Experimental production of the Late Neolithic/ Early Chalcolithic engraved schist plaques of Southwestern Iberia: an approach to techniques and tools

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Os autores escrevem segundo o Acordo Ortográfico de 1945

Abstract Engraved schist plaques are one of the most original artistic manifestations in Southwestern Iberia during the Late Neolithic and Early Chalcolithic local chrono-zones (3200–2600 cal BCE), being assumed to be the distinguishing feature of the megalithic group that develops in this region since the mid-4th millennium BCE onwards. Although their «symbolic production» (in terms of their possible meanings) is extensively debated, the stages of their «physical production» are yet to be precisely defined, especially regarding the techniques and tools used. Based on some Experimental Archaeology exercises, the authors rehearse a practical approach to the manufacture of engraved schist plaques by defining the possible tools used in their production and how they influence the final outcome of the artefact. Replicas were analysed both macroscopically and microscopically, combining SEM (scanning electron microscopy) and EDX (energy-dispersive X-ray spectroscopy), in order to identify potential micro evidence from the use of different tools, thus setting up some working basis for further analysis on archaeological samples.

Resumo As placas de xisto gravadas são uma das mais originais manifestações artísticas do Sudoeste peninsular durante o Neolítico Final e Calcolítico Inicial (3200–2600 cal a.n.e.), sendo assumidas como um elemento característico do grupo megalítico que aqui se desenvolve desde meados do IV milénio a.n.e. adiante. Ainda que a sua «produção simbólica» (a nível dos seus possíveis significados) seja amplamente debatida, as etapas da sua «produção física» ainda não estão definidas com rigor, particularmente em relação às técnicas e utensilios utilizados. Com base em alguns exercícios de Arqueologia Experimental, os autores ensaiam uma aproximação prática à produção de placas de xisto gravadas, procurando definir os potenciais utensilios utilizados na sua manufactura e de como estes influenciariam o resultado final do artefacto. As réplicas produzidas foram analisadas tanto macroscopicamente como microscopicamente, combinando análises de SEM (microscopia electrónica de varrimento) e EDX (espectroscopia de raios X por energia dispersiva), com o objectivo de identificar potenciais micro evidências do uso de diferentes utensílios, estabelecendo deste modo uma base de trabalho para análises futuras sobre amostras arqueológicas.

1. Introduction

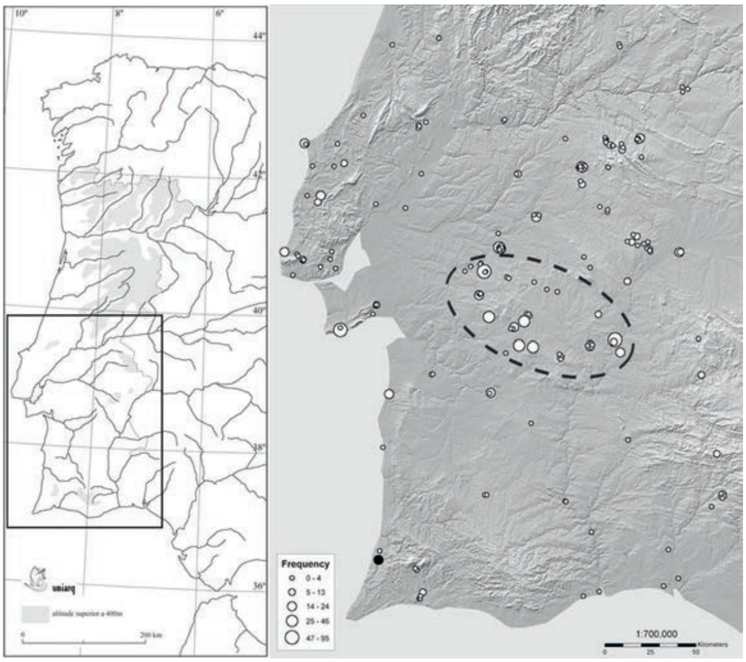


Fig. 1 – Distribution of engraved schist plaques in Southwestern Iberia, according to their frequency (adapted from Lillios, 2008a, p. 15, fig. 1.6). Despite some gaps, due to the lack of effective works (or their publication), there is a special concentration on the area of Central Alentejo, both by the number of identified contexts and by the number of engraved schist plaques within each context. The black dot indicates the set of Aljezur; the dashed ellipse indicates the area of Central Alentejo.

This paper details the experimental engraving of replicas of a schist plaque from Aljezur, a rock-cut tomb in Southwestern Portugal dating to roughly the first half of the 3rd millennium BCE (Gonçalves, 2004c). Thousands of these hand-sized perforated schist plaques have been found in Late Neolithic/Chalcolithic megalithic tombs, and naturally or artificially constructed caves in Southern Portugal and Spain. They are thought to have been associated with specific individuals in collective burials, as they tend to be found adjacent to or, in few cases, on the chest of the body when associated with fully (or partially) articulated skeletons, like in the cave of Cova das Lapas, Alcobaça or in the passage grave of Santa Margarida 3, Reguengos de Monsaraz (Gonçalves, 1989; 1999; 2003b). The engraved schist plaques display a wide range of decorative motifs (discussed below), and, with some exceptions, appear to have been produced by semi-skilled individuals (Thomas, 2009).

This study examines replicas of the plaque MNA 985.39.42 from Aljezur, the original of which is housed in the Portuguese National Archaeological Museum, in Lisbon (Gonçalves, 2004c). This plaque is of specific interest because it is engraved with over 200 small (~7 x 9 mm) densely cross-hatched triangles, triangles far smaller and greater in number than any of the other 23 plaques found at Aljezur, or any other known engraved plaques in Iberia. Because the Aljezur site is roughly coeval with the advent of copper metallurgy in this part of Portugal, it has been suggested that the stylistic shift seen in plaque MNA 985.39.42 was partially the result of technological innovation, specifically the introduction of copper-based engraving tools. To test this proposition, we created a set of replica schist plaques and engraved them with bone, quartz, flint, copper, and steel tools (the latter used as a control), and then analysed the engraving signatures both macroscopically and microscopically, combining SEM (scanning electron microscopy) and EDX (energy-dispersive X-ray spectroscopy), in order to identify potential micro evidence from the use of different tools. These analyses aim to set up some working basis for further studies, especially on archaeological samples.

2. The engraved schist plaques of Southwestern Iberia

Engraved schist plaques are undoubtedly one of the most expressive and representative (and perhaps the most unique and emblematic) artistic manifestations of the ancient peasant societies in Iberia. With an obvious symbolic force (whatever the theoretical fields on which it is read), they have a diffusion focus apparently centred on the area of Alentejo (where monuments with more than a hundred plaques are known), extending from here to bordering areas such as the Portuguese Estremadura, Algarve and Andalusia (Fig. 1). In fact, more than 60% of the plaques collected so far in Southwestern Iberia come from the region of Central Alentejo, slightly coincident with the current area of Évora district (mainly concentrated in the municipalities of Mora, Montemor-o-Novo, Évora and Reguengos de Monsaraz, with over 1500 registries of votive plaques); so, it is logical to assume that this area is the effective emergence centre of these artefacts, between 3200 and 2600 cal BCE.

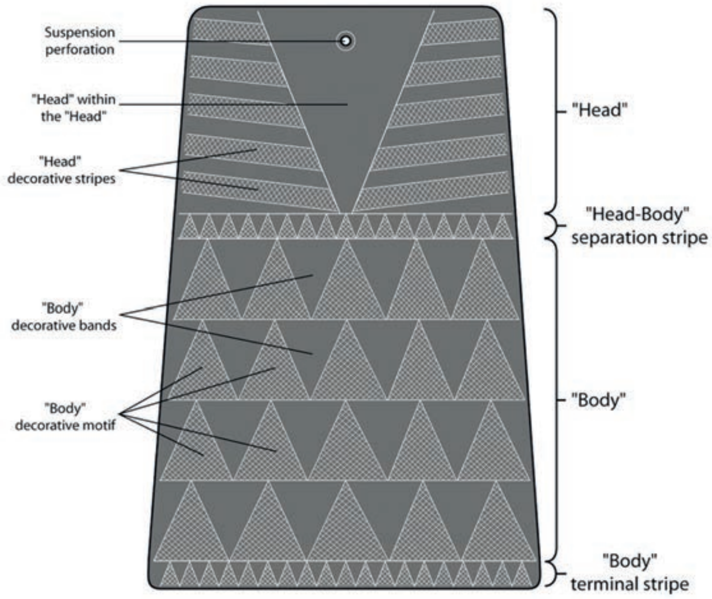


Fig. 2 – Schematic representation of the «anatomy» of a classical engraved schist plaque, with the indication of the different morphological fields.

They are precisely assumed to be the main element that characterizes (as it distinctive component) the megalithic group that develops in Southwestern Iberia during the last centuries of the 4th millennium BCE (Late Neolithic local chrono-zone), being part of the votive sets (thus reflecting specific funerary rituals) that accompany burials performed in several types of funerary contexts: orthostatic monuments, rock-cut tombs, natural caves, corbel-vaulted tombs, unstructured tombs (pit graves).

They are usually engraved with geometric motifs, but there are known examples that present some special features that contribute to a clearer definition of their strict meaning, namely (and in terms of iconography or morphology) clearly anthropomorphic attributes (or rather, teomorphic), of feminine nature, related to the distinctive symbolics of the Great Mother Goddess of the Mediterranean Neolithic.

During the first half of the 3rd millennium BCE (and perhaps closer to its mid), some symbols clearly related to the Chalcolithic archaeo-metallurgical communities are depicted in these artefacts, such as double rayed figuration designated as «Sun Eyes» or the representation of a possible male figure, equivalent to the «Young God» of the Mediterranean cultural milieu, showing perhaps the adjusting of elements of a new magical-religious subsystem to old symbols, indicating the cultural continuity of the use of engraved schist plaques between the Neolithic and the Chalcolithic.

These artefacts are preferably produced on slate (and occasionally in other kinds of schists, such as amphibolic schist, chloritic schist, serpentinite, mica-schist), with an essentially sub-rectangular or sub-trapezoidal contour (there are also examples with anthropomorphic contour, with a carved head and shoulders), engraved with a wide range of decorative motifs. Morphologically, their *design* can be divided into several independent fields (Fig. 2).

The «Head», occupying the upper third of the plaque, is usually decorated with parallel lateral stripes (horizontal, vertical or oblique), converging towards the central V (the «Head within the Head» or «Collar»). Alternatively to these lateral bands, the sides of the «Head» can be completely filled or can be also decorated with bands of triangles or zigzag stripes, sometimes prolonging the decorative motif of the «Body», with or without separation (in the latter case, the «Head» is indicated only by the «Head within the Head»). It may also be plain (undecorated) or decorated with anthropomorphic motifs, such as simple eyes or complex facial depictions (combining eyes, eyebrows, nose and facial paintings/tattoos).

The «Head within the Head» usually presents a triangular or trapezoidal feature (with the apex pointing downwards), with some cases in which it displays a rectangular or quadrangular feature. It may be bounded, enclosed by filled stripes.

The «Body» presents decorations generally formed by geometric compositions filled with reticulated lines, normally arranged in the lower two-thirds of the plaque. Note that these compositions can present multiple variances, being mentioned here only the most common ones.

The most common are, in order of frequency, the bands of filled triangles, the zigzag stripes and the checkered fields. The first motif is represented in some variants such as triangles with the apex pointing up, triangles with the apex pointing down, and hollow triangles (filled triangles with an empty triangle inside). The zigzag stripes are divided between compartmented and non-compartmented patterns, also known in the variant of compartmented zigzag lines (addorsed spine pattern). The checkered motifs are divided between the examples of cells with quadrangular feature and cells with vertical rectangular feature. Less common motifs are found in examples decorated with vertical or oblique stripes or with a central radiant motif.

Plaques may have separation areas between these two fields, the most common being characterized by a simple separation line. However, there are cases in which this separator is composed by a stripe (filled or plain) or a band with geometric motifs different from those of the «Body», highlighting also the presence of complex separators almost assumed as independent decorative motifs.

They may also have an «ending indicator», corresponding to a stripe (plain or filled) or a band with geometric motifs distinct from those of the «Body», closing the main decorative pattern («Body terminal stripe»).

In canonical plaques, these fields are object of structural pagination through the engraving of guidelines that will frame the subsequent decoration.

Mostly they have one suspension perforation, with some examples with double perforation and (less common) without any perforation (possible related to secondary depositions of already dismantled bodies).

While not wishing to backtrack to the beginning of the study of Iberian schist plaques, as this is not the place to thoroughly discuss the various interpretive readings (with one of the first comprehensive studies authored by Estácio da Veiga, precisely based on the set of Aljezur; see Veiga, 1886; 1887), it nevertheless should be mentioned the most recent contributions. During the last decades, several authors have been assiduously dedicated to the study of engraved schist plaque, namely, P. Bueno Ramírez, K. Lillios, V. S. Gonçalves and M. A. Andrade (the two latter within the PLACA-NOSTRA project, from UNIARQ). However, these authors do not follow in parallel interpretive paths regarding the significance of the engraved schist plaques.

To Bueno Ramírez, these artefacts present themselves as a means of ethnic identity of contemporary groups, invoking ancestral memories, thus denoting a strong regional slant in their production (Bueno, 1993; 2010; 2020). According to this researcher, the dispersion of similar motifs should be explained only by regional exchanges, which may include matrimonial exchanges.

Based on both the diversity and uniformity of the engraved schist plaques, Lillios argues that these artefacts are genealogical records of the dead serving as long-lasting indicators of regional group identities. These records would have contributed to legitimize and perpetuate an ideology of inherited social difference since the Late Neolithic (Lillios, 2002; 2003; 2004; 2008a; 2008b; 2008c; Lillios & Thomas, 2009). This interpretative assumption has been recently called into question, based on phylogenetic analysis applied to the engraved schist plaques, showing that the broad dispersion of identical decorative patterns, as well as the overlapping of different ones, invalidates their strict reading as clan indicators — demonstrating that one single common denominator influences their iconographic composition (García & O'Brien, 2014a; 2014b; García, 2017).

Slightly different, the idea of Gonçalves and Andrade, focuses on the hypothesis that these artefacts are exclusively the representation of one or more deities who would play a leading role in funerary rituals – hence their common designation as «plaque-idols» (for instance, for the Portuguese case, see Oliveira, 1998; 2006; Boaventura, 2009). The decorative variances are thus basically interpreted as representations of a female deity, whose coating changes but the very significant essence does not. Motifs of bands of filled triangles, zigzag stripes, checkered fields or vertical/oblique/horizontal bands are therefore basic, coded symbols, references to the same symbolic entity (Gonçalves, 1989; 1992; 1993; 1999; 2003a; 2003b; 2004a; 2004b; 2006a; 2006b; 2008; 2011; Andrade, 2015).

Their symbolic character is precisely understood not only for their prominent place in the votive sets of megalithic groups of the Late Neolithic/Early Chalcolithic but also by the very iconography and imagery that they (explicitly or implicitly) show. More or less schematic, more or less figurative, only one single idea seems to influence the design of the engraved schist plaques and their counterparts (like, for instance, the sandstone plaques): the depiction of a symbolic entity (or several) related to a conception of death/regeneration/fertility, whose image changes, though not changing the figurative content. The symbols that are clearly associated with the Neolithic/Chalcolithic Great Goddess (such as the pubic triangle, the eyes, the facial paintings/tattoos, the hair, the necklace, etc.) appear schematically depicted on engraved schist plaques. However, these features are not exclusive to these artefacts, appearing equally represented on pottery vessels, sandstone plaques, cylindrical limestone idols, limestone plaques, ceramic or bone figurines and on horse or deer phalanxes, artefacts that can hardly be assumed to be heraldic indicators. And having apparently the same symbolic weight as the engraved schist plaques, it is logical to suppose that they fall under the same interpretative framework.

3. The engraved schist plaque MNA 985.39.42 from Alzejur and its context

Plaque MNA 895.39.42 from Aljezur (already described in Gonçalves, 2004c) is assumed as a case of particular interest in the area of the iconography and imagery of engraved schist

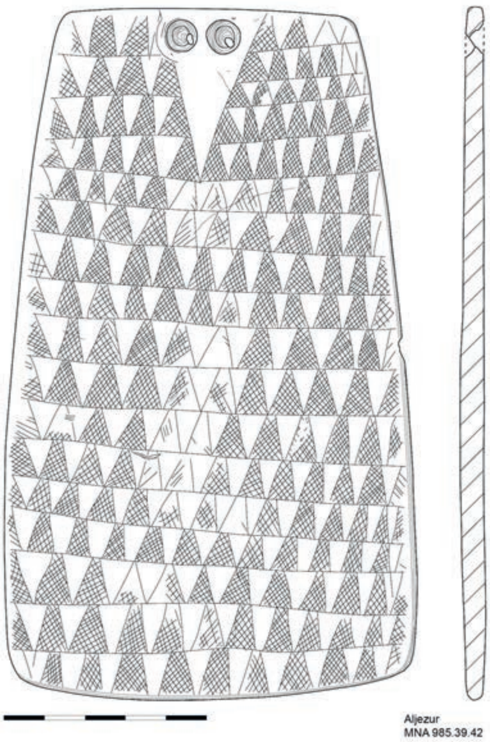


Fig. 3 – The engraved schist plaque MNA 985.39.42 from Aljezur (as presented in Gonçalves, 2004c, p. 39, fig. 8).

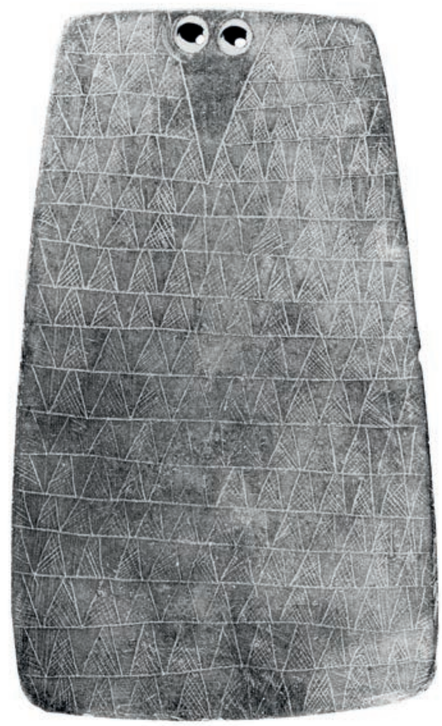


Fig. 4 – The engraved schist plaque MNA 985.39.42 from Aljezur.

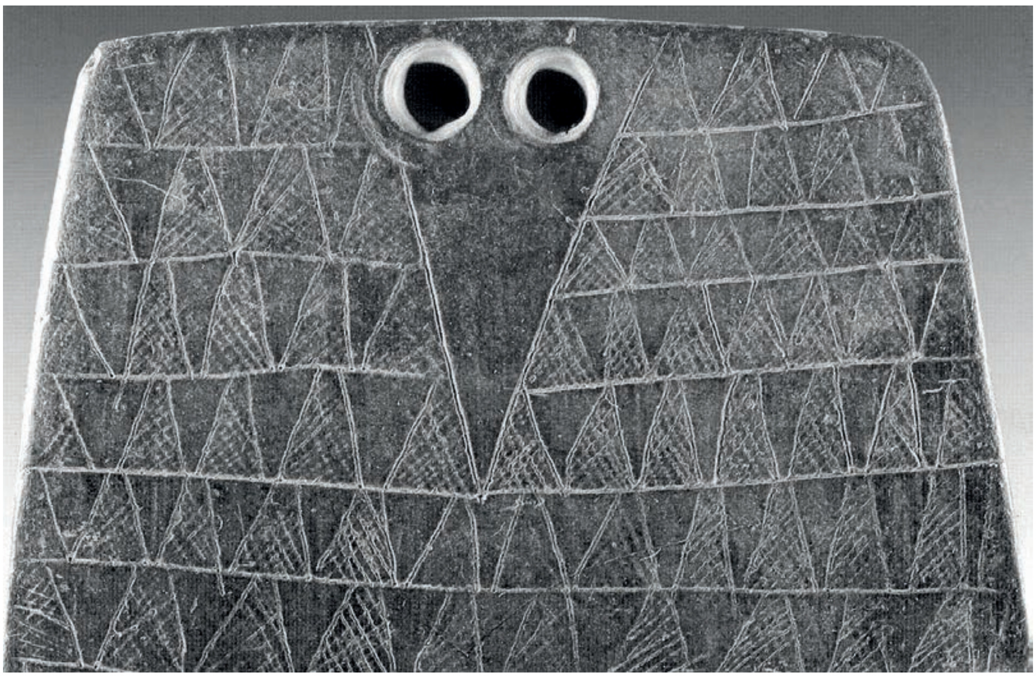


Fig. 5 – Detail of the «Head» of the engraved schist plaque MNA 985.39.42 from Aljezur.

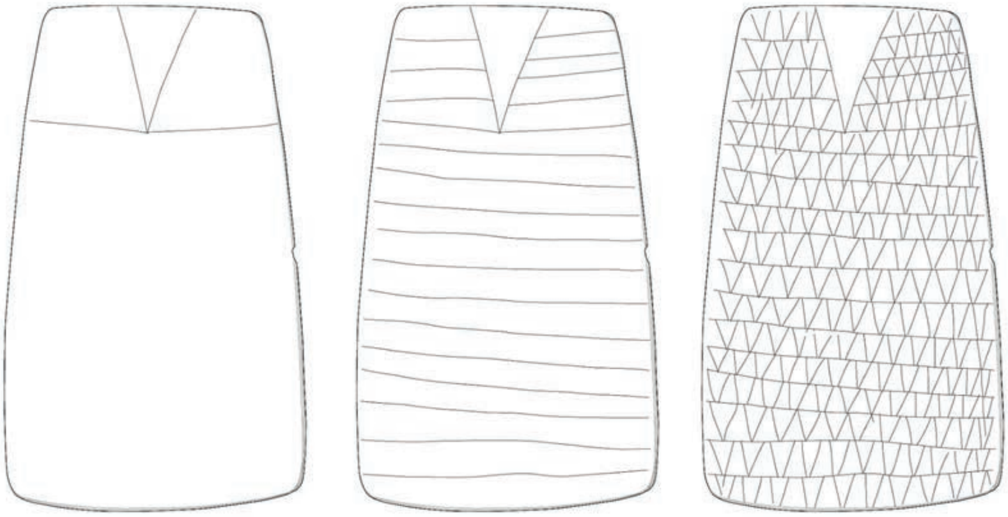


Fig. 6 – Structural pagination of the decoration of the original engraved schist plaque MNA 985.39.42 from Aljezur. 1: delineation of the «Head» and «Body», and the «Head within the Head»; 2: delineation of the decorative bands of the «Head» and «Body»; 3: delineation of the decorative motif of the «Head» and «Body» (triangles).

plaques of Southwestern Iberia, particularly in the generic *collectanea* of these artefacts. Indeed, the provision of the decorative motif is somewhat unusual: it is engraved with over 200 small (~7x9 mm) densely cross-hatched triangles, far smaller and greater in number than any of any other known engraved plaques in Iberia (including the ones collected in Aljezur). Likewise, the decorative motif engraved in the «Body» is exactly the same as the one engraved in the «Head» (which is also unusual), conveying the idea that the «Body» extends into the space of the «Head», the latter indicated only by the central V, the *Triangle-Head*, representing the «Head within the Head» (Figs. 3 to 5).

It was produced using a greyish-blue slate, with a sub-trapezoidal outline. It presents 170 mm in length, 96,3 mm in width on the base, 70,8 mm in width on the top, 6,7 mm in thickness and 213 g in weight.

The pagination of its decoration is effectuated through an engraving sequence very easy to define, established by microscopic analysis of overlapping lines. Firstly, the *Triangle-Head* was engraved; secondly, the guideline corresponding to the base of the fourth left band, that slightly bisects the apex of the *Triangle-Head*, and then the line corresponding to the base of the fifth right band, the last to connect to the *Triangle-Head*; then follows the engraving of the remaining rows of guidelines and their filling with triangles (Fig. 6).

The stroke of the twelve guidelines below the apex of the *Triangle-Head* is more or less regular, except for #11 and #12 where the engraver's trace lost direction due to the surface irregularities seen in this area of the plaque.

Above the level of the twelve guidelines, we have, to the left of the *Triangle-Head*, four lines, and another five to the right, which is naturally translated into differentiated heights of the respective filling triangles. Apparently, this makes that this plaque has an eventual «Head», formally speaking and without an undeniable separation between the «Head» and the «Body», considering in this perspective that it would correspond to the base of the fourth band of the left side and the base of the fifth band on the right side of the *Triangle-Head*. Indeed, the convergence of these lines toward the apex of the triangle creates an effective separation in the pagination of the decoration.

The engravings present very regular thin lines, appearing to have been performed with two different tools. Indeed, there is a difference between the width of the pagination lines (the guidelines) and the contour of the triangles (between 0,30 and 0,20 mm wide) and the width of the filling lines of the triangles (between 0,10 and 0,20 mm wide). This difference can be explained by the small size of the triangles, requiring a more fine-tipped tool for being objectively filled (Fig. 7).

It presents two perforations with a bi-troncoconical profile, slightly decentered in relation to the *Triangle-Head*. The left one has an exterior circle-segment mark. These perforations, apparently intact, without any macroscopic use-wear traces, were not utterly made on both sides, without full convergence. There are also marks on the reverse of unfinished drilling attempts. It is, in fact, this «unfocused» perforation, and

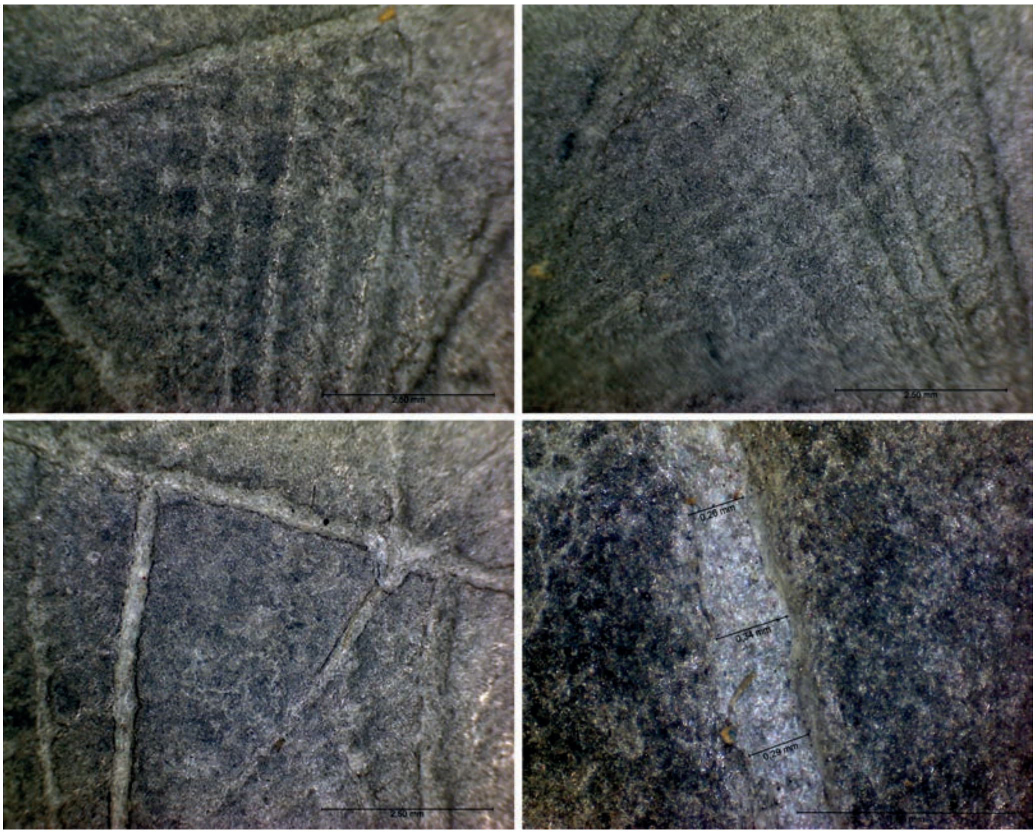


Fig. 7 – Microscopy (50x and 200x) of the decoration of the engraved schist plaque MNA 985.39.42 from Aljezur. It appears that two different engraving tools were used: a first one used in the delineation of the contours of the decorative pattern (broader lines, between 0,20 and 0,30 mm wide) and a second one used in the filling of the decorative motifs (thinner lines, between 0,10 and 0,20 mm wide).

the trace visible on the left that corresponds to a first drilling attempt, that gives to this plaque the «droll» appearance of a character from the series *Spy* vs. *Spy* from *Mad* magazine. For this purpose, it helps the «crow-beak» triangle, but are the perforations that enhance this «similarity». The double perforation acts here as a representation of «Eyes», thus strengthening the anthropomorphic character of the plaque (as detailed in Fig. 5).

The engraved schist plaque MNA 985.39.42 was collected from a rock-cut tomb constructed on soft limestone formations, located next to the parish church of Nossa Senhora d'Alva, in the village of Aljezur. It was identified and excavated by Estácio da Veiga in 1881, already in an advanced state of destruction due to its location in the urban center of Aljezur (Veiga, 1886). Along with the plaque MNA 985.39.42, another 23 engraved schist plaques were collected from this tomb (some of them equally remarkable in iconographic terms). Such a figure, combined with the minimum number of 30 individuals buried therein (counted by the osteological remains), allows us to infer that much of the burials performed therein would be accompanied by engraved schist plaques, demonstrating also the collective and egalitarian nature of this tomb.

An interesting set of votive artefacts was collected together with the schist plaques (Veiga, 1886; Leisner, 1965; Gonçalves, 2004c; Gonçalves & Andrade, in press). Pottery, present in a small number (three complete vessels), is represented by common shapes, highlighting a small «lamp» and a small globular pot with everted rim. Flaked stone artefacts include retouched and non-retouched flint blades (58 elements, some of them of large size), several arrowheads with concave or deeply notched base (21 elements, some of them with long barbs, of *Alcalar type*), three small halberds or spearheads and three geometric armatures (trapezoids). Polished stone artefacts are represented by axes (30 elements, with circular, quadrangular and rectangular cross-section), adzes (23 elements, highlighting three of large size) and one chisel. Personal adornment artefacts include one small pendant, one tubular «greenstone» bead, a cylindrical bone bead and three bone «hair-pins» with plain or ribbed removable head. Other bone artefacts include small perforators or awls. There is also reference to the collection of a small limestone vase («grail» or mortar), as well as of a schist crosier; the whereabouts of those artefacts are currently unknown, as the first was not found in the National Archaeological Museum reserves and the second was gathered by a local collector before the work of Estácio da Veiga.

This is a very culturally homogeneous set, characteristic of the Megalithic apogee in Southwestern Iberia. Considering the morphological and typological features of the artefacts, the use of the rock-cut tomb of Aljezur will not retreat beyond the transition from the 4th to the 3rd millennium BCE, possibly corresponding already to the first half of the 3rd millennium, representing a terminal phase of the local Late Neolithic or even already an early phase of the Chalcolithic.

This chronological attribution can be rectified with the realization of absolute dating, something that someone, on an unknown date, apparently tried to do (at least judging by the relatively recent mechanic segmentation of part of the human bones recovered from this tomb and currently housed in the National Archaeological Museum, Lisbon). There are, however, any notes about the author of this action and the results thereof...

4. Experimental production of engraved schist plaques

Experimental Archaeology can be seen as a considerable source of information on activities carried out by prehistoric communities, being a means of experimentation, validation and refutation of hypothesis (following a linearly scientific schema so appreciated by the processual school), with an approach to the production and use techniques, applied to the study of Prehistory (Coles, 1973; 1979; Jones, 2002). It is «the fabrication of materials, behaviors, or both, in order to observe one or more processes involved in the production, use, discard, deterioration, or recovery of material culture» (Skibo, 1992, p. 18); its utility lies therefore on the perspective of approaches to past acts (Ferguson, 2010). It is not denied, however, the obvious subjectivity of the information obtained with Experimental Archaeology; therefore, data is required to be soberly handled. Those acts should always be assumed as subjective approaches, as they «can never fully reproduce the past nor replicate past behaviours» (Malloy, 2019, p. 12; see also Reynolds, 1999; Cunningham & *alii*, 2008).

Indeed, the technical processes undertaken in Experimental Archaeology exercises shall be consistent with the recognized technology for the time in which the experimentation is focused. It is necessary, in three basic steps, to ascertain techniques and tools, to carry out the experiment and, finally, to validate the results. It is thus an attempt to recover actions, to explore everyday aspects of specific activities, approaching as much as possible to how these activities would have been experienced by prehistoric communities (Mathieu, 2002; Mathieu & Meyers, 2002; Andrews & Doonan, 2005; Busuttil, 2008–2009; Outram, 2008; Mildon, 2010; Foulds, 2013; O'Sullivan & Souyoudzoglou-Haywood, 2019), that should be conducted in four basic phases (compiled in Schenck, 2015, pp. 40–44): (1) planning the experiment; (2) preparing and executing the experiment; (3) analysing post-experimental data; (4) disseminating the results.

4.1. Methodology

This study comes in the wake of other Experimental Archaeology exercises on engraved schist plaques, being methodologically framed by those same works. The studies conducted by Woods and Lillios intended to demonstrate the effects on engraved schist plaques in terms of use-wear analyses, attempting to demonstrate the potentiality for these objects have been used in life (Lillios & Woods, 2006). The studies developed by Thomas, McCall and Lillios sought to demonstrate the individual variation in the production of engraved schist plaques, setting out the idiosyncratic criteria of their design (Thomas & *alii*, 2009; Thomas, 2013). The studies developed by Andrade within the PLACA-NOSTRA project (not yet published) also intended to demonstrate the differences and similarities between schist plaques manufactured by one same individual obeying to one single iconographic criterion, as well as to define the asymmetry and lack of objectivity of the decorative composition resulting from the lack of hand dexterity (in terms of graphical representation, using the non-dominant hand for engraving).

The techniques used in this study approached as much as possible to prehistoric techniques, especially in terms of tools used, namely, reproducing tools on raw materials used in the Late Neolithic and Chalcolithic, such as quartz, flint and bone, according to the archaeographic record available to these chronological stages in Southwestern Iberia.

Considering that the engraved schist plaques would still be in use during the advent of copper metallurgy (evident by the adoption of symbols clearly associated with archaeo-metallurgist, as well as by their presence in Chalcolithic settlements and funerary monuments, such as corbel-vaulted tombs), it was equally considered to use a copper tool for engraving schist plaques. It was also used a steel instrument for screening, as a control, in order to measure and compare the effectiveness of the stone and copper tools.

While acknowledging that the used raw materials should match those locally available, in view of a higher analytical accuracy, the ones used in this study to replicate the plaque MNA 985.39.42 from Aljezur are not from the generic geographic context of Western Algarve, being acquired in other regional areas of North Alentejo and Estremadura. Obviously, it is assumed that the same type of raw material, depending on its procurement source, may present different technical aptitudes in carrying out one same task, relying on its very quality and physical or mechanical properties (which may show significant variability in its performance, considering factors such as its compactness and texture, degree of foliation, the presence of internal cleavages or tectonic fractures, etc.).

In the specific case of Aljezur, it is known that the raw materials needed to produce an engraved schist plaque (from the blank itself to the tools used in its manufacture) are available in the local/regional geological set. In the locality of Corte Cabreira, about 7 km from Aljezur, Estácio da Veiga reported the occurrence of slates apparently similar to those used in the engraved plaques found in that tomb (Veiga, 1891, pp. 67–68). For the production of engraving tools, one can mention the occurrence of flint in the Jurassic formations around the area of Vila do Bispo, about 40 km from Aljezur, as well as the presence of quartz in veins in the regional South Portuguese Zone formations and in river beds in the form of pebbles. Rocks with the potential to be used as grinding tools are also locally or regionally available, such as sandstone, syenite and greywacke found in geological formations of the Mezo-Cenozoic Basin and in the surroundings of the Monchique and Caldeirão mountain ranges.

However, the choice for this specific plaque from Aljezur is purely circumstantial, based only on theoretical paradigms related to its particular iconographic features and its *sui generis* character in the generic *collectanea* of engraved schist plaques (as explained above), and not on its «physical» features themselves, acting here only as an example for the production of these artefacts (recalling that they are documented over a vast geographic area with different geological characteristics and, consequently, with different raw materials available for their manufacture). In fact, as items that are somehow exogenous in the geographical context of the Megalithism of Algarve (Gonçalves & Andrade, in press), their local production (and therefore the use of raw materials locally or regionally available) is not guaranteed, as they may have been acquired and transported to this regions already in the form of finished artefacts, which may originally come from more distant regions. So, this issue will be, if not secondary, at least of lateral importance in this specific study.

As technical processes of replica engraving (in terms of *design*), theoretical models already defined within the PLACA-NOSTRA project were employed, in terms of pagination and structuring of the decorative motifs (see Gonçalves, 2003a; 2004a; 2004b; Andrade, 2015).

Replicas were then analysed in search of possible engraving signatures inscribed on the engravings, both macroscopically and microscopically, combining SEM (scanning electron microscopy) and EDX (energy-dispersive X-ray spectroscopy). These analyses sought to identify and isolate potential micro evidence from the use of different tools, in order to define the criteria and physical parameters for their distinction. According to methodological processes already implemented in previous works (see Thomas, 2014), replicas were analysed using a Hitachi S-3400N variable pressure backscatter scanning electron microscope equipped with a Bruker energy-dispersive X-ray spectroscopy unit (SEM/EDX) maintained by the University of Iowa Central Microscopy Research Facilities (CMRF) and University of Iowa Department of Earth and Environmental Sciences. For the purposes of imaging production markings, photomicrographs were taken with the Hitachi S3400N in SEM mode using the SE (secondary electron) beam set between 3-5 keV and the stage set to varying heights between 5 mm and 20 mm. For energy dispersive X-ray analysis of elemental percentages in the replicas, the machine was run in VPSEM (variable pressure) mode using the BSE (backscattered electron) beam set to 10-15 kEV and the stage at the automatic analysis setting (10 mm). High-resolution photomicrographs of blanks and finished replicas for the purposes of cataloguing and analyzing raw material composition, possible use-wear, tool manufacturing marks, and breakage were taken at varying magnifications using an Olympus Stereoscope SZX12 at the University of Iowa Central Microscopy Research Facility (CMRF).

A subsequent inquiry was also conducted on the experimental engraver in order to record personal perceptions and potential difficulties in engraving schist plaques.

4.2. Phase 1: Blank replica plaque preparation

A single, compositionally homogeneous slate slab was broken into roughly «plaque-sized» segments (~12x20 cm) on a concrete sidewalk. On each segment, a border was traced using a scaled template, ensuring that the replica plaques would be the exact size of plaque MNA 985.39.42 to within a few millimetres. After the individual blanks were created, their edges were ground on the wet concrete until each plaque was essentially identical in size to plaque MNA 985.39.42 (Fig. 8). While it is certain that archaeological plaques were not ground on a concrete surface, Late Neolithic and Chalcolithic Iberians would have had a variety of similarly textured sandstones, granites, and other coarse stones on which to grind/reduce plaques. The surface and edges of each replica plaque were ground and bevelled using a sanding pad, and polished with a piece of leather, resulting in replica plaques that were indistinguishable from archaeological plaques to the naked eye (Fig. 9). It took approximately 2,5 hours to prepare each blank, unengraved plaque.

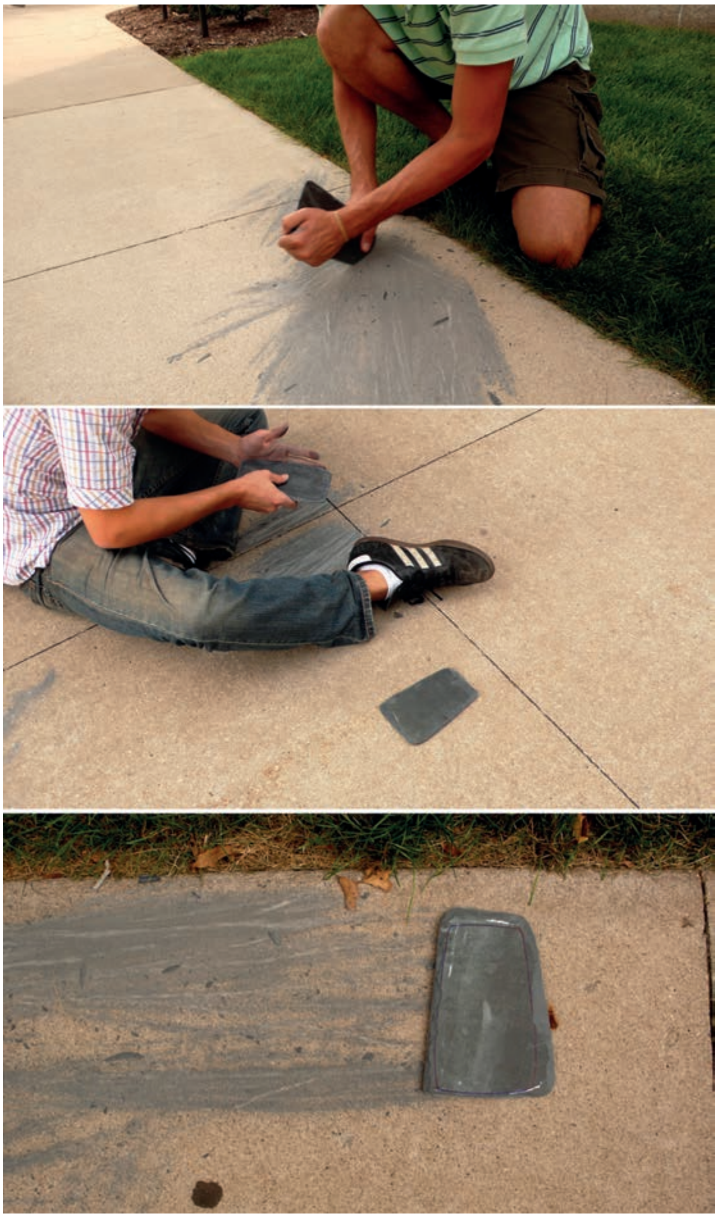


Fig. 8 – Blank plaques being ground to the same size as Plaque MNA 985.39.42 from Aljezur.

Because little is known about the actual technology used to make Late Neolithic/Chalcolithic plaques, we attempted to make their production as simple as possible, using only the pavement, a piece of leather, and the tools to be tested. In total, twenty blank replica plaques were made, from which the plaques most similar to the size and surface texture of Plaque MNA 985.39.42 were chosen for engraving. Additionally, these replica plaques

Fig. 9 – Examples of finished blank plaques.

were biconically perforated using a flint burin, although this has no bearing on this experiment as a whole.

4.3. Phase 2: Replica plaque engraving

A single plaque engraver was enlisted, as it was determined that multiple engravers would introduce unwanted variability related to fine-motor skills, coordination, and stylistic variation. The plaque engraver had no formal art training. Because this individual had little prior engraving skill, for several weeks we had him make «practice plaques» using each of the five types of tools, until variability related to his improving engraving skills was as minimal as possible. Additionally, after making the practice plaques, our plaque engraver felt comfortable both using

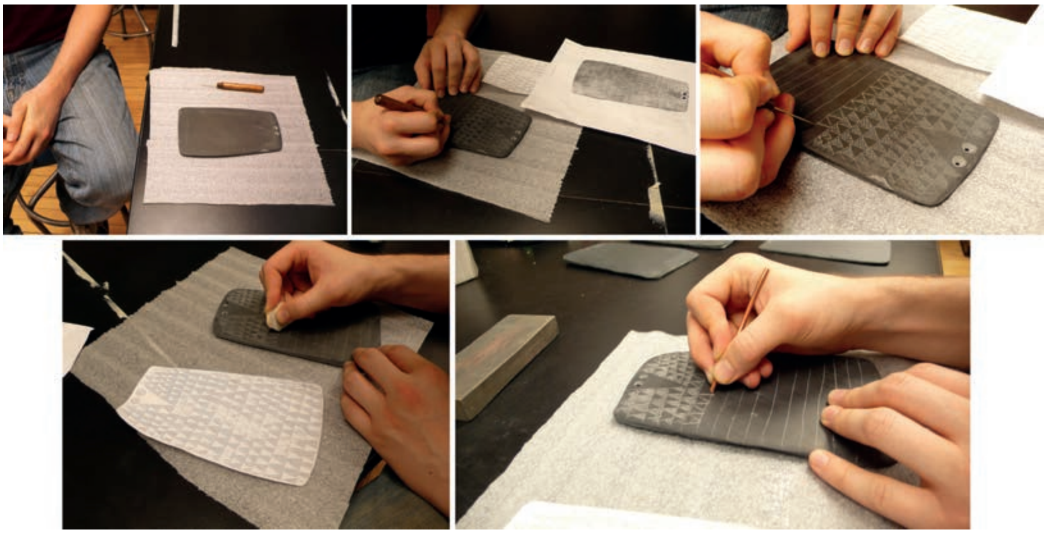


Fig. 10 – Plaque engraver at work.

the tools and creating the motif of plaque MNA 985.39.42.

After it was determined the plaque engraver had «plateaued» in his ability to engrave the practice plaques (through both our analysis and the engravers subjective experience), the experiment was begun in earnest. Four tools known to have been used in the Late Neolithic and Chalcolithic were tested: bone, quartz, flint and copper. Additionally, a steel engraving tool was used as a control. Initially, both wood and slate were to be included in the engraving experiment. However, initial tests show that even very hard woods were too soft to create durable, visible engraving lines; slate engraving tools were often also too soft, and regularly crumbled or shattered when applied to the blank replica plaques. As a result of this, neither of these tool types was included in the full analysis.

Over the course of several months, the plaque engraver engraved two plaques with each of the five tool types, using both a photo and an illustration of plaque MNA 985.39.42 (drawn from Gonçalves, 2004c, p. 39, fig. 8)

Fig. 11 – Replica plaque engraved with bone tool.

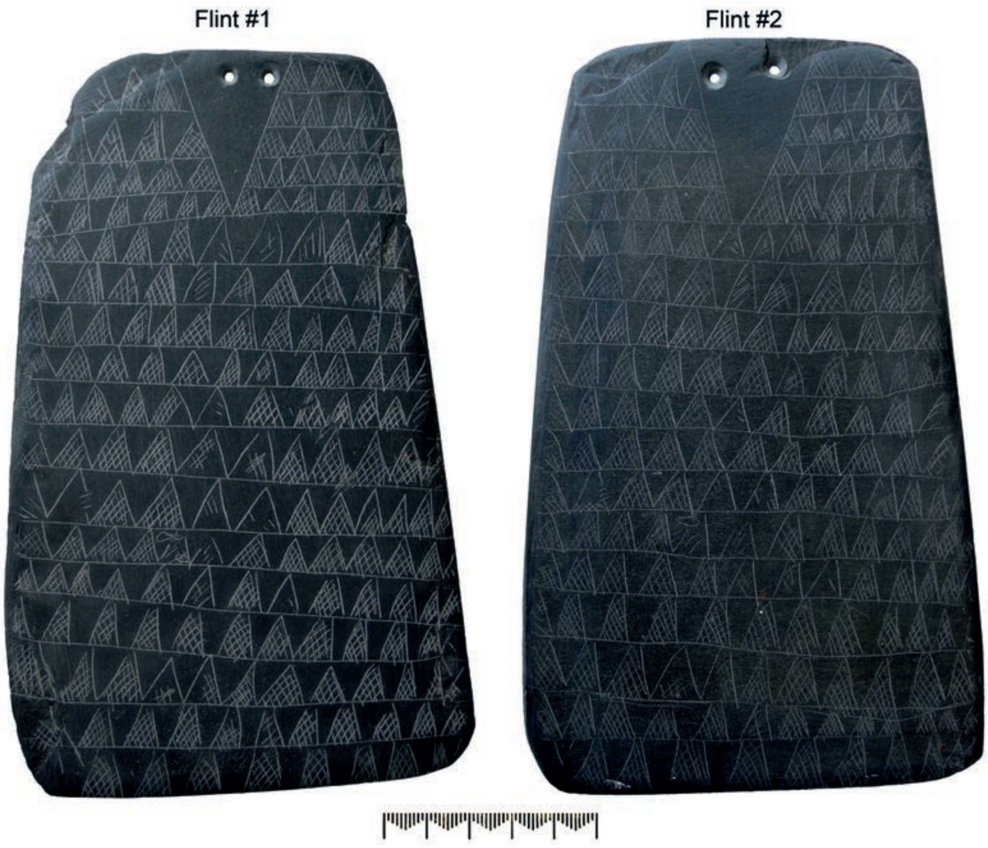


Fig. 12 – Replica plaques engraved with flint tools.

Fig. 13 (left) – Replica plaque engraved with quartz tool.

Fig. 14 (right) – Replica plaques engraved with steel.

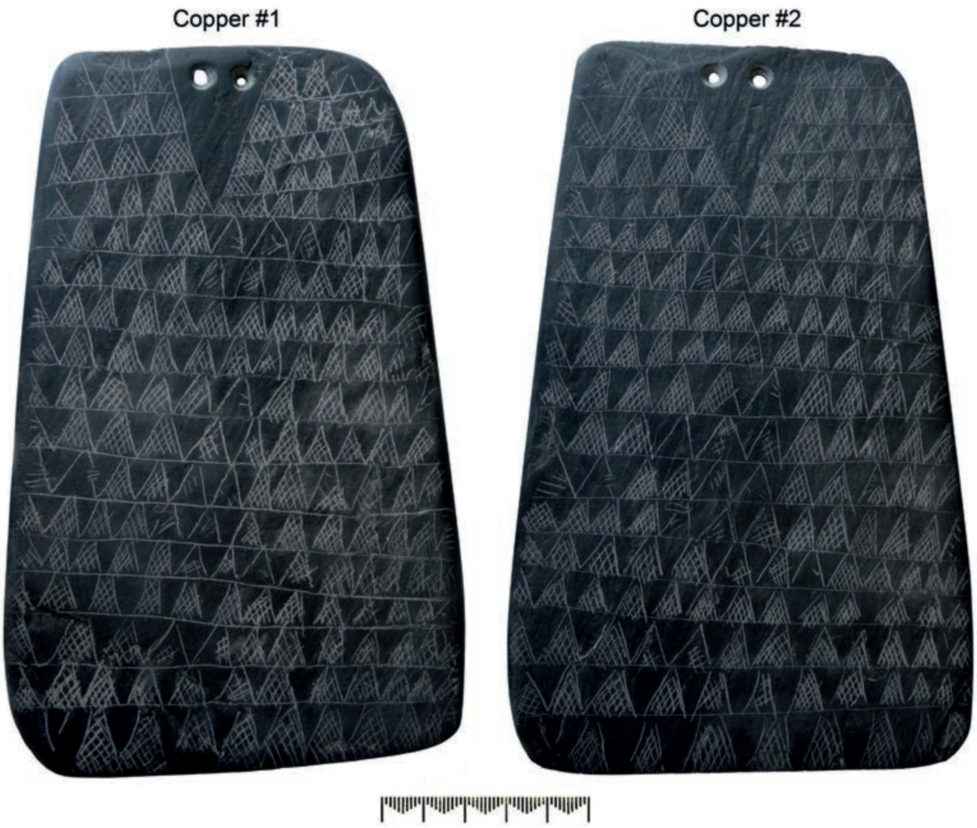


Fig. 15 – Replica plaque engraved with copper tools.

as a template. Each engraving session was followed by an exit interview in which the engraver was asked several questions related to his experience (discussed below). Although the order in which engraving lines were applied to archaeological plaques is yet unclear (but beginning with some certainty by the engraving of previous guidelines), our plaque engraver started by diving up space on the blank plaque by first engraving the horizontal lines, and then «filled» in the cross-hatched triangles. Each engraving session lasted between 40 and 50 minutes. Images of the experimental engraving process are shown in Fig. 10.
The tools for the experiment were the best analogues we could provide from contemporarily available materials. Aside from the steel control tool, which was purchased at an art supply store, all materials were repeatedly sharpened using a whetstone to maintain maximum sharpness. Quartz and flint tools were knapped by an expert flint knapper, a bone tool was crafted from a long bone that was first split with a chisel and then sharpened. A small copper rod was purchased and also sharpened repeatedly throughout the experiment with a whetstone. Examples of the resulting replica plaques are shown in Figs. 11 to 16.

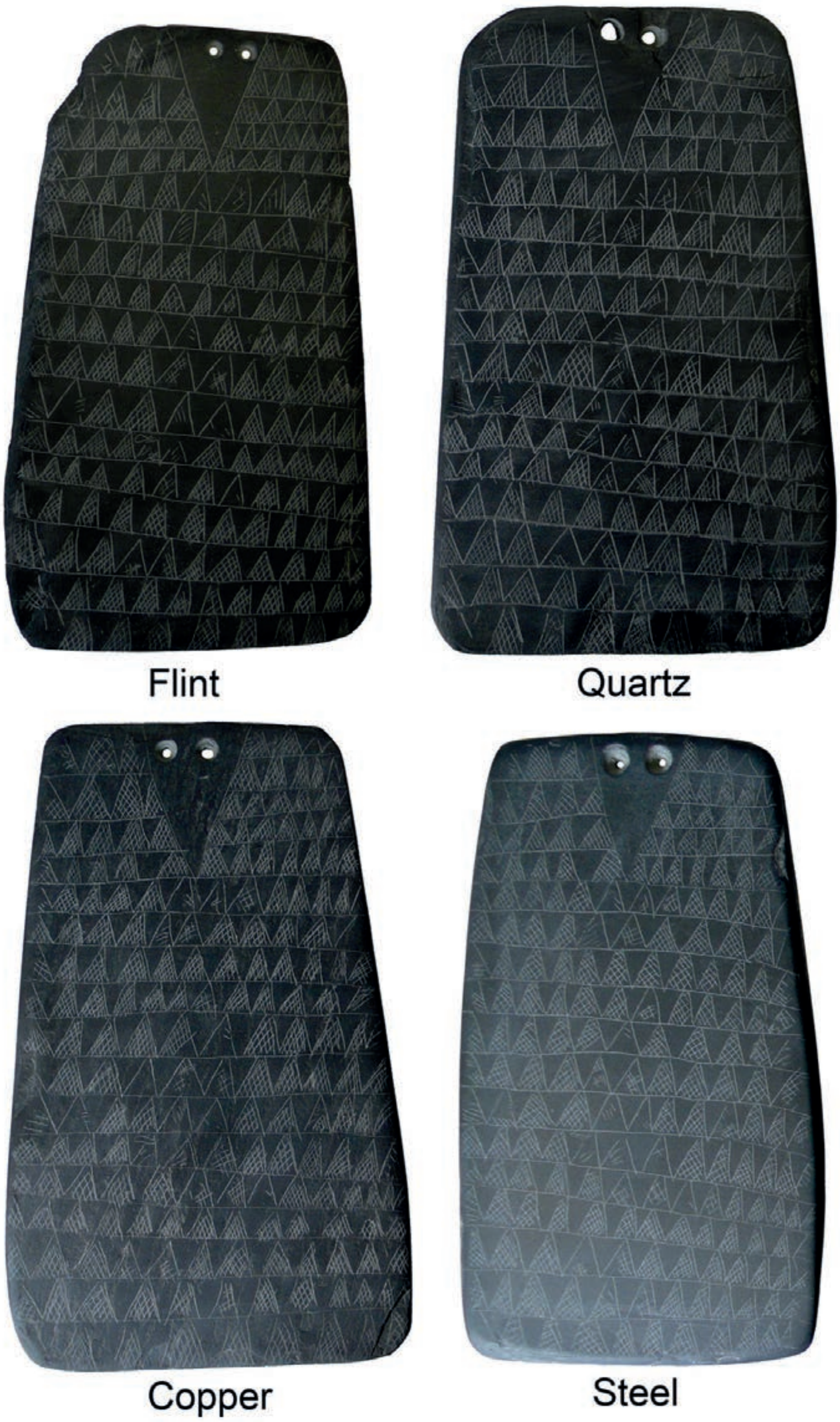


Fig. 16 – Comparison of the replica plaques engraved with different tools.

4.4. Phase 3: results

After macroscopically analysing the entire set of engraved plaques, a few things became quickly clear: (1) the steel engraving, unsurprisingly perhaps, created the «cleanest», sharpest, most well-defined engraving lines; (2) while not completely discounting the variability that does exist between the quality of engraving lines engraved with quartz, flint and copper tools, all three of these tools made fairly sharp, well-defined engraving lines; (3) bone creates very poor, non-durable, blurry engraving lines, and is unlikely to

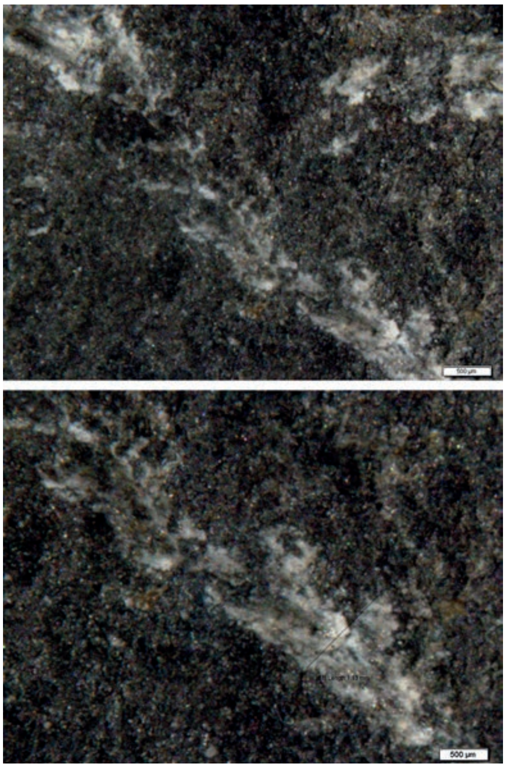


Fig. 17 (left) – Microscopy (63x and 96x) of the lines on the replica plaque engraved with bone tool.

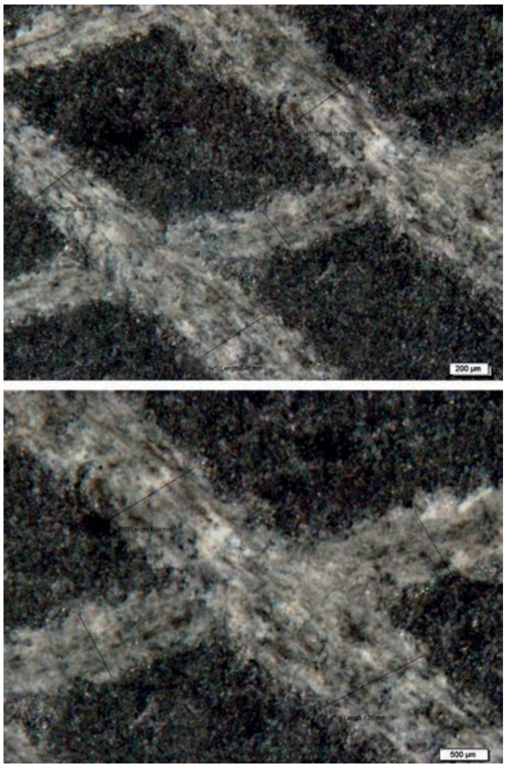


Fig. 18 (right) – Microscopy (63x and 96x) of the lines on the replica plaque engraved with flint tool.

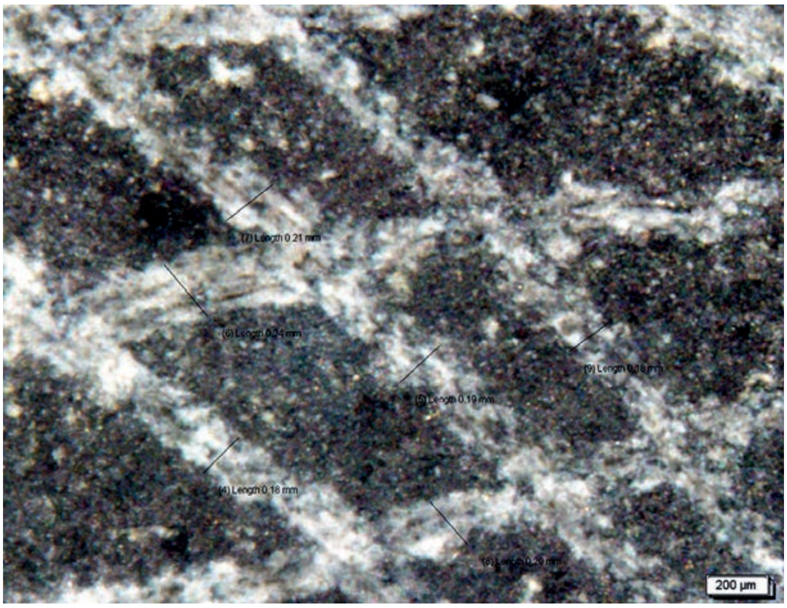
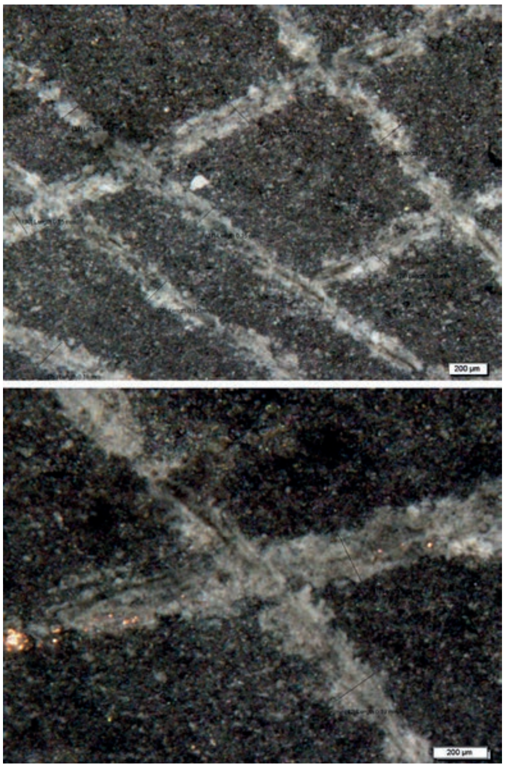


Fig. 19 – Microscopy (63x) of the lines on the replica plaque engraved with quartz tool.

have been used as an engraving tool. Lines engraved with bone can be fairly easily erased with the finger, while all four of the other tools create permanent engraving lines on the surface of the slate.

Using the exit interviews conducted with the engraver, several interesting facets of engraving with each tool came to light: (1) steel and quartz were equally rated as the easiest tools to work with, followed closely by flint, as these tools did not have to be resharpened; (2) while copper created fairly clear, well-defined engraving lines, it was rated as a more difficult material to engrave with, and had to be constantly resharpened with the whetstone, unlike steel, quartz, and flint; (3) unsurprisingly, the bone tool was rated as the most difficult material to work with, and had to be resharpened nearly four times as often as the copper tool; (4) perhaps due to their sharpness, steel and copper tools tended to «catch» or «hitch» on the surface of the slate more often than any of the other tool types; (5) the engraver reported hand fatigue of various proportions when engraving, in direct relation to how difficult each tool type was to use; (6) the engraved noted that the easier the tool was to use, the more skillfully executed each plaque seemed



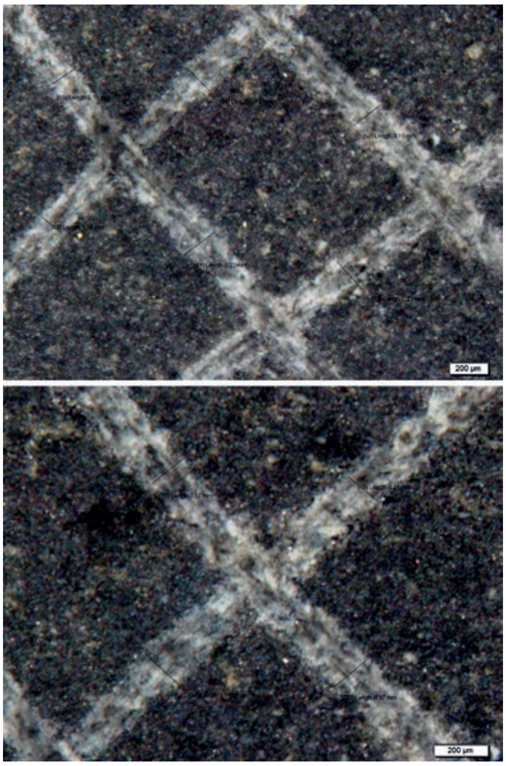


Fig. 20 (left) – Microscopy (63x and 96x) of the lines on the replica plaque engraved with copper tool.

Fig. 21 – Microscopy (right) (63x and 96x) of the lines on the replica plaque engraved with a steel tool.

to appear; (7) the engraved noted on several occasions that plaque engraving was in no way a process that could be «rushed», and that considerable time and effort must have been involved in creating the intricate patterns in archaeological plaques.

The results of the microscopic analysis, while far from conclusive, show promise in terms of microscopically analysing archaeological plaques for differential tool use-wear in the future. The results of the microscopic analysis suggest that: (1) no significant variation between the width of engraving lines exists between steel, copper and quartz engraving tools; (2) flint engraving tools, while macroscopically similar to steel, copper and quartz, actually displayed significantly wider engraving lines than other materials.

Flint, while sharp, is a more brittle, softer material on the Mohs Hardness Scale (modified) than either steel or quartz. This may be due to the obliteration of the fine edge of the knapped flint after application to the surface of the slate. This is supported by the fact that the lines initially engraved with the flint flakes appear sharper and more well-defined than subsequent lines. Alternately, quartz held its edge as well as steel when applied to the surface of the slate. Copper is a relatively soft material, dulls very easily, and had to constantly be resharpened during the engraving process, clouding its utility as a fine-line engraving tool. Micrographs of line-width for each of the engraving tools are shown in Figs. 17 to 21.

Microscopy was only focused on the engraving lines of the replica plaques; in this study context, it was not applied to perforations (for experimental traceological analyses on perforations and perforating tools, see the examples of necklace beads and wrist-guards, especially the ones using the same raw materials used on votive plaques, in Gutiérrez & *alii*, 2017; Gurova & *alii*, 2013; Gurova & Bonsall, 2017; Muñoz, 2017).

4.5. SEM/Elemental analysis of the replica plaques

Preliminary SEM/EDX (scanning electron microscopy and energy-dispersive X-ray spectroscopy) analysis of the replica plaques did not show significant variation between the wear created by different engraving tools. While there seems to be some difference between the wear created by copper, flint and quartz tools, more work using many different samples needs to be conducted before any definitive micro-

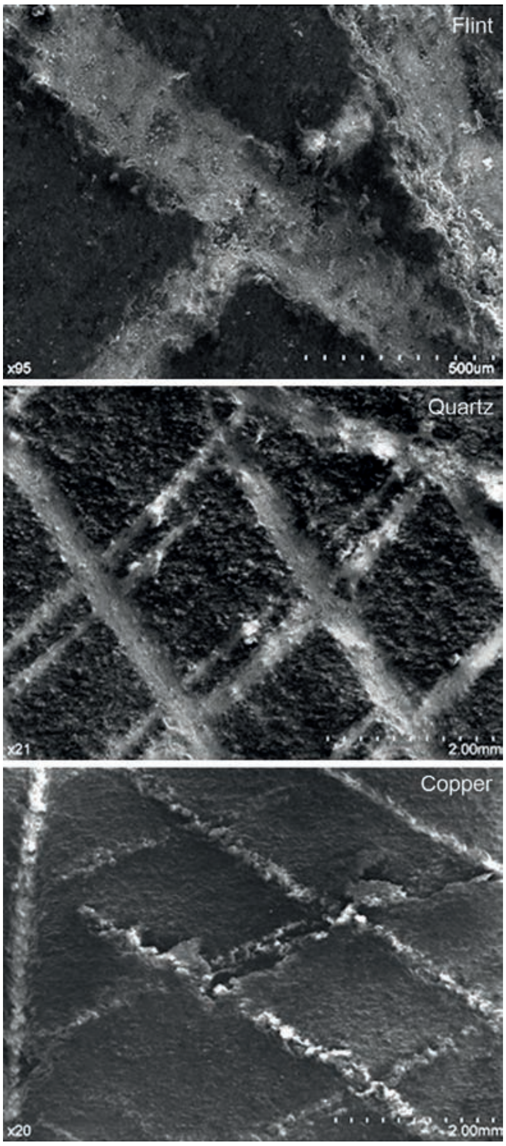


Fig. 22 – Images of the scanning electron microscopy (SEM) of the replica plaques engraved with flint, quartz and copper tools.

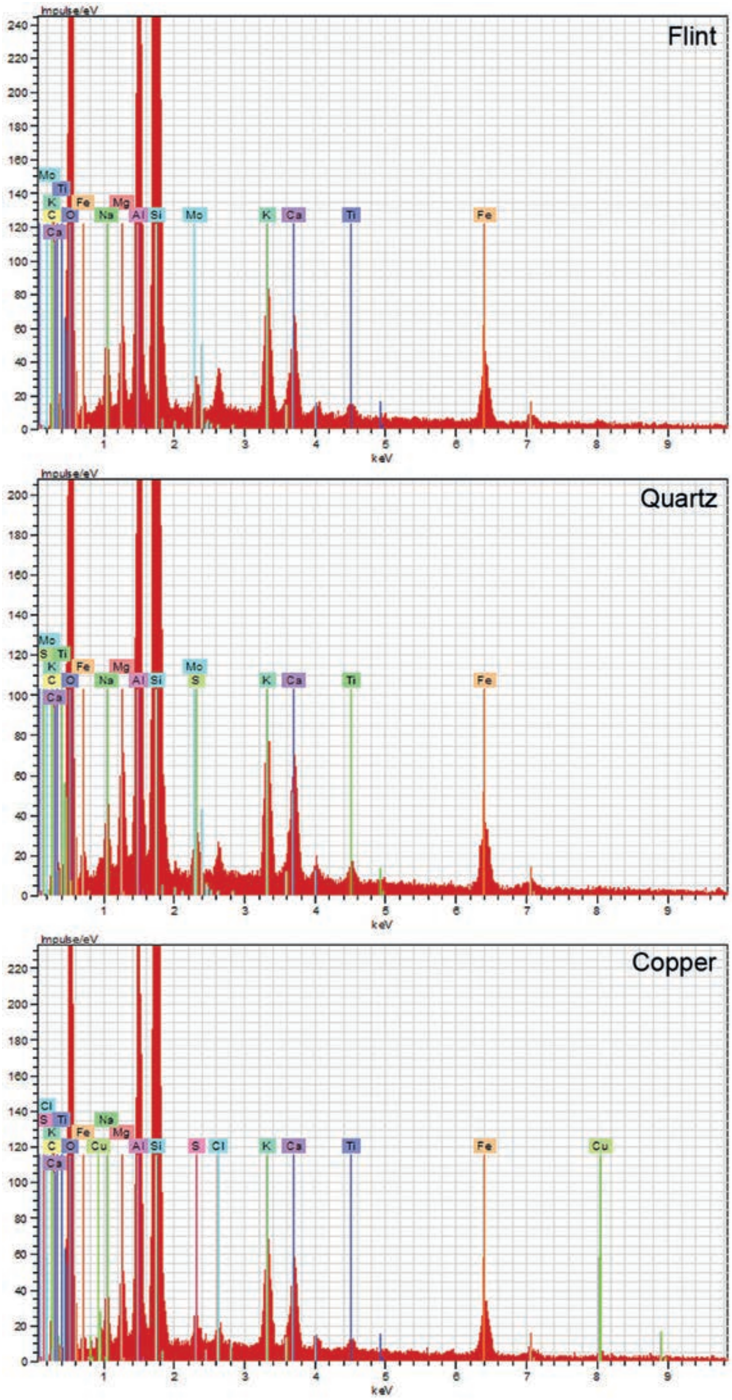


Fig. 23 – Results of the energy-dispersive X-ray spectroscopy of the replica plaques engraved with flint, quartz and copper tools, noting the Cu signature in elemental analysis of the replica plaque engraved with copper tool.

scopic wear patterns come to light. Note in Fig. 22, however, idiosyncrasies of individual tools can clearly be noted using SEM, as in the case of replica plaque engraved with a quartz flake with a secondary point, creating sets of parallel engraving lines difficult to discern with the naked eye.

However, EDX elemental analysis did show one surprising result: the replica plaques engraved with the copper engraving tool showed a significant percentage of copper which did not appear in the replica plaques engraved with either quartz or flint (Fig. 23). While it is unclear if archaeological plaques engraved with copper tools would still contain enough detectable copper after thousands of years of taphonomic degradation, EDX elemental analysis shows promise in terms of trace element analysis and, ultimately, understanding what tools were used to engraved Late Neolithic/Chalcolithic engraved schist plaques.

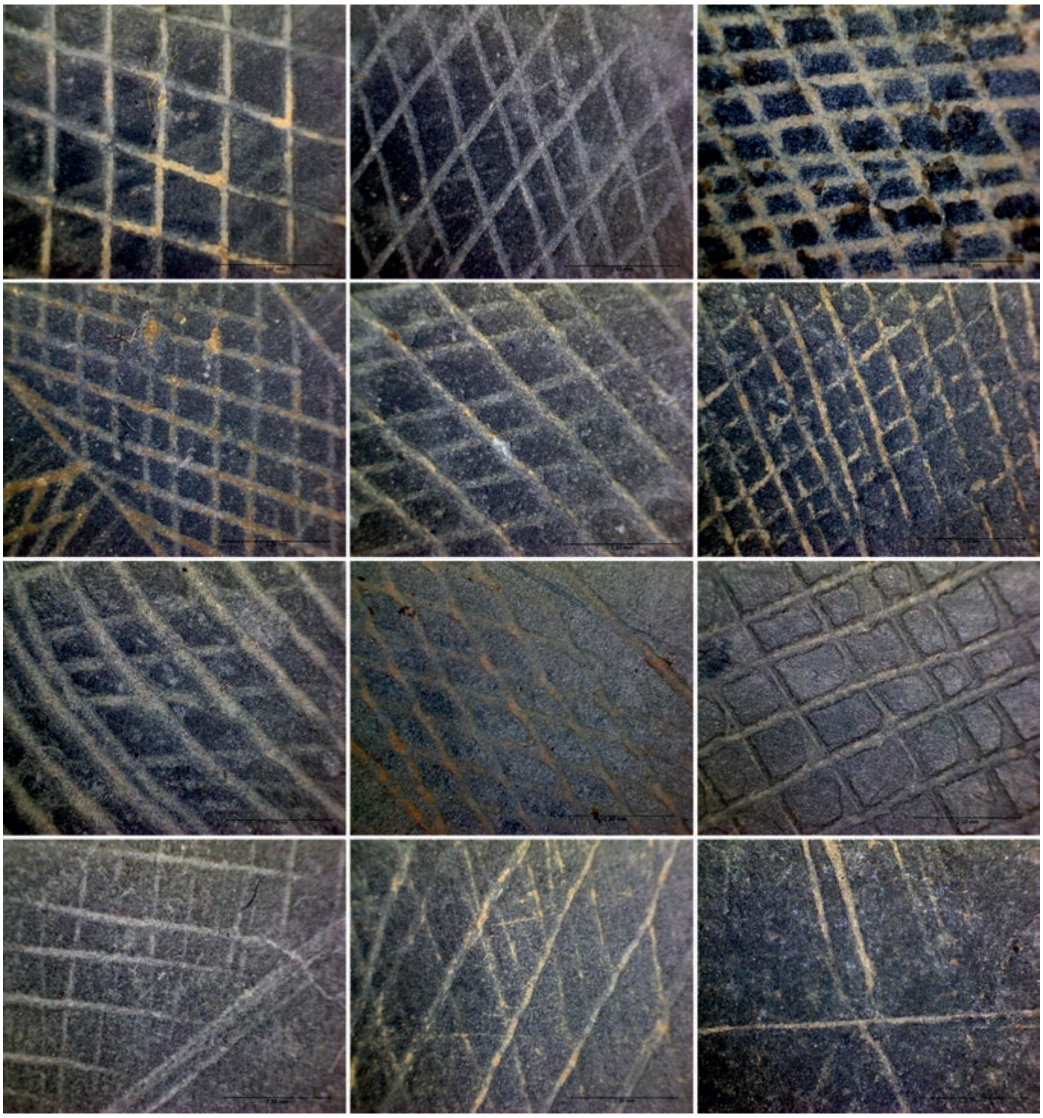


Fig. 24 – Microscopy (x50) of different types of engravings observed in archaeological plaques, with different degrees of width and depth (deep thin lines, deep medium lines, superficial shallow lines).

5. Discussion

The preliminary results of the experimental replication of the Late Neolithic/Chalcolithic Iberian schist plaques demonstrate several important points about the potential tools used to engrave them in the past: (1) softer materials, such as wood, ivory or bone, were almost certainly not used to engrave plaques, as they are difficult to use, require constant sharpening and, even at their hardest, leave very faint and often erasable engraving lines; (2) quartz, flint and copper tools all work nearly as well as a modern steel tool, suggesting that each would be suitable as an engraving tool, as would many other hard materials that could be honed to a fine point; (3) quartz and copper tools create engraving lines about the same width as steel tools, while flint tools create slightly wider engraving lines — both flint and copper tools dull much more quickly than quartz or steel tools, which did not become significantly less dull over the course of the experiment; (4) copper tools often caught on the surface of the slate, making engraving somewhat difficult, and had to be constantly resharpened.

These results leave us several options to consider in terms of understanding what tools were used to engrave plaques, especially those with numerous, very finely wrought lines such as plaque MNA 985.39.42 from Aljezur. Because the tools do not appear to show any drastic differences in terms of engraving patterns, we must remain open to the idea that there was a large degree of variability of engraving tool raw material over time and space: many types

Fig. 25 – Detail of one of the engraved plaques from Águas Frias, with coarse incisions, possibly made with a quartz or quartzite tool; this piece possibly corresponds to an engraving rehearsal of a checkered field motif.

of hard stones, and potentially metals, would have made perfectly suitable engraving tools.

However, because plaque making was an ostensibly prestigious endeavour in Late Neolithic and Chalcolithic Iberia, new technologies relying upon «prestigious tools» (i.e. newly introduced copper-based tools) may have been desirable, even if such copper-based tools were rare and «expensive», perhaps precisely *because* such copper-based tools were rare and expensive. Future elemental and microscopic analyses of existing archaeological plaques hold the potential to rule out or confirm copper as an engraving tool.

A second reasonable interpretation has little to do with the potential prestige-status of the plaque engraving tools and is primarily functionalist. In terms of lithic technology, many stone tool makers in the past eschewed tools that were difficult to make and maintain or tools made from rare materials in favour of «expedient tools», i.e., tools that could be made quickly from whatever lithic materials were at hand. From a functionalist perspective, quartz and quartzite tools would have made *excellent* plaque engraving tools: they work as well as copper or flint tools (in fact, nearly as well as modern steel tools), do not dull easily, and are abundant, easily located, and easy to use. Thus, from this perspective, the tools that Iberian schist plaque makers used were probably whatever tools worked for them, and thus we would expect a great deal of variability over time. Unlike the slate used to make the plaques, which was often obtained from over a hundred kilometres away, it appears that the raw materials that plaque makers had at hand «did the job» as well as more exotic materials such as copper. Extensive microscopic analysis of existing archaeological plaques will no doubt shed light on this question.

In fact, it is necessary to compare the data presented above with specific archaeological examples. Microscopy already implemented on various elements under study within the PLACA-NOSTRA project allowed to evidence the use of several kinds of stone tools (flint, quartz or quartzite, according to the available archaeographic record), noting that the differences in width and depth of the lines may be due to the very «condition» of the engraving tools, depending on whether they are sharper or more worn (Fig. 24), or even the use of different tools on the engraving of the same plaque, as confirmed in the plaque MNA 985.39.42 from Aljezur.

Similarly, the data recovered from the settlement of Águas Frias, Alandroal may contribute to the clarification of those issues. This site, occupied during the last quarter of the 4th millennium and the first half of the 3rd millennium BCE, corresponds to the only major centre for schist plaques production so far recognized in Southwestern Iberia, a circumstance based both on the number and diversity of the collected plaques, corresponding to elements depicting all stages of the *chaîne opératoire* (Calado & Roque, 2013; Gonçalves, 2013; Andrade & *alii*, 2015). There are several dozens of plaques from this site, in all manufacturing stages: rough blanks, summarily shaped or summarily polished blanks, engraved plaques. It should be noted, however, that the latter, given the low symmetry displayed by their decoration,

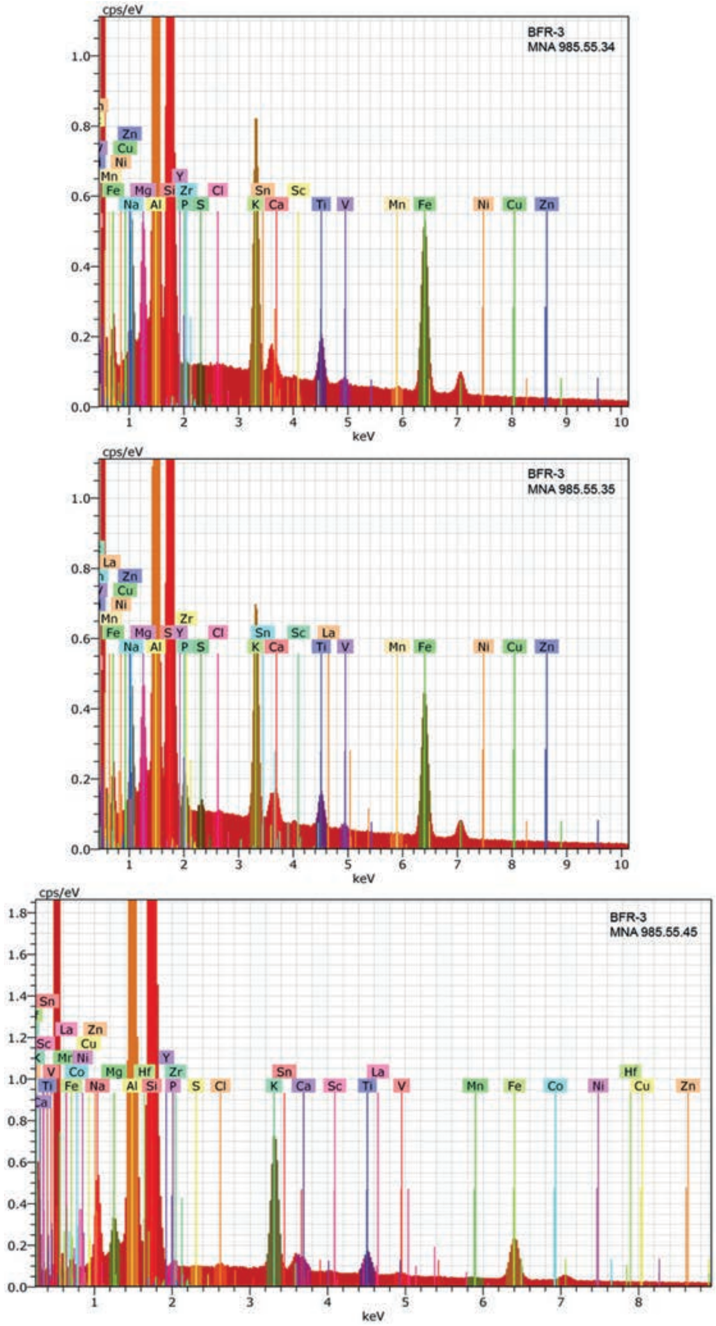


Fig. 26 – Results of the energy-dispersive X-ray spectroscopy of the plaques MNA 985.55.34, 985.55.35 and 985.55.45 from Barrocal das Freiras 3, noting the Cu signature in elemental analysis, to compare with Fig. 24. Adapted from Pinto, 2012.

could be assumed only as engraving rehearsals, reflecting possible apprenticeship schemes. In fact, there are no plaques on this site that could be considered as entirely finished, being also noteworthy the absence of perforated specimens, which suggests that the drilling of suspension perforations would actually be the final stage of the manufacturing process of these artefacts (Fig. 25).

The scarcity of flint tools (summed up to some few blades) and the dense presence of quartz and quartzite flaked stone artefacts in Águas Frias (M. Calado, personal information) allows us to suppose that those were precisely the ones used in the production of engraved schist plaques therein recognized – an assumption also confirmed by microscopy already performed on the schist plaques from this site (currently under study within the PLACA-NOSTRA project). Additionally, the relative abundance of granite grinding elements in this site may shed some light on the polishing procedures, as they may have been potentially used in this task.

On the other hand, in the Chalcolithic settlement of Cabeço do Pé da Erra, Coruche (excavations of V. S. Gonçalves), a small production context of schist plaques was identified, directly dated to the first third of the 3rd millennium BCE. It does not disclose the same level of «specialization» as the settlement of Águas Frias, and it can be related to a working context of an itinerant craftsman, stressing in this regard the actual absence of schists on the local geological substratum (however, slates can be found in about 50 km, in the region of Pavia, Mora). In this site, the flint perforators and other fine-tipped flint tools could have been potentially used in the production of schist plaques.

Regarding the potential use of copper tools (recalling that the use of engraved schist plaques extends through the Chalcolithic, perhaps until the mid-3rd millennium BCE), it will be obviously necessary to perform energy-dispersive X-ray spectroscopy on archaeological samples (in the expectation that they retain traces of its use, as recorded in the replica plaque engraved with the copper tool). Such analyses will be particularly enlightening, even if following a criterion of selective sampling, if performed on large sets collected from evolved megalithic monuments, including passage graves, corbel-vaulted tombs and rock-cut tombs (such as Olival da Pega 1, Paço 1, Zambujeiro, Mitra, Escoural, Barrocal das Freiras 3, Brissos 6, Monte da Barca, or Aljezur).

The relevance of these analyses on archaeological samples can be precisely verified in the set of one of the monuments listed above. For the set of Barrocal das Freiras 3, a medium-size passage grave in Central Alentejo (municipality of Montemor-o-Novo), energy-disper-

sive X-ray spectroscopy was carried out under the MA dissertation of L. Pinto submitted to the University of Évora (Pinto, 2012).
Although these analyses have been carried out exclusively with the primary objective to match geological samples with archaeological samples (in this case, to define the provenance of the schists used in producing the plaques), several observations are possible following the obtained results. Formally, these analyses obeyed to selective sampling criteria (as suggested above), having been selected a set of 10 plaques for analysis (approximately 14% of the total set of Barrocal das Freiras 3, consisting of about 70 engraved schist plaques). Three of these 10 plaques showed traces of copper (MNA 985.55.34, 985.55.35 and 985.55.45), corresponding to 30% of the analysed sample (about 4% of the total set of Barrocal das Freiras 3) (Fig. 26).
While the results have not been read in the prospects of the traces left by engraving tools and these were not considered in the interpretation of those same results (Pinto, 2012), we can suggest, based on the data obtained with this Experimental Archaeology exercise, that these three plaques have been effectively engraved with copper tools. The relative scientific validity of this work is therefore demonstrated, acting this study as groundwork for future analysis.
Interestingly, the three plaques that show copper traces in Barrocal das Freiras 3 have exactly the same decorative pattern (non-compartmented zigzag stripes). Furthermore, in plaque MNA 985.55.34 this is a later decorative motif, the original motif being composed of checkered fields. It was re-polished and re-engraved with a new decorative motif, thus corresponding to a recycled plaque (regarding the recycling of plaques, see Gonçalves & *alii*, 2003; Lillios, 2010; Andrade, 2014; 2015).
Thus, in addition to the practical utility of this exercise for understanding the techniques and tools used in the engraving of schist plaques, we highlight its relevance for the definition of certain procedural features identifiable in some engraved schist plaques. It allowed clarifying some curious technical processes already identified within the PLACA-NOSTRA project, based on close observation of numerous archaeological examples and ratified by the inquiry conducted to the experimental engraver in this study.
It is noteworthy, for instance: (1) the limited control in handling the engraving tool, motivated both by deficiencies of the raw material or by some characteristics of the engraving tool, which leads to pagination errors and its subsequent correction; (2) the potential identification of left and right-handed engravers, evident by the direction of the stroke and its inclination in relation to the vertical axis of the plaque; (3) the degenerative effects caused by hand fatigue in this exercise, resulting in a progressive loss of objectivity or care in the engraving, read from top to bottom.

6. Conclusions

The experiments carried out in this study allowed a successful approach to techniques and tools used in the production of engraved schist plaques in Southwestern Iberia during the Late Neolithic and Chalcolithic local chrono-zones, in addition to the formulation of the mental construction schemes prior to their physical «execution» and to the material manifestation of their specific cultural-symbolic value (namely, their prominent role in funerary rituals).
The conceptual uniformity that many plaques present, with the regulation of their graphic reproduction, ascribes to them an idiosyncratic character with parameters framed by a well-defined magical-religious subsystem of ecumenical trend – manifested also by other artefacts with the same symbolic value, assumed as counterparts of the engraved schist plaques (such as carved sandstone plaques, cylindrical limestone idols, pottery with symbolic decoration, etc.).
This exercise has shown that, with the right tools and a trained hand (as well as the prior knowledge/setting of the image to be engraved), a semi-skilled engraver would spend approximately 3,5 hours in the manufacture of one single schist plaque. Such time-frame would be divided between the initial shaping of the slab, the polishing of the blank and the final engraving of the plaque, applying in this action all the care needed to achieve an ultimate symmetrical outcome.
According to the archaeographic record of

the Neolithic and Chalcolithic in Southwestern Iberia, several types of tools could be potentially used in the production of engraved schist plaques. Consequently, several types of raw materials could be used in the production of these same tools. From the outset, artefacts produced in bone, flint and quartz were selected as potential engraving tools due to their relative frequency in contexts associated with the production and use of engraved schist plaques. Also, taking into account that the use of engraved schist plaques in funerary rituals will last until the advent and affirmation of the first archaeo-metallurgical communities, the use of copper tools could be equally considered. Thus, the use of engraving tools reproducing techniques and raw materials used in the Neolithic and Chalcolithic intended an optimized approach to the specific production criteria of engraved schist plaques. In the same way, as a control-screening test, experiments using a steel tool were performed (creating clearer and well-defined engravings) in order to measure and compare the effectiveness of the stone and copper tools mentioned above.

It was concluded that the use of bone tools would not have been viable in the production of engraved schist plaques, as they create faint, ill-defined engravings. The use of such tools should, therefore, be excluded.

All other tools work perfectly, creating clear, well-defined, durable engravings, closer to those recorded by the steel tool. Although there were no significant macroscopic differences between the engravings created by these tools, only small microscopic distinctions shown by the SEM analysis, it was noticed that flint tools present a higher wear level (brittle edges), resulting in the progressive thickening of lines during the engraving process. Copper tools also need to be constantly sharpened, frequently bumping into the cleavages of the schist surfaces. Quartz tools, on the other hand, seem to be more suitable, with a less intense wear ratio. They maintain substantially sharp edges, therefore demonstrating a greater efficiency throughout the whole engraving process. The presence of numerous flaked stone artefacts produced in quartz in the settlement of Águas Frias, the largest production centre of engraved schist plaques identified so far in Southwestern Iberia, could support the hypothesis of preferential use of quartz artefacts as a tool of choice for the engraving of schist plaques. In this case, however, we must also consider the very availability of the raw materials used in the production of these tools (recalling that there is no flint available in the local/regional geological substratum of Águas Frias).

For its part, EDX analysis showed that the use of different tools leaves different signatures on the engraving support. The use of copper tools may thus be distinguishable by the specific presence of Cu element traces in the engravings. Therefore, the identification of archaeological plaques engraved with copper tools is possible through the use of this method of analysis. This fact can be verified by the examples of Barrocal das Freiras 3, where some of the plaques analysed with EDX revealed the presence of copper signatures (thus suggesting the use of copper tools in their production).

With the establishment of this work basis, it will be necessary to validate and compare the results of this experiment with archaeological examples, carrying out comprehensive analyses of specific sets that enable statistical processing of data, in order to reach a greater convergence of techniques and tools used in the production of engraved schist plaques during the Late Neolithic and Chalcolithic in Southwestern Iberia.

Acknowledgements

The authors thank: the experimental engraver who participated in this study; Elisabete Barradas, who allowed the access, to perform the microscopy to the plaque MNA 985.39.42 from Aljezur, currently under study for her MA dissertation (supervised by V. S. Gonçalves); Manuel Calado for his input on the flaked stone industry from Água Frias (and the discussing of some polishing procedures); Luís Pinto, for the permission to reproduce the spectroscopy results of the plaques from Barrocal das Freiras 3, included in his MA dissertation.

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