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REICHERT VERLAG WIESBADEN

JOÃO LUÍS CARDOSO

POLISHED STONE ARTEFACTS AT THE PREHISTORIC SETTLEMENT OF LECEIA (OEIRAS)

Introduction

The aim of this paper is to discuss the set of polished stone materials so far found in excavations directed by the author at the prehistoric settlement of Leceia since 1983 (fig. 1): finds, therefore, made over the last 18 years, in an excavated area of more than 10.000 m^2. Drawings have been made of all the materials in which we can identify at least some of the typological characteristics under consideration, thereby bringing the reader into some kind of contact with this set of material, and with each of the pieces included in it. This study by no means exhausts the subject: some aspects dealt with here should be discussed in more depth in later studies. However, the conclusions presented here are certainly of some importance, not only because of the obvious richness and typological variety of the 184 pieces of the set, but above all in the stratigraphic evidence associated with each of them. This is the first study in the Portuguese context of the evolution of tools over a period of about 1000 years (between the last quarter of the 4th millennium and the last quarter of the 3rd millennium BC), and also of changes in the raw materials: that is, in the various sources of supply used during the period, clearly involving economic contacts on an inter-regional scale.

Questions of terminology

The designation of polished stone artefacts has been the object of numerous studies, beginning with the criterion of definition itself. The present work gives a restricted meaning to the designation, considering only those objects which were deliberately and consciously polished during the shaping of a functional piece, rather than those whose polishing was the result of use, such as parts of hand mills and sharpeners/polishers.

Concerning the pieces studied here, the traditionally agreed criteria generally base classification on the morphology of the distal extremity, the most useful part of the tool[1]. Although we consider that a definitive functional classification is only certain, if part of the wood which acted as the handle of the blade or lump of stone is preserved. Comparison with present or recent ethnographic parallels, allied with analysis of marks of use[2], gives credibility to the criterion based on the greater or lesser asymmetry of the lateral profile of the distal extremity (blade), which can be used to differentiate between axes and adzes. Thus, the former have roughly symmetrical profiles, unlike the latter, which are distinctly asymmetrical. On the other hand the general appearance of the artefact may help

[1] G. Cooney – S. Mandal, The Irish Stone Axe Project, Monograph 1 (1998); C.-T. Le Roux, L'outillage de pierre polie en métadolerite du type A – les ateliers de Plussulien (Côtes-d'Armor), Travaux du Laboratoire Antropologie, Préhistoire et Quaternaire Armoricains (Université de Rennes 1999) 1.

[2] S. A. Semenov, Prehistoric Technology. An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear (1970) 126–135.

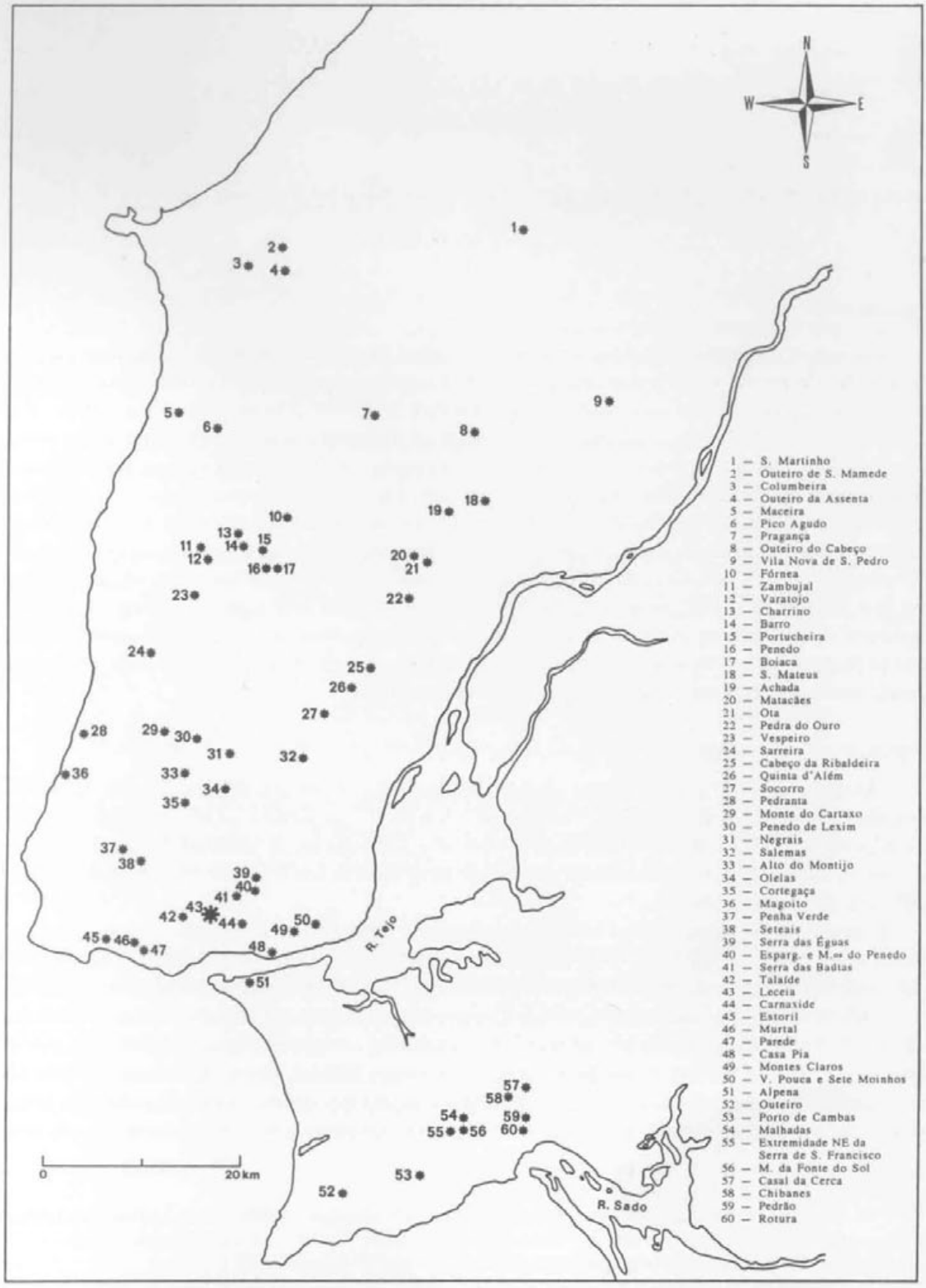


Fig. 1 Main chalcolithic sites in Portuguese Estremadura. Leceia is marked as 43.

to make the distinction: thus, adzes often have an arched body with one surface convex and the other concave, so as to fit better into the wooden handle.

The same criteria were adopted to separate formers from chisels: both differ from axes and adzes in having long bodies, but differ from each other in the lateral profile of the edge: formers are symmetrical in profile, whereas chisels have an asymmetric terminal bevel. Some reservations can be made about this criterion. Firstly, separation based on width of pieces is unclear, there are cases where the separation between narrow axes and formers is problematic. Furthermore, the function of chisels can be the same as that of gouges used in woodwork; perhaps this hypothesis is based on the almost total absence of gouges in Leceia: only one example, to add to the two already studied in the collection of the sculptor Álvaro de Brée[3].

Many axes finished their working lives as hammers: this is proof of the damage suffered by ancient blades, which was nearly always extensive at the other end also. We may therefore assume that the handle was fixed to the middle of the body, or that the tool was simply held in the hand, the piece being used in the same way as a spherical hammer.

Some axes and adzes show marks of violent impact on old blades, resulting in large flakes. These could be the effect of work outside the settlement, especially digging agricultural land, when hitting stones scattered on or just below the surface. This criterion is not certain, however, in view of some large flakes of amphibolite, sometimes conserving pieces of the blades from which they came, which were found within the settlement itself, where the hypothesis of their use as agricultural hoes could obviously not apply. Be that as it may, the earlier acceptance of what are usually called adzes as hoes[4], based on votive limestone figures from various sites in Estremadura, though interesting, is questionable, since there is nothing to show that they do not represent only adzes. Alternatively, use of wedges could make similar marks on old axes and adzes, and in this case they may have been used inside the settlement, for example in making building blocks, as in the Chalcolithic settlement of Castro de Santiago, Fornos de Algodres[5]. Marks on axes and adzes caused by intensive impact thus make the criteria of differentiation for both even more relative.

Finally, the presence of narrow frictional grooves, perpendicular or oblique to the blades, would be related to wood-work, which produces similar marks. There are frequent references to the predominance of these marks on the back of adzes rather than on the lower side, while on axes they appear on both sides equally. In the case of the tools examined here, these observations need to be followed up in further studies, bearing in mind that the oblique angle of the blades themselves, both in axes and adzes, is a factor in the orientation of these marks of use.

It is worth mentioning another type of artefact, which has an asymmetric final bevel like an adze but, unlike both these and axes, has instead of a blade a narrow convex polished surface occupying the whole of the useable distal end. It was because of the pieces collected by the author in Leceia that this detail was first noticed in Portugal[6]. The study supposed a specific function for these pieces, not to be confused with any circumstantial reuse of adzes. In some cases the narrowness of the working

[3] J. L. Cardoso, O povoado pré-histórico de Leceia (Lisboa/Portugal). Estudo da colecção do Escultor Álvaro de Brée, Revista de Guimarães 90 (1980) 211–304; id. ibid. 91 (1981) 190–233.

[4] G. Leisner – V. Leisner, Antas do concelho de Reguengos de Monsaraz, Instituto para a Alta Cultura (1951).

[5] A. C. Valera, O Castro de Santiago (Fornos de Algodres, Guarda). Aspectos da calcolitização da bacia do Alto Mondego, Câmara Municipal de Fornos de Algodres (Textos Monográficos 1, 1997).

[6] J. L. Cardoso, Leceia. Resultados das escavações realizadas 1983–1988 (1989) 104.

area suggests that they were for precision work; however, an example in Leceia – in fact the smallest – in Layer 4, from the Late Neolithic, refutes the theory that they were only used for hammering copper, although this may have been the function of the other pieces, which are all from Layer 2, the Middle Chalcolithic. In fact, the similar tools on display in the Musée des Antiquités Nationales at Saint-Germain-en-Laye (France) are connected to this type of work; in view of morphological similarities with adzes, they have been called transverse hammers.

Another chapter of the study just mentioned describes some almost unworked amphibolite blocks: these are ingots, slightly shaped by polishing, and in accordance with their own shape they were intended to be later made into short thick pieces, compatible with the current types of axes found. The fact that so few have been found shows the high degree of transformation of this imported raw material, and indirectly indicates its intrinsic value. The recognised examples in fact show signs of use as hammers, so they were included in this category. A further proof of this is the reuse, by new polishing, of pieces broken in the course of work, the clearest example of which is the axe, broken lengthways and later made into an adze, which has parallels with others from Estremaduran settlements.

In conclusion, the following main groups of polished stone artefacts emerge from our typological analysis; the set from Leceia is distributed between all of them:

1 Axes, 2 Adzes/hoes, 3 Formers, 4 Chisels, 5 Transverse hammers, 6 Hammers, 7 Gouges.

Techniques of manufacture

Some examples show signs of the processes used when they were made, apart from polishing. In fact, this final operation wiped out previous signs of manufacture, which are only found sporadically.

In anisotropic rocks such as amphiboloschists, the preferred orientation of the crystals caused more or less evident foliation or schistosity, which conditioned the splitting of rocky masses into regular, parallel-sided blocks, more or less paralleliped in shape. This sometimes meant that axe and adzes could be obtained with a minimum of work, which was basically limited to the creation of the blades by polishing.

We should emphasise that the orientation of blades, perpendicular to the foliation of the blocks themselves, corresponds to the maximum mechanical resistance, both in wearing and fracture, as previously shown[7].

Furthermore, we must remember that these pieces, strictly functional in character, were produced in accordance with the principle of greatest economy of labour, a principle which applied both to manufacture and use[8]. In fact, despite their distant source we can easily see that amphiboloschists, because of their superior quality, the economy of action required in their shaping and the size of the natural blocks themselves, would have been the preferred rocks for the different types of tools found at Leceia.

Despite such useful characteristics, we see marks of sawing in some cases. We do not know, however, the technical processes of this operation, which could have involved using a silica abrasive and a thick silex blade moving back and forward. Only thus would the narrow deep cuts, seen in at

[7] Idem, Arquivo de Cascais 5, 1984, 65–67.

[8] J. L. B. Morate, et al., Trabajos de Prehistoria 44, 1987, 87–142.

least one example, have been possible, which in itself shows that this practice was the exception rather than the rule. In fact, the regularity of the natural surfaces of the blocks, after initial splitting and trimming by hammering, meant that the next stage would be finishing by polishing: despite the fact that the raw material was sometimes found near water-courses, there seems to have been no use of smooth pebbles.

The arrangement of the schistoid surfaces perpendicular to the plane of the axe blades often leads to these blades being split into two roughly equal halves; we have already mentioned the use of such pieces as adzes, by rapid polishing of the separated surface, which reinforces what we said earlier about the pragmatism of the manufacturing processes.

Descriptive morphological analysis

In this section we present the criteria and terminology used in our classification of polished stone tools, based on their different attributes; these terms will be systematically used in the tables below. We could have used the work of many different authors, given the interest which has long been aroused in the classification of polished stone tools, based on the different characteristics they present.

Integrity

There are considered to be 3 categories of artefacts[9]:

1 Complete pieces, which may have been used, 2 Incomplete pieces, which could however be classified into one of the typological groups mentioned above, 3 Unclassifiable fragments, but with some relevant identifiable attributes.

Finishing

The quality of finishing, based on the surface of artefacts, should, as far as possible, separate cases where this was achieved by alteration, thus presenting a rough appearance, from those which were never finished by polishing. In fact the quality of the finishing is expressed in the relation of the polished surface to the rest, which may appear rough polished or unworked, that is, preserving the fracture surface of the original block. Thus we have to consider the following categories:

1 Total polishing, 2 Incomplete polishing of the smaller and part of the larger sides (in the cases of pieces sub-rectangular or sub-quadrangular in section), 3 Polishing only of the bevel.

Section

Considering the maximal transverse section of the body of the artefact or of the remaining part of it, the following classes have been defined:

1 Sub-circular, 2 Oval, 3 Lenticular, 4 Sub-quadrangular, 5 Sub-rectangular, 6 Irregular.

Blade

Here, two attributes were considered:

[9] J. M. Pereira, Os artefactos de pedra polida do Almonda ao Zêzere (marcas do povoamento da região), Dissertação de Mestrado em Pré-História e Arqueologia, Faculdade de Letras da Universidade de Lisboa (1999) 1.

Symmetry: Ricq-de-Bouard[10] defines symmetry in three classes, based on quantifiable characteristics. Although in the examples from Leceia these characteristics have been systematically applied both to axes and to adzes with sufficiently well-preserved blades, we do not in fact consider it necessary to go into such a detailed classification. We have simply opted for two classes, which we consider more relevant to the observable conditions:

1 Symmetric blades (value index equal to or less than 1), 2 Asymmetric blades (value index higher than 1).

Convexity: The same author defines convexity of blades from characteristics which were also tried out on the Leceia set. The results lend support to three classes, but, as with the attribute above, these were in fact reduced to only two, since these were easier to perceive:

1 Sub-rectilinear blades (value index equal to or less than 1)

2 Convex blades (value index higher than 1).

Marks of finishing

This subsection concerns the surface evidence of finishing. These can be divided into intentional and accidental: in both cases they were not considered as genuine attributes with descriptive value, but simply as details worthy of mention.

Among intentional marks there are residual punched zones, found on the unpolished middle and near parts of the tools, which are not only due to the previously mentioned principle of minimum energy use, but also because the state of these areas would make for a better attachment of the stone to the handle.

More obviously intentional are the grooves made by polishing, so that a cord could be fixed transversely around the middle of the piece. Leite de Vasconcellos, in a study of the finishing processes of polished stone tools, called attention to such grooves[11], which can be seen in two medium-sized examples, probably axes (in one case the degree of fracture makes this function uncertain) and in a small adze with the narrowest groove, almost an incision, across the middle of the back of the tool. In this particular case, which we think is unique, the most obvious parallels are the previously mentioned limestone votive model adzes from a number of sites in Estremadura, some of which have incisions on the back in exactly the same position as the present example, showing how the vegetable fibres or strips of leather would have been attached to the wooden handle.

Another type of fixing marks are slight depressions, more highly polished than the surrounding area. These are simply a result of friction from the wooden handle or the socket (sometimes of bone) at the place where the stone body fitted into it. It is therefore a purely accidental phenomenon, often only detectable by the presence of a slight surface sheen if seen under good lighting.

Marks of use on blades and heels

This aspect has already been considered when dealing with the reuse of adzes and axes as hammers and hoes, according to the nature of the marks. Their use as wedges, also mentioned, merits some further comment. Thus, while at the working end one expects to find marks of violent impact, especially signs of flaking, on the heel these marks are seen in a damaged surface, as in hammers. Anyway, separating tools which fit these requirements from the axe group, in the absence of detailed studies, is problematic, and has not been attempted here. Wedges could have been used for cutting large trees lengthways for canoe

[10] M. Ricq-de-Bouard, Les outils lithiques polis du sud de la France, CNRS, 1983.

[11] J. L. de Vasconcelos, O Arqueólogo Português 25, 1922, 288–298.

building (in this case the working part, instead of showing marks of violent impact, would probably have deep grooves perpendicular to the blade), and in quarrying near the settlement, where the siliceous modules or veins, interbedded with cretaceous limestones, would have required the use of wedges. In addition, they may have been used in the rough shaping and finishing of blocks used in building the defences: this would explain the large amphibolite flakes, which would have been broken off during these operations.

In view of these observations, the following marks of use were considered for both blades and heels:

1 Intact or little used, 2 Flaked, 3 Hit, 4 Polished.

Inventory of materials

The materials found come from three main cultural phases: Late Neolithic, represented by Layer 4, Early Chalcolithic in Layer 3, and Mid-Chalcolthic, contemporary with the appearance of bell beakers in the last phase of the culture, represented by Layer 2. The stratigraphic and chronological significance of all these phases is clear, and has been successively confirmed and reinforced with the enlargement of the area being excavated, the chronological boundaries of which have been exactly determined[12].

The situation of each of the artefacts on the ground and in the three layers successively excavated is shown in figs. 2–4.

In the inventory of materials that follows, we shall consider the attributes and characteristics mentioned above.

Late Neolithic – Layer 4

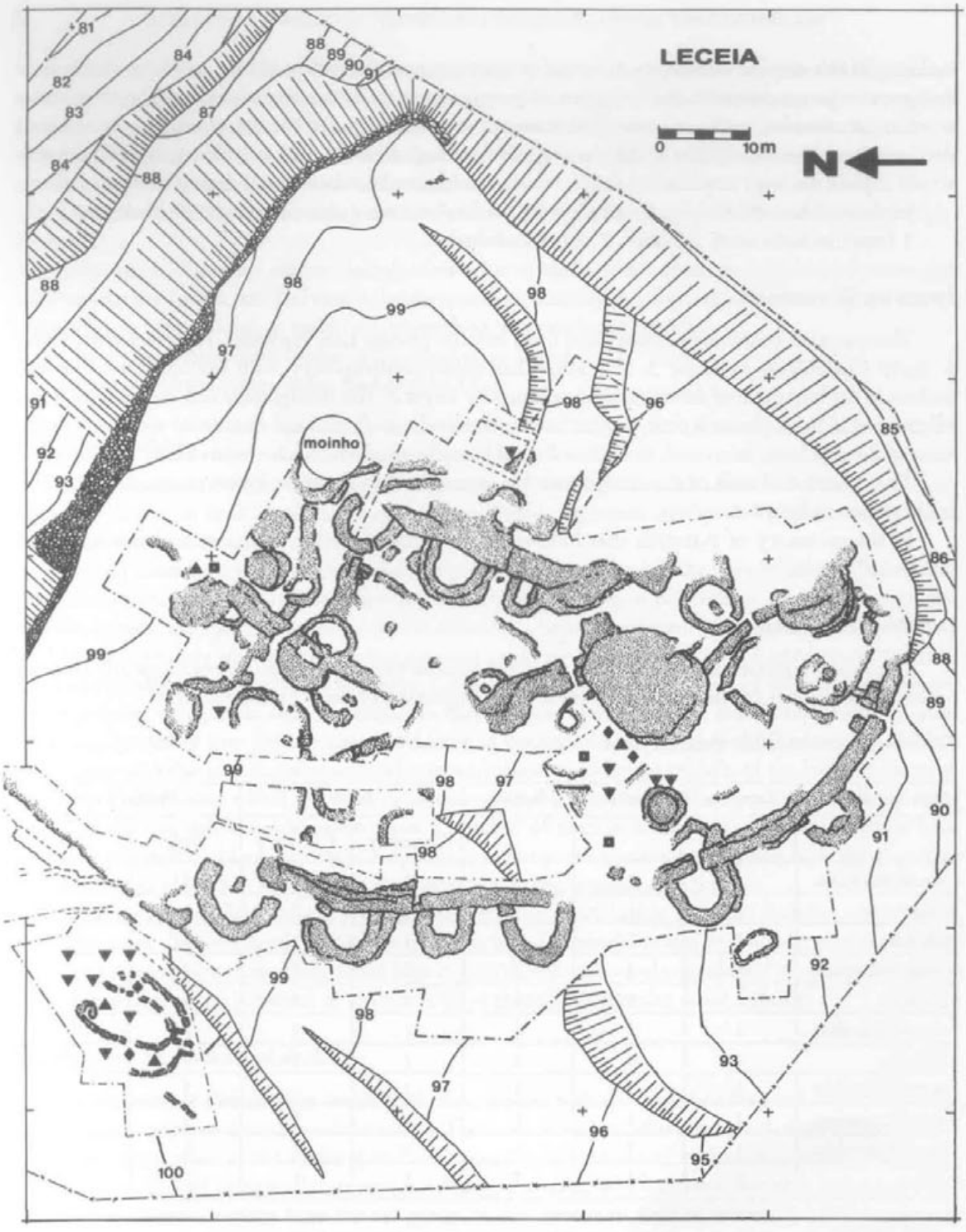
The following artefacts belong to this earliest cultural period in Leceia, chronologically situated between last quarter of the 4th millennium and the beginning of the 3rd millennium BC:

Table 1 Late Neolithic axes, Layer 4.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Amphiboloschist	2	1	5	1	1	2	3
Chert	1	1	5	2	2	1	1
Dolerite	2	3	2	1	2	2	-
Amphiboloschist	1	2	5	2	2	2	1
Dolerite	1	3	1	1	2	3	1
Amphiboloschist	1	3	2	1	2	3	1
Dolerite	2	3	2	1	2	3	-
Amphiboloschist	2	2	5	1	-	2	-
Amphiboloschist	2	1	5	1	1	3	-
Amphiboloschist	1	2	5	1	2	3	1
Chert	2	2	3	1	1	2	-

[L] Thin section.

[12] J. L. Cardoso, Leceia 1983–1993. Escavações do povoado fortificado pré-histórico, Estudos Arqueológicos de Oeiras, Número Especial (1994); idem, O povoado de Leceia sentinela do Tejo no terceiro milénio antes de Cristo, Museu Nacional de Arqueologia/Câmara Municipal de Oeiras (1997); idem, Oxford Journal of Archaeology 19 (1), 2000, 37–55.



1▼ Axes
2▼ Adzes/Hoes
3▲ Hammer-strikers
4▲ Transverse hammers
5◆ Formers/Chisels
6■ Unclassifiable fragments.

Fig. 2 Leceia, Layer 4 (Late Neolithic). Distribution of polished stone artefacts. 1) Axes; 2) Adzes/Hoes; 3) Hammer-strikers; 4) Transverse hammers; 5) Formers/Chisels; 6) Unclassifiable fragments.

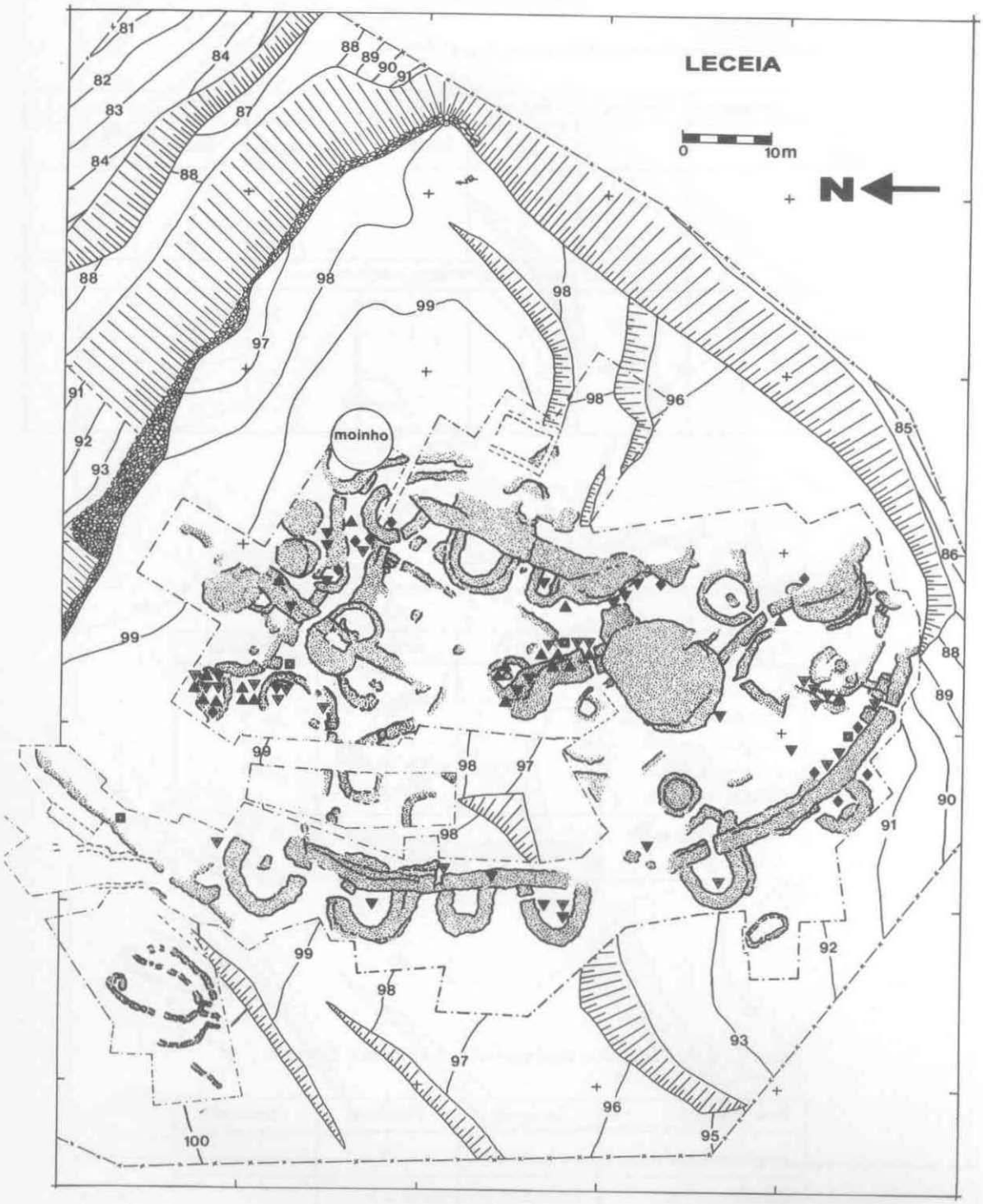


Fig. 3 Leceia, Layer 3 (Early Chalcolithic). Distribution of polished stone artefacts. 1) Axes; 2) Adzes/Hoes; 3) Hammer-strikers; 4) Formers/Chisels; 5) Unclassifiable fragments.

Table 2 Late Neolithic adzes/hoes and formers, Layer 4.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Adzes/hoes							
Chert	2	1	3	1	1	1	-
Chert	2	2	6	-	2	2	-
Basalt	1	(rolled gravel utilised without transformation)				2	2
Formers							
Amphiboloschist	1	2	4	1	2	3	3
Amphiboloschist	1	2	6	-	-	2	3
Amphiboloschist	2	3	2	-	-	3	-
Amphiboloschist	1	3	5	-	-	3	3

Table 3 Late Neolithic hammers and transverse hammers, Layer 4.

Raw material	Integrity	Finishing	Section
Hammers			
Amphiboloschist	1	1	4
Amphiboloschist	1	1	5
Amphiboloschist	1	2	6
Amphiboloschist	2	2	5
Transverse hammers			
Chert	1	1	4

Table 4 Late Neolithic unclassifiable fragments, Layer 4.

Raw material	Integrity	Finishing	Section
Amphiboloschist	3	2	-
Chert[L]	3	-	-
Chert	3	-	-
Schist	3	1	3

[L] Thin section.

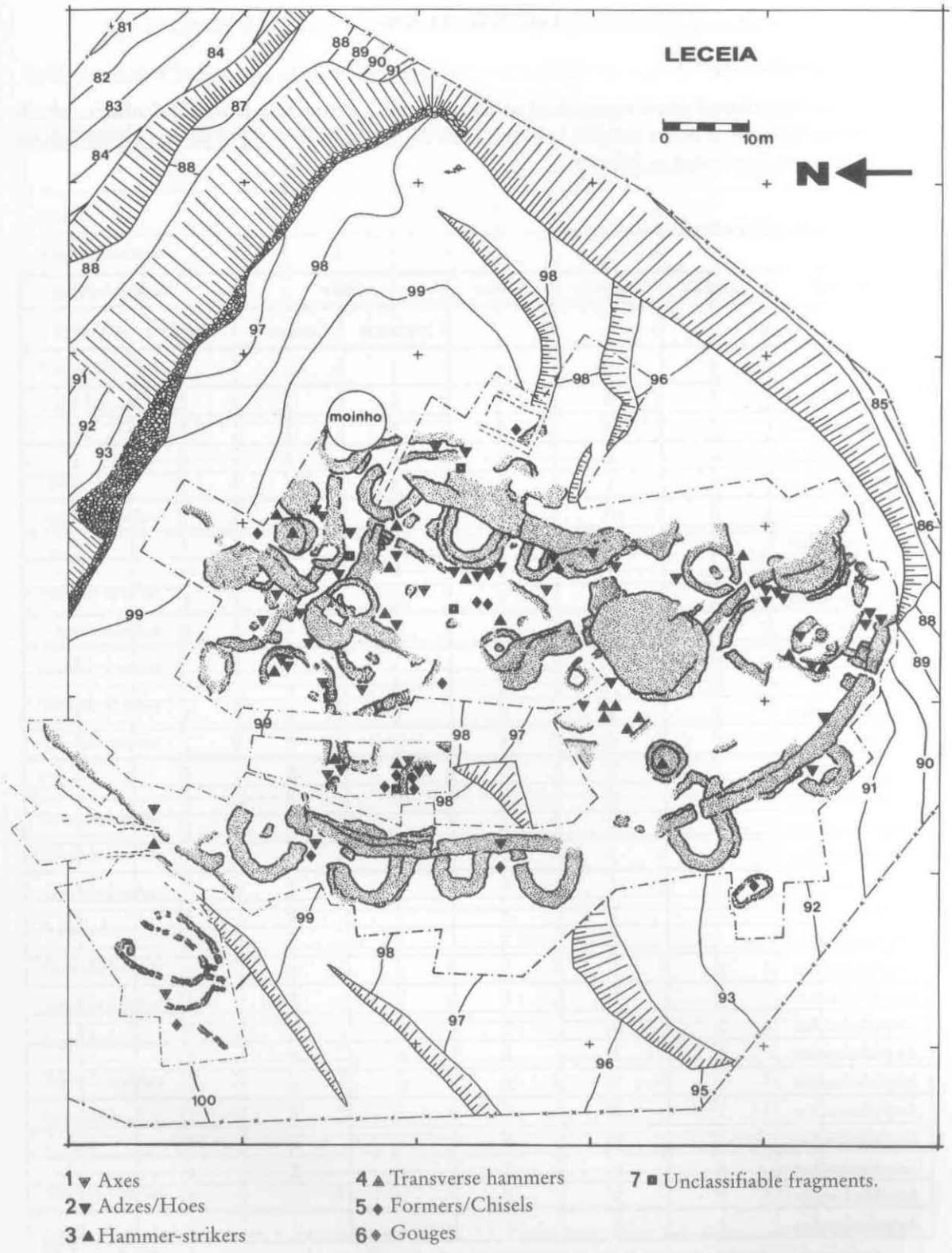


Fig. 4 Leceia, Layer 2 (Middle-Chalcolithic). Distribution of polished stone artefacts. 1) Axes; 2) Adzes/Hoes; 3) Hammer-strikers; 4) Transverse hammers; 5) Formers/Chisels; 6) Gouges; 7) Unclassifiable fragments.

Early Chalcolithic, Layer 3

The second cultural phase represented at Leceia is the Estremadura Early Chalcolithic, which corresponds to Layer 3 and is situated between 2900/2800 and 2600 BC. The polished stone goods relating to it are distributed as follows:

Table 5 Early Chalcolithic axes, Layer 3.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Dolerite[L]	2	1	1	-	-	-	-
Amphiboloschist	1	2	4	1	2	2	1
Amphiboloschist	1	2	5	1	1	2	-
Amphiboloschist	1	2	5	1	2	1	1
Amphiboloschist	1	3	5	2	2	1	1
Amphiboloschist	1	1	5	1	2	1	1
Amphiboloschist	1	3	5	1	2	1	1
Amphiboloschist	1	2	5	1	2	2	1
Amphiboloschist	2	2	5	1	1	1	-
Amphiboloschist	1	2	5	-	-	2	3
Chert[1]	2	2	2	-	-	3	3
Basalt	2	3	2	-	-	3	-
Amphiboloschist	1	2	5	1	2	3	1
Chert	2	1	3	1	2	2	-
Amphiboloschist	1	1	5	1	2	3	3
Amphiboloschist	1	3	2	1	2	3	3
Amphiboloschist	1	1	5	1	2	3	3
Amphiboloschist	1	2	5	2	2	3	1
Amphiboloschist	1	2	5	2	2	3	1
Dolerite	1	1	3	1	2	2	1
Amphiboloschist	1	2	5	1	2	1	1
Amphiboloschist	2	1	5	1	2	2	-
Amphiboloschist	1[2]	1	4	1	2	1	2
Amphiboloschist	1	2	5	1	2	2	3
Amphiboloschist	1	1	5	1	2	1	1
Amphiboloschist	1	1	5	2	2	1	2
Amphiboloschist	1	2	5	2	1	1	1
Amphiboloschist	2	2	5	-	2	3	-
Amphiboloschist	1	2	5	1	2	1	3
Amphiboloschist	2	2	5	-	-	2	3
Amphiboloschist	1	1	5	1	2	1	1

[1] With transverse socket polished on one major side, [2] With longitudinal socket polished on a top side (perhaps used for manufacture of bone artefacts), [L] Thin section.

Table 6 Early Chalcolithic adzes/hoes, Layer 3.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Basalt[1]	1	-	5	1	2	-	-
Amphiboloschist	2	2	5	-	-	-	1
Amphiboloschist	1	1	5	2	2	2	2
Amphiboloschist[2L]	1	2	6	2	2	2	1
Amphiboloschist	2	2	5	-	-	2	-
Amphiboloschist[3]	1	2	5	2	2	2	1
Amphiboloschist	1	2	4	2	2	2	1
Chert	2	1	3	-	-	-	-
Amphiboloschist	2	2	5	-	2	2	-
Chert[L]	2	1	3	1	1	1	-
Amphiboloschist	2	1	6	-	-	-	1
Amphiboloschist	2	1	5	1	2	2	-
Amphiboloschist[L]	2	3	5	2	2	3	-
Amphiboloschist	1	2	5	1	2	2	1
Amphiboloschist	1	1	5	2	2	2	1
Chert	2	2	5	1	2	1	-
Amphiboloschist	1	1	5	1	1	2	1
Amphiboloschist	1	1	3	1	2	1	1
Amphiboloschist[4]	1	1	5	1	2	2	1
Andesite[L]	2	1	-	-	-	-	-
Amphiboloschist	1	2	5	2	2	1	1
Amphiboloschist	1	2	5	1	2	1	2
Amphiboloschist	2	2	5	2	2	1	-
Amphiboloschist[5]	1	2	5	1	2	2	2
Amphiboloschist	1	2	3	1	2	3	1
Amphiboloschist	1	2	5	2	2	2	1
Amphiboloschist	2	1	5	-	2	2	-

[1] Unfinished piece, cut from a natural basalt 'blank', [2] 5 Pieces made from half an axe, accidentally broken, [3] Blade probably restored by polishing, [4] Piece with a longitudinal mark showing sawing, [L] Thin section.

Table 7 Early Chalcolithic, hammer-strikers, Layer 3.

Raw material	Integrity	Finishing	Section
Amphiboloschist[1]	1	2	6
Amphiboloschist[2]	2	2	5
Amphiboloschist[3]	2	1	5
Amphiboloschist	1	2	5
Amphiboloschist[4]	1	2	5
Amphiboloschist[1]	1	2	5
Amphiboloschist	1	2	5
Amphiboloschist[1]	1	2	5
Amphiboloschist	1	2	6
Amphiboloschist[4]	1	2	5
Amphiboloschist[4]	2	2	5
Amphiboloschist[1]	1	2	5
Amphiboloschist[4]	1	2	5
Amphiboloschist[4]	1	2	5
Amphiboloschist[4]	1	2	4
Amphiboloschist[2]	1	2	4
Basalt[3]	1	2	4
Amphiboloschist[3]	3	2	4
Basalt	3	2	4
Amphiboloschist[5]	1	2	4
Amphiboloschist	1	2	5
Amphiboloschist	2	2	-

[1] From a lightly polished rock, [2] From an adze fragment, [3] From an axe or adze, [4] From an axe, [5] From an ingot.

Table 8 Early Chalcolithic formers, chisels and gouges, Layer 3.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Formers							
Amphiboloschist	1	1	5	1	2	1	1
Amphiboloschist	1	1	4	1	2	1	1
Amphiboloschist	1	1	4	2	2	2	1
Chert	2	1	1	1	1	1	-
Amphiboloschist	1	1	4	1	1	1	1
Amphiboloschist	1	2	5	-	-	2	3
Amphiboloschist	2	1	4	1	1	2	-
Amphiboloschist	1	1	4	1	2	1	2
Amphiboloschist	1	2	4	1	2	2	2
Amphiboloschist	1	1	4	1	1	1	2
Amphiboloschist	2	2	4	-	-	-	1
Amphiboloschist	2	2	4	-	-	-	1
Chisels							
Amphiboloschist	1	2	4	1	1	1	3
Amphiboloschist	1	1	4	1	2	2	2
Amphiboloschist	1	1	4	2	1	2	1
Amphiboloschist	2	1	-	-	-	-	1
Gouges							
Schist	2	2	3	-	-	-	-
Formers or chisels							
Trachyte[L]	3	2	6	-	-	-	-

[L] Thin section.

Table 9 Early Chalcolithic transverse hammers, Layer 3.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Amphiboloschist	2	2	-	-	2	4	-

Table 10 Early Chalcolithic fragments of indeterminate polished stone tools, Layer 3.

Raw material	Finishing	Section
Amphiboloschist[1]	2	5
Amphiboloschist[L]	2	5
Amphiboloschist	2	5
Amphiboloschist	2	5
Diorite	1	5
Diorite	1	3

[1] With socket polished by handle, [L] Thin section.

Middle Chalcolithic – Layer 2

The following polished stone tools were found in Layer 2, from the Middle Chalcolithic.

Table 11 Middle Chalcolithic axes, Layer 2.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Amphiboloschist	1	2	5	1	2	3	3
Amphiboloschist	1	2	5	2	2	3	3
Amphiboloschist	1	2	5	-	-	2	1
Amphiboloschist	1	2	5	2	1	2	1
Amphiboloschist	1	2	5	1	2	2	1
Amphiboloschist	2	2	5	2	2	2	-
Amphiboloschist	2	1	5	2	1	2	-
Amphiboloschist[L]	2	2	5	-	2	1	-
Microssienite[1L]	2	3	1	1	-	-	1
Amphiboloschist	1	1	5	1	2	1	1
Amphiboloschist	1	2	4	1	2	2	1
Amphiboloschist	1	2	4	1	2	2	1
Amphiboloschist[L]	2	2	4	1	2	2	1
Amphiboloschist	1	2	5	1	2	1	1
Dolerite	2	3	2	1	2	3	-
Amphiboloschist	1	2	5	1	2	3	1
Amphiboloschist	2	2	5	1	2	1	3
Amphiboloschist	2	1	5	-	2	3	3
Amphiboloschist	1	2	6	1	2	2	1
Amphiboloschist	1	2	4	1	2	3	3
Amphiboloschist	1	2	5	1	2	3	3
Amphiboloschist	1	2	5	2	2	3	3
Amphiboloschist	2	2	5	-	2	2	3
Amphiboloschist[L]	2	2	5	-	2	3	-
Dolerite	2	1	1	-	-	-	1
Dolerite	2	1	1	-	-	-	3
Amphiboloschist	1	3	5	1	2	2	2
Dolerite	1	3	2	1	2	3	1
Amphiboloschist	2	2	5	-	-	2	-
Amphiboloschist	1	1	5	2	2	1	3
Amphiboloschist	1	2	5	1	2	3	3
Amphiboloschist	1	1	5	1	2	2	2
Amphiboloschist	1	1	5	1	2	2	3
Amphiboloschist	1	1	5	2	1	1	3
Amphiboloschist	2	1	5	-	-	-	3

[1] Has marks of fixing or finishing (friction polishing). Because of its archaic type it may actually be from Layer 4,
[L] Thin section).

Table 12 Middle Chalcolithic adzes and hoes, Layer 2.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Amphiboloschist	1	2	5	1	2	2	1
Dolerite	2	1	3	2	2	1	-
Amphiboloschist	1	1	5	2	1	2	-
Amphiboloschist[L]	2	1	5	-	2	1	-
Amphiboloschist	2	3	5	1	2	2	-
Amphiboloschist	1	2	5	-	2	2	1
Amphiboloschist	1	2	5	1	2	3	1
Amphiboloschist	1	2	6	1	2	2	1
Amphiboloschist	2	2	5	-	1	2	-
Amphiboloschist	2	1	5	2	2	2	-
Amphiboloschist	1	2	5	1	2	2	1
Amphiboloschist	1	1	4	2	2	3	1
Amphiboloschist[L]	2	1	5	1	2	2	-
Amphiboloschist[L]	2	1	5	-	-	-	1
Amphiboloschist[1]	2	1	5	1	2	1	-
Amphiboloschist	1	1	5	1	2	1	1
Chert	2	2	3	1	1	2	-
Shale[L]	2	2	5	-	2	2	-
Amphiboloschist	1	2	4	-	-	3	1
Amphiboloschist	1	1	5	-	-	2	2
Shale	2	2	5	1	2	2	1

[1] Has small transverse socket for fixing, [L] Thin section.

Table 13 Middle Chalcolithic transverse hammers, Layer 2.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Amphiboloschist[L]	1	2	5	1	2	4	1
Amphiboloschist	1	1	5	1	1	4	1
Amphiboloschist	1	1	5	1	1	4	1
Amphiboloschist	1	1	5	2	2	4	1
Amphiboloschist	1	2	5	1	2	4	1

[L] Thin section.

All the tools called transverse hammers are very similar typologically, with all the examples in the inventory, of amphiboloschist, coming from Layer 2 (except a small piece from Layer 4, whose only similarity with the others is that it too has a polished surface in place of a blade, whereas the typology, size and material are different). They all have bodies which are sub-rectangular in cross-section, and are medium sized, with an asymmetric longitudinal distal profile, like adzes (this allows us to suppose that their handles were similarly fixed, hence their name).

Table 14 Middle Chalcolithic hammer/strikers, Layer 2.

Raw material	Integrity	Finishing	Section
Amphiboloschist	1	2	5
Amphiboloschist	1	1	5
Amphiboloschist	1	2	5
Amphiboloschist	1	2	5
Amphiboloschist	2	2	5
Amphiboloschist	1	2	5
Amphiboloschist	2	2	5
Amphiboloschist	1	3	1
Amphiboloschist	1	1	5
Amphiboloschist	1	2	5
Amphiboloschist[L]	2	2	5
Andesite[L]	1	2	5
Amphiboloschist	1	2	4
Amphiboloschist	1	2	5
Basalt[1]	1	2	3
Amphiboloschist	2	2	5

[1] This seems to have been the only piece found which was originally used as a hammer, [2] This was a stone ingot used for hitting, [3] This may be considered a wedge, since there are marks of flaking on both sides, [L] Thin section.

Table 15 Middle Chalcolithic formers, chisels and gouges, Layer 2.

Raw material	Integrity	Finishing	Section	Blade		Marks of use	
				Symmetry	Convexity	Blade	Heel
Formers							
Amphiboloschist	1	2	4	1	2	1	3
Amphiboloschist	2	2	4	-	-	-	1
Amphiboloschist	1	2	4	1	1	1	1
Amphiboloschist	1	1	4	2	2	2	3
Amphiboloschist[L]	2	2	4	-	-	2	2
Amphiboloschist	1	1	4	1	2	1	3
Amphiboloschist	2	1	5	1	1	2	-
Amphiboloschist[L]	1	2	4	1	2	2	3
Chisels							
Amphiboloschist	2	1	6	2	2	1	-
Amphiboloschist	2	1	4	1	2	1	-
Amphiboloschist	1	1	5	1	2	1	1
Amphiboloschist	1	1	5	1	1	2	1
Amphiboloschist	2	1	5	1	2	1	3
Formers or Chisels							
Amphiboloschist	3	1	4	-	-	-	2
Gouges							
Amphiboloschist	2	2	5	-	-	-	-

[L] Thin section.

In some cases, the separation between 'former' and 'axe' was problematic: it was impossible to define strict criteria of difference based on the relationship between length and width, since there are narrow axes similar in shape to formers.

Table 16 Middle Chalcolithic unclassifiable polished stone artefacts, Layer 2.

Raw material	Finishing	Section
Amphiboloschist	2	1
Amphiboloschist	2	5
Basalt	4	6
Amphiboloschist	1	-

Discussion

This section presents comparisons of the set of material, under the following aspects:
- Typological composition of each cultural set
- Internal typological evolution of each type
- Relation between petrography and typology
- Variation in rocks used over time
- Sources of rocks used.

Typological composition of each cultural set

The results of typological distribution, carried out separately for each of the chrono-cultural groups, is set out in the table below:

Table 17 Typological composition of each cultural set.

	Axes	Adzes/ Hoes	Hammers/ Strikers	Transverse hammers	Formers	Gouges	Ingots/ & Chisels	Unclassified Strikers
Late Neolithic								
Layer 4	11	3	4	1	4	-	-	4
%	40,7	11,1	14,8	3,7	14,8	-	-	14,8
Early Chalcolithic								
Layer 3	31	27	21	1	17	1	4	6
%	28,7	25,0	19,4	0,9	15,7	0,9	3,7	5,6
Middle Chalcolithic								
Layer 2	35	21	16	5	14	1	-	4
%	36,4	21,9	16,7	5,2	14,6	1,0	-	4,2
Total	77	51	41	7	35	2	4	14
%	33,3	22,1	17,7	3,0	15,2	0,9	1,7	6,1

In commenting on this table the first thing that stands out is the low percentage of unclassified pieces, with a maximum of 14,8% in the earliest set. Also, there are a large number of manufactured pieces: only in Layer 3 are there four amphiboloschist ingots with very little polishing finish - they were used as hammers or strikers. In fact, their slight polishing may be due to rapid shaping of the raw blocks, before they were finally made into any of the types of artefacts considered here.

Axes are the commonest type of polished stone tool in all sets from Leceia. The percentages vary in inverse proportion to those of adzes: this explains the maximum in the earliest set, 40,7%, when adzes are at their minimum of 11,1%. There may be a reason for this: in the earliest period of the settlement the most important thing was to clear the surrounding land of trees, creating clearings for agriculture or grazing. The slight variations in the relative quantities of axes and adzes in the two Chalcolithic sets are probably explained by a stabilisation of these activities around the settlement, but are above all a reflection of the reuse of these tools as hammers in the final stages of their working lives. Nonetheless, despite the large number of adzes, axes tend to be in the majority, a sign of the importance of wood-working in the construction of defences, palisades and gates, in house- and boat-building and in the making of agricultural implements, such as primitive wooden ploughs. In this respect it is worth mentioning that there are a large number of adzes with marks of violent impact on the blades – probably due, at least in part, to digging stony ground, among pieces which still have a working extremity. In Layer 4 too there was a piece with deep marks of impact on the blade, which has been seen as a hoe.

Also notable is the high percentage of hammers in the two Chalcolithic sets, relating to the reuse of axes and adzes; this would be even higher if we considered all tools with traces of impact at the ends. In fact there are numerous axes and adzes in this state, but the impact marks on them are not strong enough to warrant their inclusion as hammers. This suggests, however, a low level of

renovation of these blades, which goes against good management and economy of raw materials, bearing in mind that the large majority of such pieces are of amphioschist, which would certainly have been costly to import, and that the work they did as hammers could equally have been done by tools made of easily obtainable local rocks.

Some of the tools within the hammer group were used for quarrying and wood-working. There may be a case for creating a sub-group of 'wedges' but it is difficult to separate these from the rest.

Mention should also be made of some small, narrow pieces, generally finished with care, in the group of formers and chisels. Nearly all have well-preserved blades, with slight marks of impact or flaking, suggesting work with fairly soft materials such as wood. In contrast, the opposite ends sometimes show signs of impact, having been hit directly with a hammer, but others are intact, indicating that they probably had a wood or bone socket. In fact, some pieces of deer antler show impact marks compatible with this.

Also related to wood-work are the two fragments of gouges found from Layer 2. The scarcity of this type of tool shows that the work done by it – hollowing and perforating wood, and work on horn and bone – would have been done using other artefacts, namely chisels.

Intern evolution of each type

The typology of some polished stone artefacts has traditionally been related to successive chrono-cultural stages which they supposedly represent; this line of study pays particular attention to the morphology of axes. In this context, the precisely stratified finds from Leceia are an important contribution to an informed discussion of this important and still uncertain question.

The Late Neolithic axes (Layer 4) are predominantly (54,5%) sub-rectangular in section, although the percentage of these is lower than those in the two subsequent Chalcolithic phases (74,2% and 71,4% respectively). This characteristic is directly related with the quality of finishing. Thus, while in the earliest layer only 45,5% of the axes are completely or almost completely polished (classes 1 and 2), this percentage rises to 87,1% and 88,6% respectively for the sets from the Early and Middle Chalcolithic. We may therefore conclude that circular or elliptical cross-sections and partial polishing, sometimes limited to the blade, are archaic characteristics, still found in the earliest axes at Leceia but tending to disappear in the course of the Chalcolithic. This would be seen even more clearly if we could eliminate the movement of materials, inevitable in vast settlements like Leceia, where post-depositional processes – erosion, sedimentation, and redeposition – would certainly have played a large part.

As for the remaining tools, we can see that adzes/hoes do not show such a clear typological evolution as do axes. The two examples from the late Neolithic are flattened, lenticular in cross-section and are completely polished, like most contemporary examples from Estremaduran necropoles, such as the pieces found at Lapa do Bugio, Sesimbra[13]. The early Chalcolithic adzes at Leceia have mainly sub-rectangular sections (66,7%); a proportion which increases in the Middle Chalcolithic (71,4%); in both Chalcolithic groups the polishing is generally good. In conclusion, we can see an evolution of adzes from flattened/lenticular to sub-rectangular in section: as with axes, the latter shape predominates in the Chalcolithic.

[13] J. L. Cardoso, Setúbal Arqueológica 9/10, 1992, 89–225.

Other attributes investigated in both, axes and adzes, are the symmetry and convexity of the blade. In Table17 these are correlated:

Table 18 Relation between symmetry and convexity of axe and adze blades.

Blades	Layer 4 (n=11)	Layer 3 (n=31)	Layer 2 (n=35)
Axes			
Symmetrical blades	81,8%	80,0%	73,1%
Convex blades	30,0%	92,0%	89, 6%
Adzes			
Symmetrical blades	n. r.	55,0%	71,4%
Convex blades	n. r.	90,9%	78,9%

n. r. = non-representative.

These results show that symmetrical blades are commoner in axes than adzes, which may be related to the action of the blade itself: cutting obliquely and horizontally, as in adzes, a blade would be more efficient than if all its length penetrated the material at the same time – this same principle explains the oblique blades of guillotines in the French Revolution. Furthermore, adzes are less likely to have convex blades than axes, apart from those from the earliest layer, where low numbers may account for the anomaly.

Diachronically, axe blades became less symmetrical during the Chalcolithic, unlike adzes, whereas symmetry varies inversely over time, decreasing in axes and increasing in adzes. Looking at each group in isolation, there is a disproportion between convexity and symmetry of blades, both of axes and adzes: in axes, the more convex, the more symmetrical are the blades; in adzes, the more convex, the less symmetrical are them. This situation can be justified by the different technique of manipulation and utilisation of the both types of tools.

Relation between petrography and typology

There has long been an interest in Portugal in understanding the petrographic nature of polished stone artefacts, as can be seen in many pioneering studies, such as Carlos Ribeiro's monograph on Leceia[14]. However, the first study in Portugal on the relationship between petrography and typology of artefacts, dealing with the Late Neolithic polished artefacts of the cave necropolis of Lapa do Bugio, Sesimbra is much more recent[15]. It was seen that while axes were only made from amphibolite rocks, adzes, flatter in shape, were from black volcanic rocks, compact and afiric in texture. This study also aimed to relate the petrographic types identified in thin section by polarised light microscope with their sources. This task and methodology were continued with material from Leceia, based on a previously selected set of materials from excavations by the author and from the vast, but without stratigraphic information collection in the National Archaeological Museum[16]. While the

[14] C. Ribeiro, Noticia de algumas estações e monumentos prehistoricos. 1 – Noticia da estação humana de Licêa (1878) 69 ff.

[15] See note 13.

[16] J. L. Cardoso – A. B. Carvalhosa, Estudos Arqueológicos de Oeiras 5, 1995, 123–151.

percentage of each petrographic type was precisely determined, the question of the correlation between the nature of the rocks and the typology was only touched on; we should therefore take up this question from a diachronic perspective, which is only possible based on the stratigraphic elements of each piece being studied.

Considering the main types of artefacts identified, the relationship between typology, petrography and chronology is as follows:

Table 19 Relationship between typology, petrography and chronology of the main types of polished stone tools.

Axes	Amphiboloschists (%)
Late Neolithic	54,5
Early Chalcolithic	83,9
Middle Chalcolithic	85,7
Adzes	
Late Neolithic	0 (only 2 artefacts found)
Early Chalcolithic	81,5
Middle Chalcolithic	81,0
Formers and Chisels	
Late Neolithic	100 (only 4 artefacts found)
Early Chalcolithic	88,2
Middle Chalcolithic	100,0
Hammers	
Late Neolithic	100 (only 3 artefacts found)
Early Chalcolithic	90,5
Middle Chalcolithic	87,5

The conclusions to be drawn from these results may be summarised as follows:

1 – There are no significant deviations in the preference for amphiboloschists among axes and adzes, except for the Late Neolithic group, in which, of the two adzes found, neither is of amphiboloschist. Despite reservations due to the paucity of samples, we can see that this fact agrees with what we have seen in Lapa do Bugio, and so conclude that during the Late Neolithic in Estremadura there was a clear preference for making adzes from afiric, black volcanic rocks, which were no longer applied in the Chalcolithic, when both adzes and axes were made mainly of amphiboloschists.

2 – Formers and chisels, more than axes and adzes, required rocks with high tenacity and strength: hence there is a clear preference for amphiboloschists, more marked than in the two previous groups of tools.

3 – As with the previous group, hammers also show a greater incidence of amphiboloschists than axes and adzes. These differences leave open two possibilities:

– as the large majority of hammers derive from reused axes and adzes, only the pieces made of amphiboloschists would have been reworked;

– the hypothesis, however remote, that some of the hammers or strikers were made as such, and of amphiboloschist for preference, for the reasons mentioned above. According with this order of reasons we should emphasise that all the four ingots of amphiboloschist identified (all from Layer 3) were utilised as hammers or strikers.

Variation in time of the rocks used

Discussion of this subject is of the greatest relevance in the context of the Chalcolithic economy of Portuguese Estremadura. Since this region is poor in hard rocks suitable for making polished stone artefacts, such type of rocks had to be imported if daily activities were to be carried out efficiently.

Signs of such importation have already been demonstrated[17] in the constant presence of amphiboloschists in Leceia, with a figure of about 75% of the total of polished stone artefacts as based on thin section petrographic analysis of a carefully selected set of material. But we needed to improve the quality of the results, especially in defining any variations in the supply or acquisition of the raw materials over the thousand or so years the site was occupied. We could only achieve this, however, if we had an ample, representative and stratigraphically referenced set of material - conditions which only the present materials, collected in the author's excavations, could satisfy.

Thus, taking as a reference point the thin section petrographic classifications previously published[18], we tried, by direct comparison based on macroscopic examination, to classify the remaining finds. Naturally this did not enable any detailed classification, especially of igneous rocks of the region around; however, it showed enough for us to separate these from amphiboloschists, permitting the following conclusions:

Layer 4 (Late Neolithic) has 27 polished stone artefacts. Of these, 15 are amphiboloschists, the rest being distributed between the following petrographic groups: dolerite rocks – 3; chert (silexite) – 7; basalt – 1. In this group, the last three types of rocks are local or regional in origin, all being available in the region. 55, 6% of the rocks used for polished stone artefacts from the earliest settlement of Leceia are amphiboloschists imported from the Hercinian Massif;

Layer 3 (Early Chalcolithic) has 108 polished stone artefacts, 91 of amphiboloschists (including the four ingots mentioned above). The rest are distributed between the following petrographic groups: dolerite rocks – 4; chert (silexite) – 6; basalt – 4; andesite – 1; trachyte – 1. In this group, 84,2% of the raw materials are imports, made up of amphiboloschists. There is, however, an increased variety in the use of local or regional hard rocks such as basalt, andesite and trachyte, which do not appear in the previous group (which may perhaps be explained by the fact that it is smaller).

Layer 2 (Middle-Chalcolithic) has 96 pieces, distributed petrographically as follows: dolerite – 5; cherte (silexite) – 1; microssienite – 1; argillaceous schist (shale) – 2; andesite – 1; basalt – 2. The remaining 84 pieces, 87,5%, are of amphiboloschists.

These results clearly indicate the growing importance of amphiboloschists during the lifetime of the settlement, which, as we have said, covers three distinct cultural phases over roughly 1000 years, since the second half of the IV, until the second half of the III millenium BC. The explanation for this

[17] Ibid. 123–151.
[18] Ibid.

must be sought in two different directions: the specific nature of these rocks, which accounts for the clear preference for them, and the conditions governing their supply. Concerning the former, amphiboloschist is obviously mechanically superior to the hard rocks of the Lower Estremadura region, where Leceia is situated. The intense economic activity which characterised the III millennium BC in Estremadura imposed a growing need for high quality raw materials: increased agricultural production necessitated artefacts of suitable quality which these rocks could produce – the axes, adzes, hoes, etc. which have been found even in the Early Neolithic in Estremadura, as at the cave of Caldeirão near Tomar[19], in the proximity of the amphibolitic sources.

A good supply of these rocks could only be had through exchange of surplus products, which could be agricultural (grain, dried fruits) or geological (silex). In fact, the possibility has already been noted[20] that amphibolite rocks were exchanged for silex, which was quarried close to Leceia. Not only is there direct evidence of this extraction[21], but there are also artefacts of Estremaduran silex among finds at contemporary sites in the Alentejo, as well as typically Estremaduran decorated pottery, such as the 'acacia leaf' type found at the Chalcolithic settlement of Monte da Tumba, Torrão[22]. Together with the amphiboloschists in Leceia there are also a few arrowheads of reddish jaspoid schist, definitely originating in the Alentejo; these, although not indispensable in local daily life, have in many cases an unequalled aesthetic value which might justify their being imported.

Nevertheless, the apparent quantity of amphiboloschists in Leceia and many other settlements in Estremadura becomes less impressive when we consider the time-scale involved. In fact, even at the height of the trade, in the Chalcolithic period between 2900 and 2400 BC, there are only 204 pieces of amphiboloschists, an average import of 0,41 pieces per year, assuming constant occupation of the settlement, which seems to be the case. Even including the approximately 400 pieces in the National Archaeological Museum and the Museum of the Institute of Geology and Mining – whose origin in the prehistoric settlement is not absolutely certain – the annual average of 'imports' is no higher than 1, 2 pieces per year, which is obviously very little, and contradicts the idea of massive, permanent and steady imports of this raw material. That it was so widespread and dominant in Estremadura during the III millennium BC clearly indicates organised systems of quarrying and distribution, with this particular trade fitting into a much wider pattern expressed in complex processes of supra-regional cultural interaction securely based on economics.

In other words, amphiboloschists in appreciable quantities in Estremaduran settlements must be seen as part of a context of wide interchange, so that it is impossible to explain their existence in separation from a set of very diverse material, some of cultural or ideological character, such as the well-known Alentejan schist plaques in Estremaduran Late Neolithic sites. However, the situations should not be confused: doubtless the motive, within an integrated exchange system, for the import of amphiboloschist by Neolithic and Chalcolithic communities in Estremadura was dictated by objective and ever-increasing demands for the distribution of a raw material suitable for the productive activities of the communities: if the number of imports was no higher, it is because it answered the communities' needs satisfactorily, and not because it was logistically or materially impossible to

[19] J. Zilhão, Gruta do Caldeirão O Neolítico Antigo, Trabalhos de Arqueologia 6 (1992), 326 ff.

[20] J. L. Cardoso, O povoado de Leceia sentinela do Tejo no terceiro milénio antes de Cristo, Museu Nacional de Arqueologia/Câmara Municipal de Oeiras (1997).

[21] J. L. Cardoso – J. B. Costa, Setúbal Arqueológica 9/10, 1992, 229–245; J. L. Cardoso – J. Norton Estudos Arqueológicos de Oeiras 7, 1997/1998, 35–45.

[22] C. T. Silva – J. Soares, Setúbal Arqueológica 8, 1987, 29–79.

increase production or distribution. We cannot therefore agree with the recent symbolic interpretation of these rocks when made into artefacts such as those we are studying[23], which is contradicted by the material evidence itself; this all too often takes second place to theoretical constructs, when exactly the opposite should happen.

In summary, we have here a good example of the transregional supply of a raw material which we would nowadays call 'strategically important', in the context of the economic intensification, which is the cultural interaction, characteristic of the Chalcolithic.

Sources of supply

It is important to consider the geographical distribution of amphibolite rocks in the westernmost part of the Hercinic Massif, a subject already discussed in this context[24]. In that study, the significant sample which was subjected to thin section analysis by polarized light microscope revealed the following general petrographic characteristics of these rocks:

- the presence of schistosity, more or less pronounced;
- fine granulation;
- mineralogical paragenesis normally consisting of bluish-green hornblende ± actinolite and plagioclase (albite-oligoclase or acidic oligoclase). In some cases epidote-zoizite occurs subordinately. Opaque minerals, sphene and apatite are also found;
- residual minerals (plagioclase) are occasionally found, suggesting an orthoderivative origin (metadolerite?);
- petrographically this is a homogenous group, differing only in the content of feldspar, and fitting into the group of epimetamorphic rocks (low-grade amphibolites), mostly albite-epidote-amphibolitic facies.

Apart from these general characteristics, the amphiboloschists at Leceia usually show distinct foliation, as they are made up essentially of hornblende in association with plagioclase and some epidote.

Amphibolite is particularly represented by bluish-green hornblende, often accompanied by actinolite, occurring in elongated prisms usually oriented in parallel (schistosity). Sometimes the hornblende forms fenocristals which may be associated with granules of epidote.

Plagioclase usually has the same composition as oligoclase, sometimes with sodium. It occurs in sub-idiomorphic crystals; at other times it is anedric, forming granoblastic aggregates like quartz, or appearing in intersticial grains.

Other constituents, such as epidote-zoizite, quartz and biotite, may be present in variable quantities. Apart from these, magnetite, ilmenite, pyrite, apatite and sphene occur subordinately. Chlorite appears as a secondary mineral.

Very occasionally these rocks are metabasites with residual characteristics which are still quite obvious, such as the shafts of plagioclase replaced by epidote and chloritic aggregates filling the vesicles, which shows the orthoderivative origin of some of these green rocks.

In view of these petrographic characteristics – which could only have been seen in a systematic study at this level – we have tried to locate the different regions where the rocks could have been

[23] K. T. Lillios, Trabajos de Prehistoria 57 (1), 2000, 19–28.

[24] See note 15.

obtained; naturally those nearest to Lower Estremadura have been preferred. The following sources of supply have been identified, going from north to south (fig. 5):

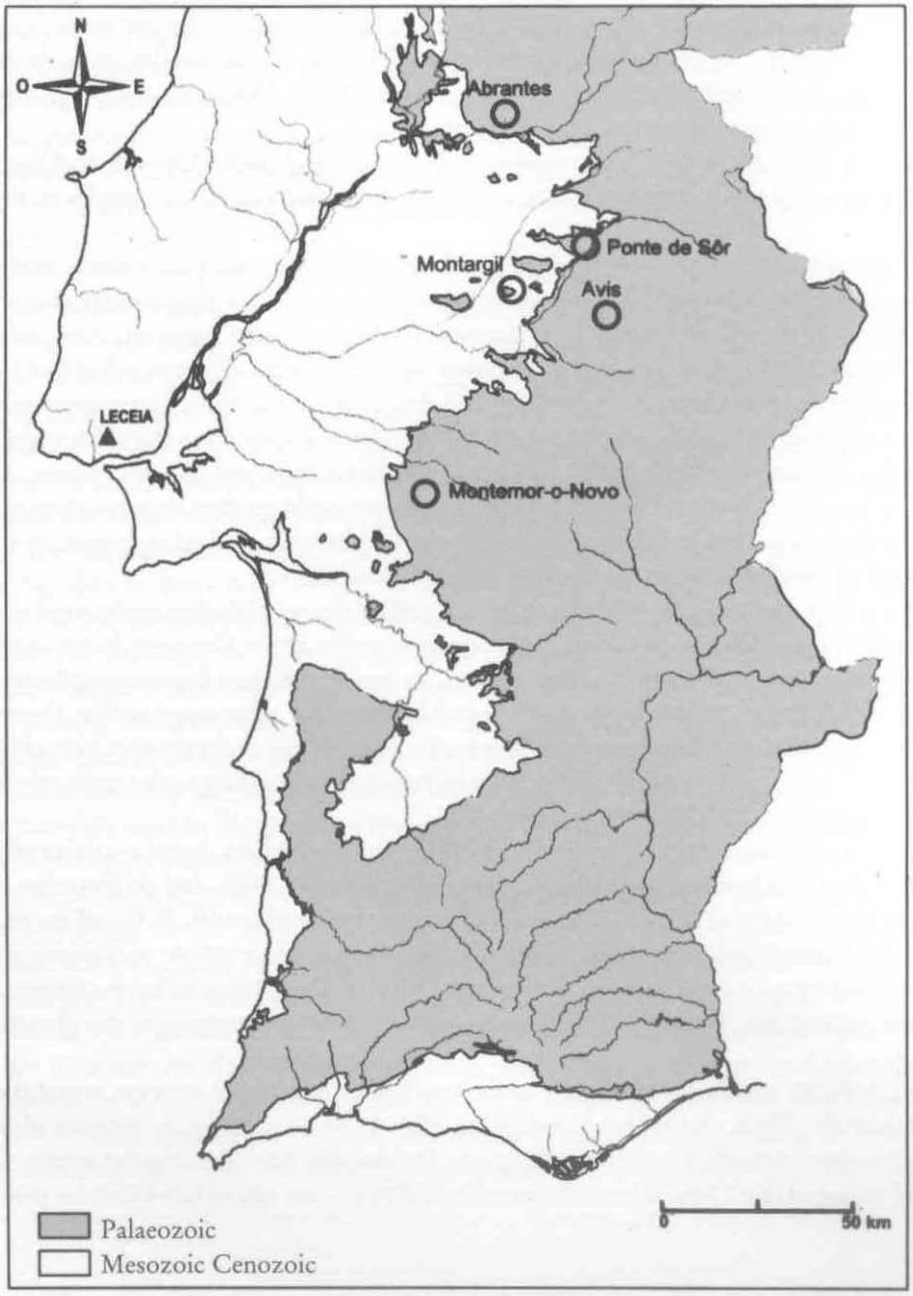


Fig. 5 Probable sources of amphiboloschists. Location is indicated by circles.

Abrantes: amphiboloschists are found near the city of Abrantes, in bands within 'Serie Negra' schists (Upper Pre-Cambrian), crossed by the River Tagus. Some epizonal outcrops from the top of the Pre-Cambrian series may have been a source for rocks of the type found at Leceia.

Ponte de Sor: near the reservoir of the Maranhão dam and near or very close to the Seda brook, we again find amphibolite associated with 'Serie Negra' schists medium or low in metamorphism. The amphibolite and metabasites of the Volcano-sedimentary Complex of Santo António (Cambrian) are also of the same mineralogical facies and paragenesis as the materials being studied.

Montargil: massive amphibolites and green amphibolitic schist, similar in both cases to the Leceia materials, are found near or next to the reservoir of the Montargil dam (Sôr brook), interspersed in the schisto-psammitic series of the Cambrian.

Avis: close to the Maranhão dam, equidistant from Avis and Santo António de Alcorrego, there are amphibolite rocks intercalated in Siluric schists, with characteristics very similar to the materials at Leceia.

Montemor-o-Novo: in the so-called green schists of Silveiras, near the railway station and the road between Vendas Novas and Montemor-o-Novo, there are rocks with similar characteristics to Leceia, despite differences in texture and variation in the associated minerals. Also, near Cabrela, south of Vendas Novas, there is amphiboloschists associated with siliceous schists of the Pulo do Lobo Formation (Lower Devonian?), with similar characteristics to those just mentioned.

Region south of Grândola: in this region, further from Leceia than the others, there is green schist, usually in mafic metatuffs with a low grade of deformation and metamorphism. These rocks are spilite in nature, and because of their low level of metamorphism they have a variety of structures and residual minerals. They are rather different from the materials studied in Leceia, so they should be eliminated as possible sources for the raw materials used there.

In conclusion: the areas most likely to have supplied the amphibolite rocks used in Leceia are the Pre-Cambrian and Silurian outcrops on the eastern border of the Cenozoic basin of the Tagus. It is interesting to note that all these outcrops are near or beside the most important tributaries or subtributaries of the Tagus, or the Tagus itself near Abrantes. We may suppose that these valleys or watercourses would themselves have been the main channels for the transport of merchandise by boat, especially the great river of the Peninsula which was already acting as the main axis for this and other transregionally distributed raw materials.

We should emphasize the fact that the conclusions presented here, based on those obtained earlier[25] are based on one hand on meticulous petrographic study of finds, and on the other on detailed information based on the geological cartography by one of the authors (A. B. C.) of the regions most favourable for obtaining the raw material. In fact, only thus it was possible to advance with discussion of the question on a credible basis and with the level of detail required by the nature of the data itself. Other approaches, as the study mentioned above contribute nothing to the discussion of the question.

In fact, Lillios's conclusions[26] appear to be insufficient to provide answers about the origin of the raw materials. Thus, the author's indication (fig. 1) of two zones as sources of supply for Estremadura – in the north, the 'Morais-Bragança Ophiolithic Zone', and in the south, the oriental portuguese sector of the 'Ossa-Morena Metavolcanic Zone' – are not in fact the most probable areas

[25] Ibid.

[26] See note 23.

for effective supply of these rocks; as the present study and its predecessor have clearly shown: these were to be found nearer at hand, at the edge of the Tagus basin (fig. 5).

The essential preoccupation of the Late Neolithic and Chalcolithic populations of Estremadura who were responsible for importing amphibolite rocks, such as those based in Leceia, was justifiably practical in nature. To try to see any other underlying reasons for using these rocks, by recourse to fallacious arguments, like those presented by Lillios, such as that these people, originated from the Alentejo, wanted to emphasise their roots symbolically by using rocks from there, does not merit discussion. Nevertheless, there is no doubt that the neolithic and chalcolithic populations of Estremadura were in direct and frequent contact with contemporary communities living in the interior of the Upper Alentejo; as mentioned above, ideas, raw materials and even artefacts, both practical and symbolic, circulated between the two cultural areas (paradigms are the Alentejan schist plaques in Estremaduran necropoles) in a process of cultural interaction characteristic of the Late Neolithic and the Chalcolithic.

The presence of stone ingots, unworked or only partially worked by polishing, in Leceia, although they are few, leads us to conclude that at least some of the tools were made locally. In view of the high rate of reworking – only 4 unworked ingots, and these used directly as strikers, among 231 artefacts, as well as the high percentage of amphiboloschist pieces reused as hammers, we may conclude that the material was scarce and valued, conserved and reused to the limit. This explains the reuse of artefacts broken in the course of work, as in the case of two axes which, split accidentally along its length, were reutilised as adzes. On this subject we should mention that the frequency with which amphibolite flakes resulting from violent impact are found within the settlement, some still with part of the original blade, has parallels at the Chalcolithic settlement of Castro de Santiago, near Fornos de Algodres in Beira Alta[27], where they were interpreted as related to the preparation and shaping of stone blocks used for building: the same could have happened at Leceia.

At Castro de Santiago, A. Valera found thirteen ingots of hard rocks (green schists group): although their origin is still uncertain, they could have been prepared at source or in specialised workshops nearby; further south, amphibolite ingots were found at the settlement of Rexaldia, Upper Ribatejo[28] and at Outeiro de S. Mamede, Bombarral (information from Júlio Roque Carreira), and others could certainly be mentioned in the Upper Alentejo, a region where the essential sources of the raw materials used in Estremadura were found. On this subject it may be mentioned that in the region of the upper Reno there is evidence of roughly shaped pieces in places two days away from the quarries: these seem to be the zones for storage and finishing by polishing[29].

The morphology of the amphiboloschist ingots (fig. 6), shows a little transformation by polishing (like some examples at Castro de Santiago). They are short thick pieces, sub-rectangular to sub-trapezoid in outline, and by rough cutting and polishing they could be used for making short thick axes of the type common in Leceia. It should be noted that the example most changed by polishing has its distal end deliberately broken and used. Thus, as seen in the Castro de Santiago examples, here in Leceia too, pieces which had obviously been longer were split transversely in order to obtain blocks more suitable for the sizes and shapes of the intended artefacts. It is not however possible to determine where this was done: if it was in Leceia, or in the source area of the raw material itself.

[27] See note 5.
[28] See note 19.
[29] See note 9, 44.

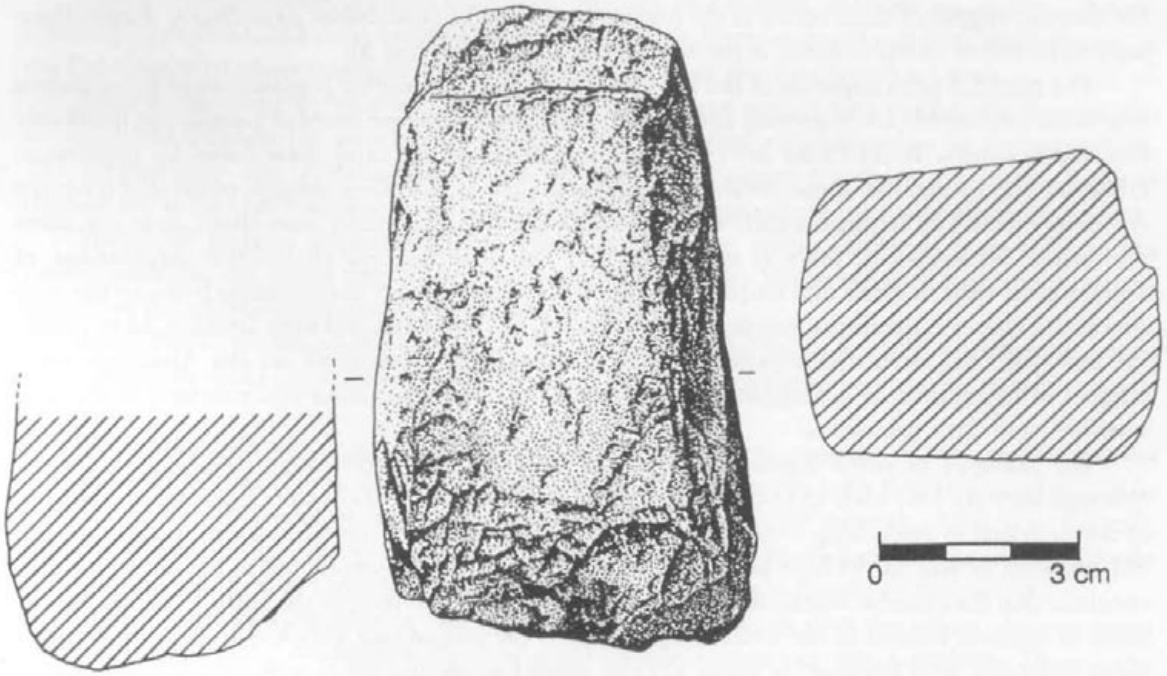


Fig. 6 Leceia. Ingot of amphiboloschist reutilized as hammer-striker.

It is interesting to note that the only piece from a non-amphiboloschist ingot is an unfinished piece of basalt, roughly cut by swelling (fig. 7), obviously of local origin. For non-amphibolite rocks like this, the source of supply would have been within a circle reaching no further than 10-15 km: their petrographic characteristics have been carefully identified (greatly assisted by study of the rich collection from the Leceia region in the National Archaeological Museum, collected in the 1920s and 30s by Abílio Roseira), using a selection of examples from which thin slices were obtained for petrographic analysis; the reader is referred to the conclusions of the study conducted in 1995 by the author in collaboration with Dr. A. B. Carvalhosa.

The inferior quality of local and regional rocks is seen in their relative unimportance in comparison with amphiboloschists, as mentioned above.

Conclusions

This study is a development of considerations and conclusions previously presented[30], dealing now with all the polished stone artefacts collected in the eighteen excavation campaigns directed by the author from 1983 to 2000, a total of 231 pieces. In view of the large number of these pieces and

[30] J. L. Cardoso, Estudos Arqueológicos de Oeiras 8, 1999/2000, 241–323.

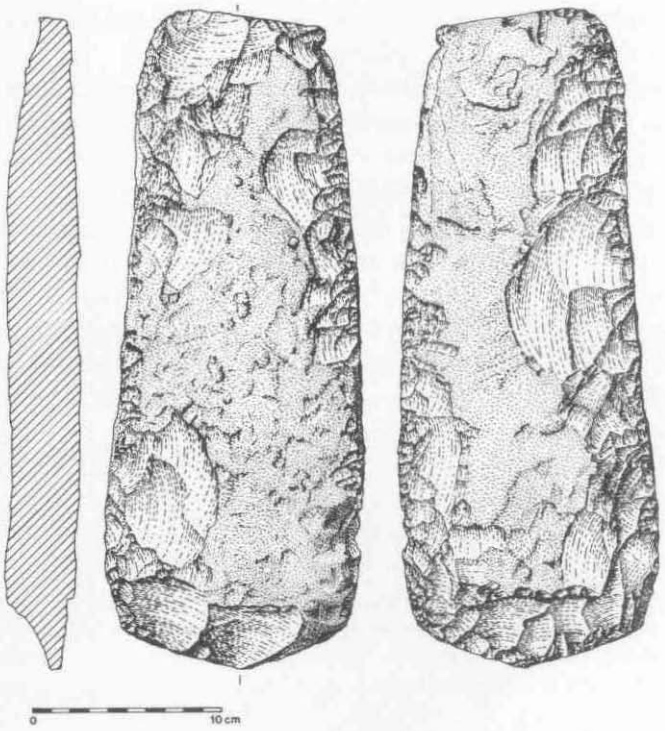


Fig. 7 Leceia, Layer 3. Early Chalcolithic. Unfinished olivinic basalt adze.

the stratigraphic evidence associated with each, it is now possible for the first time to present conclusions on the evolution of tool types and on the use of raw materials over a period of about 1000 years and three distinct cultural phases, the Late Neolithic, Early Chalcolithic and Middle-Chalcolithic of Estremadura.

Our conclusions show the importance of continued study of this nature, using appropriate scientific techniques, both in the laboratory and in the field (which naturally requires profound knowledge of the geological conditions of whole regions, or effective collaboration with those who have such knowledge) so as to construct a rational picture of the economic life of the Chalcolithic of Portuguese Estremadura.

Resumo

Artefactos de pedra polida do povoado pré-histórico de Leceia (Oeiras)

Neste estudo apresentam-se os resultados do exame petrográfico (por observação macroscópica e com recurso a observações ao microscópio de luz polarizada, em lâmina delgada), de mais de duzentos instrumentos de pedra polida recolhidos em estratigrafia nas escavações conduzidas pelo signatário entre 1983 e 2002 no povoado pré-histórico fortificado de Leceia (concelho de Oeiras, distrito de Lisboa). Uma atenção particular foi dispensada ao grupo dos anfiboloxistos cujos

afloramentos mais próximos se localizam a mais de 100 km de distância, na bordadura ocidental do Maciço Hercínico, limitando desse lado a bacia terciária do Tejo.

Mais de 75% das rochas identificadas em Leceia são deste grupo, como em outros povoados do Neolítico Final e do Calcolítico da Estremadura portuguesa. Tal facto configura a existência, durante cerca de 1000 anos, entre a segunda metade do IV milénio a. C. e os meados do milénio seguinte, de um comércio transregional de matérias-primas de origem geológica, organizado de maneira mais ou menos estável e permanente. O interesse dos resultados obtidos encontra-se ainda sublinhado pela informação estratigráfica associada a todas as 231 peças inventariadas. Deste modo, demonstrou-se a crescente importância da utilização de rochas importadas, desde o Neolítico Final ao Calcolítico Pleno, fenómeno que se integra no quadro da intensificação económica e consequente interacção que caracteriza o Calcolítico. Não se deve, porém, valorizar excessivamente tal situação: considerando a vida útil do povoado, de cerca de 1000 anos, ou apenas o período de florescimento do mesmo, entre cerca de 2900 e 2400 anos a. C., e a totalidade de peças recolhidas em Leceia ou na área adjacente, desde o século XIX, a qual ascende a cerca de 600 peças de pedra polida, e mesmo admitindo que todas fossem de anfibloxistos, a razão média de importação não ultrapassa 1, 2 peças por ano, o que é manifestamente pouco, não se podendo falar em um abastecimento maciço de tal matéria-prima.

Source of figures: All the illustrations are made under supervision of the Author by Bernardo Ferreira (Centro de Estudos Arqueológicos do Concelho de Oeiras/Câmara Municipal de Oeiras).

Address: Prof. Doutor João Luís Cardoso, Universidade Aberta, R. da Escola Politécnica, 147, P-1200 Lisboa and Centro de Estudios Arqueológicos do Concelho de Oeiras, Câmara Municipal de Oeiras, 2800 Oeiras, Portugal.