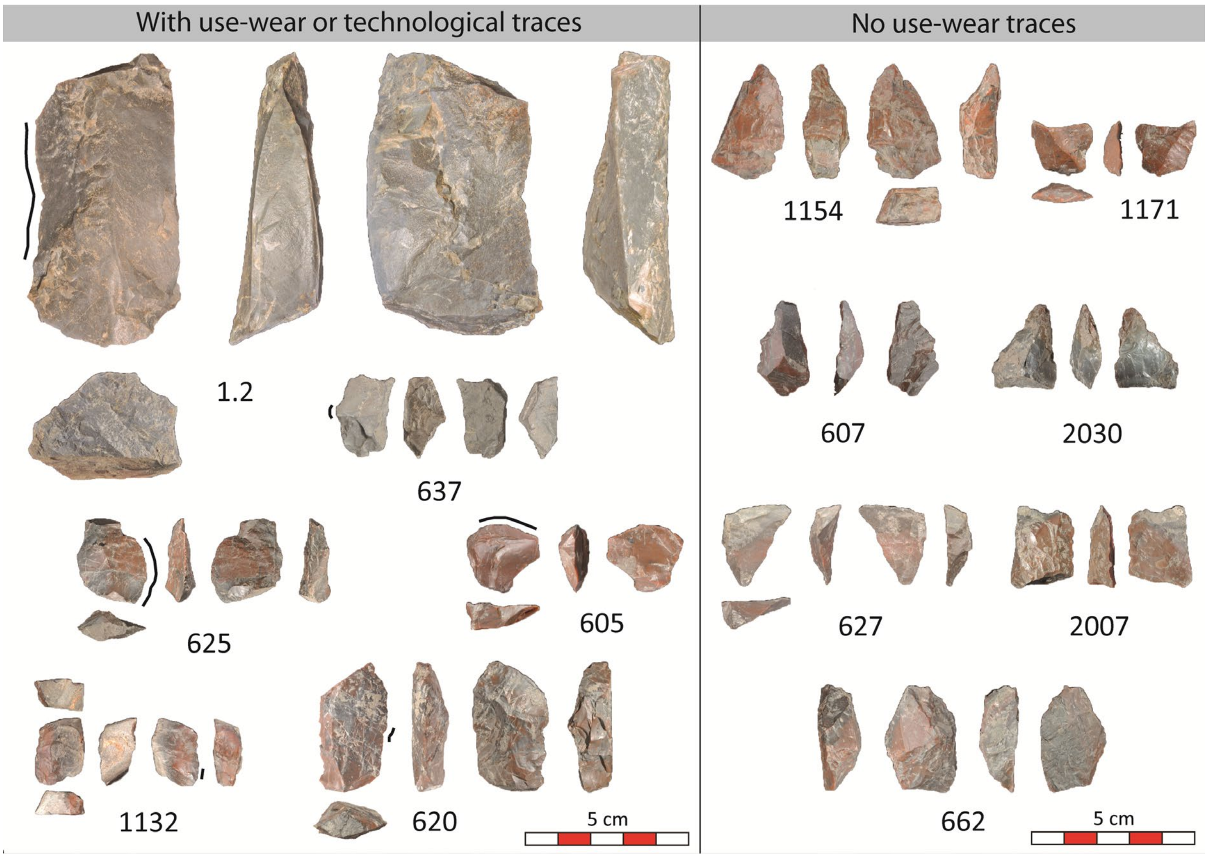

Figure 4. Lithics studied for use-wear analysis and localization of the active area (white line). 1.2: used to process hard material in a longitudinal motion; 620: used in a longitudinal motion possibly for butchering activities; 625: used in a longitudinal motion for butchering activities; 605: used to process plant in a transversal unidirectional motion; 637: bears technological traces, or to work a semi hard material in a transversal bidirectional motion; and 1132: technological traces. The remaining specimens, in the right half of the figure, do not have use-wear or technological traces.

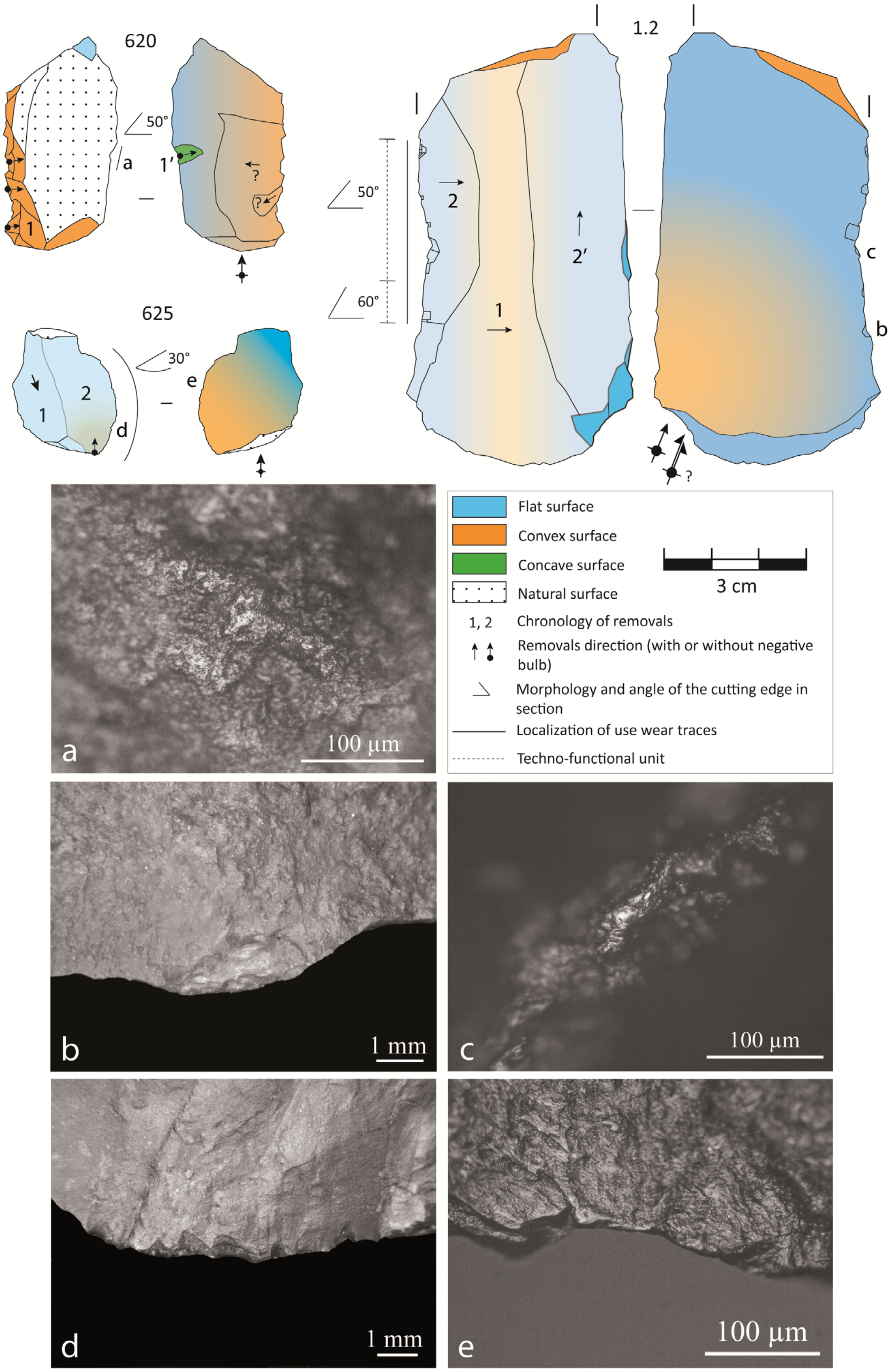

Figure 5: Diacritical sketches of lithics with use-wear traces and photos of traces. a. functional spot polish from flake 620 (used in a longitudinal motion possibly for butchering activities); b. and c. crushing and smooth spot polish visible on the cutting edge of flake 1.2 (used to process hard material in a longitudinal motion); d. and e. angular scars oblique to the edge, smooth spot polish and striations oblique to the edge of flake 625 (used in a longitudinal motion for butchering activities).

The unretouched radiolarite flake, MAR1 625 (Figure 5) has been used for butchery activities in a longitudinal motion. On the right lateral edge, bifacial scars and striations oblique to the edge, and a symmetrical rounding showing a longitudinal motion are evident. The material processed is both soft and hard, with numerous small scar patterns. Also, polish and rounding are evident on the highest parts of the edge microtopography. Polish and striations resemble microscopic traces related to bone processing, as evident by the smooth texture, clear boundaries and a compact linkage (Figure 5e). The scar characteristics are the same as those that one would expect from butchering activities, namely isolated or aligned, with a triangular shape, bending and cone initiations and, feather, step and rarely hinge terminations (Figure 4d and Figure 7a).

The unretouched radiolarite flake, MAR1 605 has a short back on the proximal left side (Figure 6). The secant cutting edge has been used to process plant material in a transversal unidirectional motion. Traces are dissymmetric, scars are on the dorsal surface and rounding is mostly visible on the ventral surface, so the motion is transversal and unidirectional. The scars are similar to those which form by working plant materials, *i.e.*, they have circular and elongated forms and with feather or hinge terminations (Figure 6a and Figure 7c). The polish confirms this interpretation because it is domed, smooth, with undulations, and on the high to medium parts of the microtopography (Figure 6b). These characteristics are indicative of plant polish (Figure 7d). However, this functional polish seems to be slightly altered. Chemical alterations are more developed on this piece than on any other specimen of the sample, possibly modifying the appearance of the polish.

The specimen MAR1 637 is a thick radiolarite chunk with a convergent spine created by retouch (Figure 6). Use-wear traces are located on this spine and are related to the contact with a semi-hard and abrasive material in a transversal bidirectional motion. The scars are bifacial and the striations are perpendicular to the edge, implying a transversal bidirectional motion. The material processed is semi-hard because polish and striations are on high areas indicating a rigid material and the scars are infrequent, a pattern consistent with use on soft materials (Figure 6c and d). Rounding and numerous striations characterize use on an abrasive material. Polish and striations are altered by soil sheen, hindering the identification of the material processed. These traces are possibly production traces and may be the result of retouch along this edge. The abrasive nature of the material possibly matches traces from hammerstones, although these traces could also indicate the processing of a semi-hard and abrasive material by the use of the pointed tip.

In summary, macro and micro use-wear traces are preserved and attest to a variety of motions and materials processed. Tools exhibiting use-wear traces include unretouched and retouched flakes that frequently display a back opposite to the active edge that is either formed by blunting retouch or it is natural (either cortical or along a cleavage plane fracture).

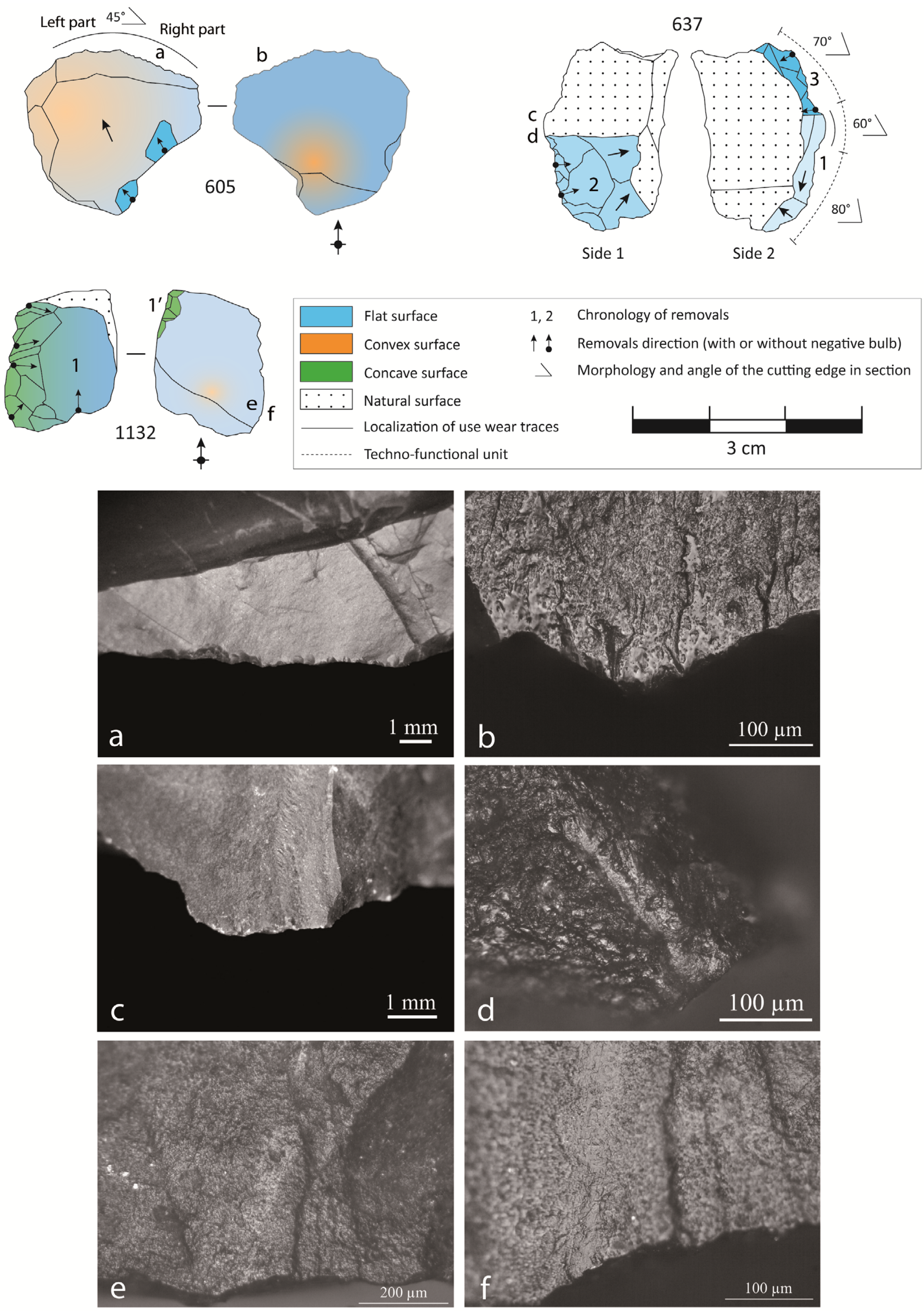

Figure 6: Diacritical sketches of lithics with functional and technological traces and photos of traces. a. and b. circular and elongated small scars opposite to a smooth domed polish on the cutting edge of flake 605 (used to process plant remains in a transversal unidirectional motion); c. and d. small irregular scars opposite to a rough to smooth polish on a slightly rounded arris with long striations perpendicular to the edge of flake 637 (related to technological traces or utilized on a semi hard material in a transversal bidirectional motion); e. and f. large band of polish in the center of a crescent-shaped crack and numerous organized striations on the ventral surface opposite the retouch scars of flake 1132 (technological traces).

4.3. Technological traces

Technological traces are the result of both knapping and retouch. The thick flake, MAR1 1132 has a cortical back opposite to a retouched edge (Figure 6). The latter bears a band of polish and associated concentrated striations (Figure 6e and f), while the cutting edge is fresh. These marks are not considered as use-wear traces, because they are unrelated to other traces of use, and they are isolated. Also, they cannot be PDSM because they are too organized. The striations are strictly parallel to each other, indicating that they derive from the same event. Polish is only evident on one isolated location and is invasive. It is associated with an impact mark, possibly a crack formed by the impact of a hammerstone on the edge. These traces are located on the ventral surface, whereas the retouch is on the dorsal surface. These types of traces formed by retouching are occasionally described by traceologists (Anderson-Gerfaud 1981: 40; Claud 2008: 186; Mansur-Franchomme 1986: 136-137; Rots 2002: 159-163; 2010). The traces from retouching are on the opposite side to the retouch as in the case of direct percussion. They come from the impact of the hammerstone on the surface, explaining why their specific qualities depend on the type of hammer utilized (Rots 2002; 2010;). Retouch traces can be long, isolated, wide and discontinuous striations as in the case of MAR1 1132.

5. Discussion

5.1. Implications for Marathousa 1

MAR-1 is currently the only Middle Pleistocene assemblage in Greece where a functional analysis can be investigated in a reliable framework. While only a limited number of lithics have been studied, the preliminary use-wear analysis provides promising results. Nearly half of the studied pieces (N=6 out of 13) exhibit traces of human activity (use-wear or technological traces), which is rare for an assemblage of this age (Beyries 1990; 1993). Traceological data confirm and complement the information already available from the lithic and faunal remains of MAR-1 by providing data on taphonomy, tool function, morphology and site function.

First, the taphonomical analysis on radiolarite and flint artifacts confirms the exceptional state of preservation of the site. Alterations are mainly of chemical origin, but some mechanical alterations attest to slight movements of the artifacts in the sediment. Minor reworking of the lithic and faunal assemblages has already been identified by previous analyses (Giusti *et al.* 2018; Karkanas *et al*. 2018). Nevertheless, the microscopic analysis of taphonomic marks identified in this study demonstrates a very low frequency and intensity of mechanical alterations. It confirms the initial, macroscopic evaluation, which argued that the artifacts are preserved in mint condition and have not been affected by processes such as trampling, or battering and rounding due to long distance transport (Tourloukis *et al*. 2018b). Moreover, the scarcity of mechanical alterations, as well as the fact that PDSM are generally poorly developed, reinforces the validity of the identification of use-wear traces in the studied sample; additionally, it also indirectly supports the identification of anthropogenic cut-marks on bones, as opposed to marks made by natural processes, because it indicates the latter were either sporadic or of low intensity and duration. In turn, this data supports the arguments about an autochthonous origin of the find-horizon and the taphonomic integrity of the site (Giusti *et al.* 2018), as well as the hypothesis that the finds did not remain exposed to subaerial elements for any considerable time-span (Giusti *et al.* 2018; Karkanas *et al*. 2018; Konidaris *et al.* 2018; Tourloukis *et al.* 2018b)

Secondly, this preliminary use-wear analysis provides new data about potential associations between blank morphology and tool function in the MAR-1 toolkit. As of yet, tools with use-wear traces do not show any significant standardization in terms of blank shape or form (Table 4). The most recurrent characteristics are the length of the active part (often around 20 to 25mm), the unretouched active edge with a straight delineation and the occasional presence of a natural or retouched back opposite the active edge (Table 4). The backing and its possible relationship to prehension demonstrates the importance of considering the complete morphology of the tool, as well as the need to conduct a systematic techno-functional analysis. However, even if the sample of specimens with identified use-wear traces remains limited, it is still noteworthy that more than half of the latter involve blanks that are backed, supporting the original identification of backing as an important technological element in the reduction process (Tourloukis *et al.* 2018b). Nevertheless, at this stage of research, the results are still too preliminary to identify overall trends, and the functional analysis must continue in order to further highlight the techno-economic choices made by hominins. Future traceological analysis of a larger sample will hopefully elucidate important questions that involve not only the MAR-1 toolkit, but also the overall research on small tool assemblages in general. Several questions remain open and need to be addressed in the future, including questions about the type of blank selected for tool use, whether there is a preferred tool type or edge morphology for specific activities, and whether the recurring presence of a backing is associated with hafting, or instead, it reflects choices aimed at facilitating precision gripping.

Thirdly, functional data serve as an independent line of evidence to confirm the zooarchaeological assessment that butchering activities took place at both excavation areas (Konidaris *et al.* 2018). Palaeoenvironmental data demonstrate that plant resources were abundant and in close vicinity to the site, but do not provide direct evidence for the on-site use of plants (Field *et al.* 2018). Here, we demonstrate that plants were exploited by hominins at MAR-1, even though it is not possible to precisely characterize the nature of these activities. Plant processing includes a relatively broad array of possible activities, such as gathering and food preparation, or the production of wooden tools and weapons such as spears. The traceological evidence for plant processing supports the inference that the activities carried out at MAR-1 involved a broader range of tasks than originally hypothesized, and were not restricted solely to the butchering of carcasses.

In summary, considering all data from MAR-1, it appears that a group of hominins produced tools on local materials and utilized them to process vegetal and animal resources before discarding them. Combined with existing knowledge about the context of the site (see Panagopoulou *et al.* 2018 and references therein), this new data on the use of the MAR-1 lithics raises new questions about site-function. Specifically, the evidence presented in this study opens up the possibility that MAR-1 was not necessarily a special-purpose site for the extraction of animal resources, but included other tasks, possibly involving to various degrees of intensity the exploitation or use of plants in combination with stone tool maintenance and use.

Table 4. Summary of pieces from MAR-1 with use-wear traces.
Abbreviations: Long. - longitudinal; Transv. - transversal; Unidir. - unidirectional; Bidir. - bidirectional.

Speci-men	Lithic type	Length (mm)	Raw material	Techno-functional unit					Functional data							Opposite back
				Retouch	Edge angle (°)	Plan view	Profile view	Cross section	Scars	Rounding	Polish	Striations	Motion	Direction	Material	
1.2	Unretouched flake	46	Flint	No	50-60	Concave	Straight	Biplane	x		x	x	Long.	/	Hard	Siret?
605	Unretouched flake	20	Radiolarite	No	45	Convex	Straight	Biplane	x	x	x		Transv.	Unidir.	Plant	Absent
620	Retouched flake	25	Radiolarite	No	50	Straight	Straight	Biplane		x	x	x	Long.	/	Hard. Butchery?	Retouched
625	Unretouched flake	24	Radiolarite	No	30	Convex	Straight	Plano-convex	x	x	x	x	Long.	/	Butchery	Absent
637	Retouched chunk	25	Radiolarite	Yes	60-80	Pointed	Straight	Biplane	x	x	x	x	Transv.	Bidir.	Semi hard abrasive	Natural

5.2. Implication for the discussion on small tools during the Lower Paleolithic

Functional data on small tool assemblages are scarce for the Lower Paleolithic. Use-wear analyses on small blanks and tools have been performed on assemblages from fewer than ten sites in total (Supplementary file 2). Similar to MAR-1, the small tools are typically the dominant component in these assemblages. One of the most striking features is the relatively high number of small blanks with use-wear traces in the analyzed samples, which suggests that small flakes were the intended blanks. Even though few studies have been able to demonstrate the deliberate production of small flakes (*e.g.*, Zaidner 2013), this hypothesis can be indirectly supported by considering some arguments: 1) Lower Paleolithic small flakes are produced with local raw materials or not (even of low quality) as in Qesem cave, which indicates that their production was not related to the absence of large blocks in the vicinity of the site to produce larger tools and 2) cores are at times heavily reduced and exhausted; however, it is not always clear whether these are formal cores or tools.

Throughout these sites (Supplementary file 2), small tools are mainly used to process soft and semi-hard materials. When worked materials can be identified, they primarily involve butchering activities and to a lesser extent, vegetal materials (Lemorini 2018; Venditti 2019). The MAR-1 lithics investigated so far seem to fit into this functional scheme where small blanks are found in association with remains of large- or medium-sized mammals (see Supplementary file 2 and references therein). It is frequently suggested that these are tools used in the final stages of the butchering process (Longo *et al*. 1997; Venditti 2019: 153-154 ; Venditti *et al*. 2019b). Clark & Haynes (1970) suggest that small items were predominant in the Paleolithic butchery toolkit in addition to larger tools. Our preliminary results suggest that small tools were used for different tasks, as also seen at La Ficoncella and La Polledrara di Cecanibbio (Aureli *et al.* 2016; Lemorini 2018).

Small tool assemblages incorporate a wide variety of tool types and morphologies, which therefore may have potentially been used to process a wide range of materials in several distinct types of motion. Frequently, there is little to no standardization in the morphology or the type of blanks that are selected for the production of tools. At MAR-1, the utilized blanks typically have a sharp edge opposite to an edge with a more obtuse angle, frequently along a cleavage plane fracture or blunted by steep retouch, which may have facilitated prehension (Vergès 2002: 467-469). The active edges are either utilized unretouched or retouched. The retouch promotes shaping and resharpening to obtain different edge morphologies (denticulated, pointed, straight and regular) which possibly corresponds to specific needs or provides a stronger active edge (Lemorini 2018). Currently, at MAR-1, the active edge is typically unretouched. However, functional analyses on small flakes need to continue to better understand hominin preferences for tool morphologies.

One of the most recurring questions about small tools is the mode of prehension. Small flakes from Revadim, La Polledrara di Cecanibbio and Schöningen exhibit prehension traces, whereas they were possibly wrapped (in a sheath, vegetable or leather, to facilitate gripping or before being mounted on a handle; Rots 2002: 54) at Qesem Cave (Lemorini 2018; Venditti 2019: 97-142; Venditti *et al*. 2019a; 2019b). With the current functional data on tools from MAR-1, there is no evidence to determine if they were hand-held, hafted or wrapped. For the Lower Paleolithic small tools, the question of prehension is still unresolved, primarily because of the lack of functional studies, and secondly, because we do not fully understand the motor and cognitive skills of various hominin groups (Beyries 1990). However, experimental reproductions of small tools demonstrate that backing opposite to a sharp edge provides a superior grip and promotes the application of force and precision. Experiments also attest to shorter cutting edges providing higher precision during activities, but these are quickly exhausted or dulled (Chazan 2013; Jones 1980; Starkovich *et al*. 2021; Venditti 2019: 50-88;

Venditti *et al*. 2019a). This possibly explains why these tools were frequently used, but only at brief intervals, as seen for example at Isernia la Pineta, La Ficoncella, Revadim and Qesem Cave (Aureli *et al.* 2016; Lemorini *et al.* 2015; Longo *et al.* 1997; Venditti *et al.* 2019a; 2019b).

In summary, numerous questions regarding the function, morphology or prehension, and the role of small tools in the hominin toolkit remain unresolved. Functional data are useful to answer some of these questions regarding small tool assemblages, but are in themselves inadequate to sufficiently or fully evaluate these assemblages. The site context, including faunal remains, palaeoenvironmental data, raw material properties and availability, altogether constitute important elements that must be taken into account when trying to explain and interpret the production and use of small tools. The latter occur alongside larger flake industries or assemblages with bifaces and bifacial reduction sequences, thus adding to the complexity of toolkits from this period. This broad variability of the Lower Paleolithic industries is still poorly understood, hindering the assessment of techno-economical choices of hominins. We must begin to reconsider the assemblages in their entirety, instead of focusing only on artifacts such as bifaces or small flakes recently defined in opposition to them. The work presented in this study is part of a broader project, which includes the Lower Paleolithic industries at Valle Giumentina (MIS 15-12; Abruzzo, Italy) and Soucy (MIS 9; Yonne, France) in order to identify tools and their modes of use (Guibert-Cardin *et al.* 2021; Nicoud *et al.* 2020).

6. Conclusions

The preliminary study on a sample of lithics from Marathousa 1 has yielded promising results. The traceological analysis of 250 specimens succeeded in identifying modifications of taphonomical origin on 223 lithics, while 13 lithics were subjected to a more detailed analysis for the assessment of possible use-wear traces. In general, all artifacts are very well preserved and almost half of the 13 pieces investigated demonstrate traces of human activities, namely use-wear traces or technological traces, which is significant for an assemblage of this age. As the analysis is on-going, this pilot study highlights the potential of the MAR-1 assemblage for identifying more lithics with evidence of utilization. On the basis of the results presented here, the use-wear traces confirm the zooarchaeological evidence for butchering activities. Our results also provide the first direct evidence for on-site processing of plants at MAR-1. Consequently, the MAR-1 toolkit was not utilized only for butchering, but served also as the technological means to process vegetable resources.

Lower Paleolithic tools remain inadequately understood, particularly with regard to the modes of use, morphology and potential for prehension. Middle Pleistocene assemblages that have been subjected to functional analyses are still rare, which hinders our understanding of these ancient lithic industries. Small tool assemblages co-exist at times with bifacial industries, but also concurrently with core-and-flake industries based on (larger) flake-blanks. Recent research on the Middle Pleistocene lithic variability investigates whether the differences in the composition of these diverse industries is related to cultural or temporal trends, site functions, or availability of raw materials. The pilot techno-morpho-functional study presented here is part of this broader reassessment, which begins with well-dated, well-preserved and well-documented sites, as a solid chronostratigraphic and contextual framework constitutes a prerequisite for conducting reliable techno-morpho-functional analyses. MAR-1 meets these prerequisites and the further development of a use-wear dataset from this site is essential in order to advance the identification of activities that have taken place on-site, and to better characterize tool use during the Middle Pleistocene.

Acknowledgements

We would like to thank the Wiener Laboratory and the American School of Classical Studies at Athens for welcoming us and for providing us with the optical equipment to conduct this study. We especially thank Dr. P. Karkanas, Dr. D. Michailidis (Wiener Laboratory, ASCSA), Dr. G. Tsartsidou (Ephorate of Palaeoanthropology and Speleology, Hellenic Ministry of Culture and Sports) and Dr. P. Fernandes (UMR 5199 PACEA and Paléotime) for their assistance in the traceological analysis and meaningful discussions. We are grateful to the Ephorate of Palaeoanthropology and Speleology of Greece for granting us the permit to conduct this study. We also thank the two anonymous reviewers for their constructive comments, which helped improve the manuscript.

This work has been supported by the French government, through the "Université Côte d'Azur UCA[JEDI] Investments in the Future" project managed by the National Research Agency (ANR) with the reference number ANR-15-IDEX-01. This research was also supported by the European Research Council (ERC StG 283503 "PaGE" and ERC CoG 724703 "CROSSROADS", both awarded to KH) and the DFG (HA 5258|TO 1474).

Data accessibility statement

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary files

List of supplementary files

Supplementary file 1
"GUIBERT-CARDIN_supplementary file 1_SpecimenDescription.docx"
The file includes the detailed descriptions and the diacritical and functional analysis of the specimens with traces of human activity mentioned in the article.

"GUIBERT-CARDIN_supplementary file 2_table_summarise.xls"
The file shows the use-wear data on small flakes from Lower Paleolithic sites in Europe and the Levant (from oldest to most recent). They are all open-air sites except for Qesem Cave.

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La fonction des petits outils sur éclat en Europe au Pléistocène moyen : le cas de Marathousa 1 (Megalopolis, Grèce)

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Abstract:

Les petits outils sur éclat sont présents dans de nombreuses industries européennes mais demeurent mal appréhendés (Rocca *et al.* 2016). Définie sur des critères typologiques (denticulés, grattoirs, pièces à dos) et dimensionnels (environ 20-40 mm ; Burdukiewicz & Ronen 2003 ; Rocca 2013 : 236-251), cette catégorie d'outil a été créée en opposition aux plus gros outils, comme les pièces bifaciales. Le terme de petit cache toute une variété de comportements techno-économiques englobant, entre autres, de multiples méthodes de production (alterne, multidirectionnel ou discoïde) ou de supports d'outil (nucléus, outils, éclats ou débris ; Tourloukis *et al.* 2018b). Les petits éclats ne sont spécifiques ni à une région ni à contexte et l'origine de ces séries est encore débattue. La question se pose de savoir si elles sont liées à leur ancienneté, à des activités spécifiques ou encore à une préservation différentielle des sites où les petits éclats sont parfois conservés tandis qu'ils auraient disparu dans d'autres contextes.

Pour améliorer notre compréhension de ces artefacts, nous proposons de nous intéresser à leur fonction à travers une analyse techno-morpho-fonctionnelle (Boëda 1997 ; Lepot 1993) et tracéologique (Semenov 1964). Cette approche combinée permet de documenter la chaîne opératoire lithique depuis la production des outils jusqu'à leur utilisation en passant par l'analyse de leur morphologie finale avant leur abandon (Guibert-Cardin *et al.* sous presse). Elle offre l'opportunité de définir si les outils étaient multifonctionnels ou destinés à une utilisation précise, si leur mode d'utilisation était complémentaire ou similaire à celui des plus grands outils ou permet de documenter leur mode de préhension. Pour aborder ces questions, les séries lithiques se doivent d'être bien conservées et issues de sites bien datés et ayant fait l'objet d'analyses pluridisciplinaires.

Ici, nous présentons les résultats de l'analyse tracéologique préliminaire de l'industrie lithique de Marathousa 1 (MAR-1 ; Megalopolis, Grèce). Le site se situe dans le bassin de Megalopolis qui a périodiquement accueilli un ancien lac (Panagopoulou *et al.* 2018). Attribué au Stade Isotopique Marin 12 (*ca*. 400-500 ka BP ; Tourloukis *et al*. 2018a), MAR-1 est le plus ancien site de plein-air du sud-est de l'Europe. Les vestiges, rapidement enfouis, sont préservés dans une matrice à grain fin et ont subi des remaniements mineurs (Karkanas *et al.* 2018). La fouille est divisée en deux aires. L'aire A a révélé le squelette presque complet et en connexion anatomique approximative d'un éléphant

(Konidaris *et al*. 2018). Il porte des traces de découpe et est associé à une faible densité de vestiges lithiques. L'aire B présente une quantité plus élevée d'artefacts lithiques ainsi que des ossements de différentes espèces, attestant de modifications d'origine anthropique. La série lithique de MAR-1 contient 2 058 artefacts, produits à partir de différentes matières premières (radiolarite, silex, calcaire et quartz) collectées à proximité du site. L'industrie révèle des supports d'outil variés et se compose de nucléus et de petits éclats. Le dos, fréquent dans la structure des artefacts, semble occuper une place importante dans la production des supports d'outil et est généralement opposé à un bord fin.

Pour cette analyse préliminaire, nous avons étudié 223 artefacts pour une analyse taphonomique et 13 pour une analyse fonctionnelle. Les pièces présentent un état de conservation exceptionnel. Les altérations sont principalement d'origine chimique. Quelques altérations d'origine mécanique confirment que les artefacts ont subi de légers mouvements après leur abandon. Les premiers résultats fonctionnels documentent des activités de boucherie ainsi que l'exploitation de végétaux. Les activités réalisées étaient donc plus variées que ce qui était initialement envisagé : Marathousa 1 n'est pas seulement un site de boucherie. En outre, plusieurs pièces portent des traces technologiques ce qui est rarement mis en évidence sur des artefacts aussi anciens. Il ne semble pas exister de lien entre le support d'outil, le type de tranchant et l'activité réalisée. Les artefacts avec des traces d'utilisation sont des petits éclats bruts ou retouchés, non standardisés et il semblerait que leur sélection soit dictée par la présence d'un dos, avec un potentiel préhensif, opposé à un bord coupant.

Ces premiers résultats tracéologiques sur les artefacts de MAR-1 sont en accord avec les rares données fonctionnelles disponibles sur les petits outils sur éclat au Paléolithique inférieur en Eurasie. Ces outils sont principalement utilisés dans le cadre d'activité de boucherie et dans une moindre mesure pour l'exploitation de végétaux (Lemorini 2018 ; Venditti 2019 : 153-154). Les petits outils sur éclat semblent donc être utilisés pour des activités variées (Aureli *et al*. 2016 ; Lemorini 2018). Aucune trace de préhension n'a été observée au sein de l'échantillon de MAR-1. Cependant, la présence d'un dos ou d'un bord non tranchant associé au bord actif, ainsi que l'absence de standardisation des outils, suggèrent une utilisation à mains nues plutôt qu'un emmanchement. Les expérimentations menées avec des petits outils sur éclat attestent que la présence d'un dos opposé à un bord fin fournit une bonne prise en main de l'outil et permet d'appliquer force et précision lors de l'utilisation (Chazan 2013 ; Jones 1980 ; Starkovich *et al*. 2021).

La poursuite de l'analyse combinée techno-morpho-fonctionnelle et tracéologique de l'industrie lithique de MAR-1 permettra de documenter plus précisément les activités réalisées sur place et de mieux appréhender la structure des outils et leurs modes de fonctionnement. Cette étude contribue à enrichir les rares données fonctionnelles disponibles sur les petits outils sur éclat et plus généralement sur les outils du Pléistocène moyen. Elle s'inscrit dans le renouveau des connaissances sur la période visant à mieux caractériser la diversité des productions lithiques.

Mots-clés : Paléolithique inférieur ; Pléistocène moyen ; Grèce ; petits outils sur éclat ; taphonomie ; analyse fonctionnelle ; analyse techno-morpho-fonctionnelle