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The Zambujal's arrowheads (Torres Vedras, Portugal): Functionality and Raw Material Provenance

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ABSTRACT

The Arrowheads of Zambujal (Torres Vedras, Portugal)

Functionality and Raw Material Provenance

Patricia Jordão

Zambujal is considered one of the most important reference sites in Portuguese Estremadura for understanding the Chalcolithic of south-western Iberia. This study combines raw material provenance studies and analyses of functionality and typology to contribute to our understanding of war in the Chalcolithic. This paper is a synthesis of the techno-typological and petrographic studies of the arrowheads found in Zambujal during the excavations by Hermanfrid Schubart and Edward Sangmeister (1964–1979) and Michael Kunst (1994–2012). The evaluation of their effectiveness is based on ballistic analysis (penetration index) and suggests that the majority of projectiles with all the parameters necessary for this study would cause physical damage only to small animals. However, further experimental studies need to be carried out in the future. The results of the petrographic studies of flaked tools show the dominance of flint from the Lisbon region (30–40 km). However, it should be emphasised that there is a smaller proportion of raw material from local sources (up to 10 km) than from Rio Maior, suggesting a regional origin (up to 30–35 km).

KEYWORDS
Chalcolithic, Portuguese Estremadura, provenance studies, petrography, techno-typology, flint, arrowheads, war in the Chalcolithic

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1 Introduction

1 Conflict and competition play an important role in explaining and tracing some of the social and cultural changes that took place in prehistoric Iberia from the Late Neolithic and throughout the Chalcolithic. With regard to the use of space, some authors emphasise the defensive nature and usefulness of the enclosures as defensive fortifications, in association with areas of higher frequency of warfare, indicating the need for defence against external threats[1]. Warfare as a key factor in understanding settlement dynamics, providing valuable insights into the relationship between warfare and settlement strategies in the region.

2 Apart from their use in hunting, arrowheads seem to have played an important role from the Late Neolithic onwards[2]. The diversity of typology, the specialised workshops and the low proportion of hunted animals in the faunal assemblages are interpreted as indicators of the emergency of war[3]. Furthermore, the raw material acquisition strategies of each site in relation to the proportions of arrowhead flint types helps us to assess their specialised production and social importance.

3 This article examines the raw materials in relation to the typology and preliminary ballistic analysis of the Zambujal arrowheads to contribute to the characterisation of the functionality of these artefacts in the context of the site.

Zambujal

4 The Chalcolithic walled settlement of Zambujal is located about 3 km SW of Torres Vedras in the Portuguese Estremadura. It is situated on a hilltop (120 m asl), on the right margin of the Ribeira de Pedrulhos, a tributary of the Sizandro river (Fig. 1). The archaeological interventions in Zambujal go back to the years after the excavations in the cave site of Cova da Moura in 1932, when Leonel de Freitas Sampaio Trindade

1 Kunst 2000; Aranda Jiménez – Sánchez Romero 2005; Cámara Serrano – Molina González 2013.
2 Liesau et al. 2014.
3 Chapman 1990; Ramos Millán 1991; Gibaja – Mazzucco 2023.

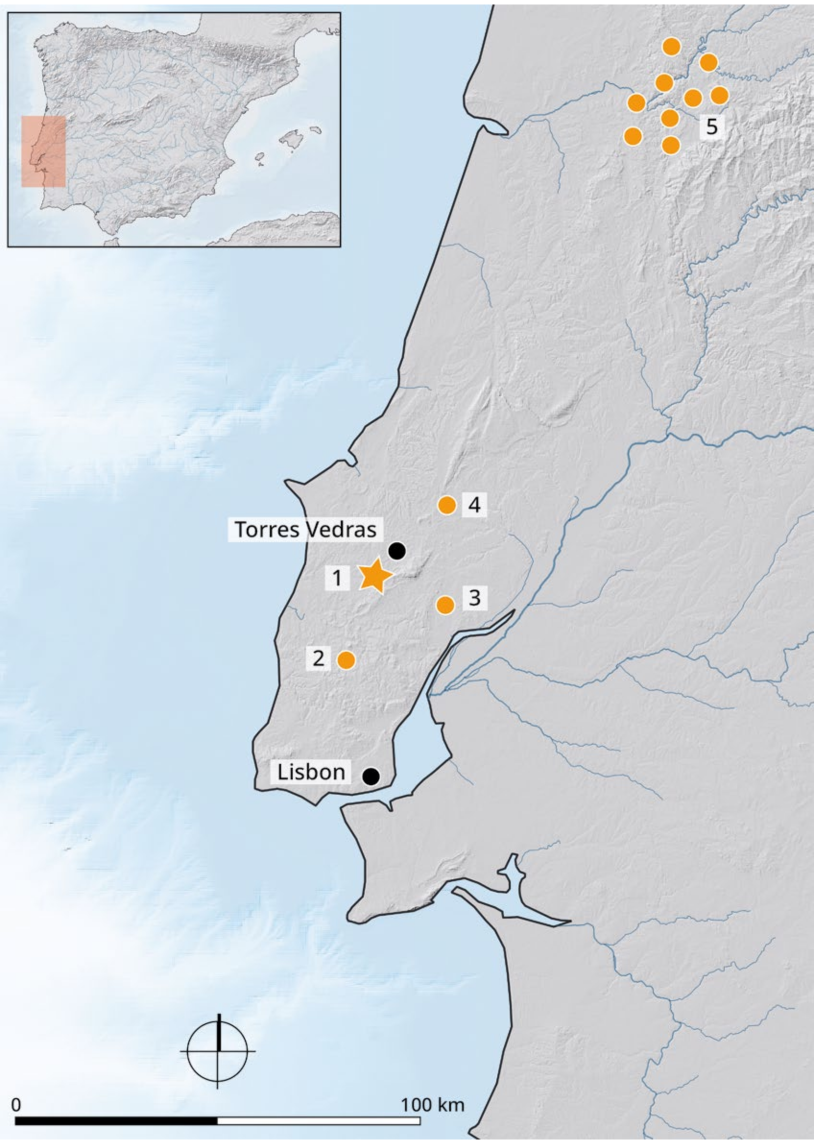

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Fig. 1: Mentioned sites in the text: 1 Zambujal; 2 Penedo do Lexim; 3 Pedra de Ouro; 4 São Mamede; 5 Necropolis group in the Plataforma do Mondego.

(1903–1992) discovered the site[4]. Beginning in 1938, non-systematic surface collections were performed at Zambujal until the first archaeological sondage was carried out by Trindade in 1944, when he discovered a small, semicircular wall at the top of a small mound behind the farm house of Zambujal (Casal do Zambujal), which he reconstructed as a little tower[5]. Between 1959 and 1961, Trindade together with Aurélio Ricardo Belo (1877–1961) – director of the Museum of Torres Vedras between 1932 to 1950[6] – established 13 trenches (»Cortes«), with the purpose of understanding the typology and the complexity of the archaeological site[7]. Longer excavation campaigns were carried out from 1964 until 1973, which were supported by an effective cooperation between the Torres Vedras Municipal Museum (Trindade), the German Archaeological Institute (Hermanfrid Schubart), and the Institut für Ur- und Frühgeschichte Freiburg (Edward Sangmeister)[8]. The final map of the site showed several complex structures, with three fortification lines and four construction phases[9].

5 The recovered ceramics in the campaigns from Schubart and Sangmeister were studied by Michael Kunst[10], who published the Bell Beaker pottery and so-called Acacia Leaf decorated pottery[11]. In 1986 and 1987, geoarchaeological studies were performed simultaneously in the Sizandro Valley by Gerd Hoffmann, who pointed to an estuarine vicinity of Zambujal[12]. These results were further developed in the subsequent interdisciplinary project »Sizandro and Alcabrichel« through various drilling campaigns in the river valleys of the Sizandro and Alcabrichel rivers and also the Ribeira de Pedrulhos, the confluence of the Sizandro river, which had formed the valley in front of Zambujal[13].

6 The results of the 1964-1973 excavations, in particular, the evidence of copper metallurgy[14], the complexity of the fortification walls, and the geoarchaeological data, contributed to generating a set of questions related to Zambujal and its role in 4th/3rd mil-

4 Sangmeister – Schubart 1981, 4; Kunst 1993, 48–50.
5 Jalhay 1946, 389 f.
6 Luna 1999.
7 Paço 1964.
8 Sangmeister – Schubart 1981, IX 1–7.
9 Sangmeister – Schubart 1981, 226–262.
10 Kunst 1987.
11 Kunst 1987.
12 Hoffmann 1990.
13 Dambeck et al. 2010; Kunst 2010; Kunst et al. 2016.
14 Sangmeister – Jiménez Gómez 1995.

lennia BCE settlement networks as well as in its production and exchange economy. To answer these questions, Kunst, together with Hans-Peter Uerpmann, began the third phase of excavations which was initially centred in the Modern settlement (located on top of a rocky promontory) and in the area below the rocky promontory as a preventive archaeology project.

7 The first results of the fieldwork developed between 1994 and 2012 were published[15]. Our current image of the site is of four lines of fortifications in the enclosure, which developed in five different phases. The first represents a kind of labyrinth with several towers and walls between these fortification lines; then there were outer courtyards and small doorways. Afterward, these outer courtyards were filled by stones and substituted by higher platforms. In a fourth phase they were equipped with hollow towers, and in a fifth phase these towers were integrated into the higher platforms[16]. In addition, some functional activities areas were identified, such as those for the copper metallurgical process. The best example is house V with many remains of copper manufacture[17].

8 The flaked stone material recovered between 1964 and 1973 at Zambujal was studied by Margarethe Uerpmann[18], although the complete inventory was not published. Concerning the arrowheads, the author highlighted the high number collected inside the fortification compared to other Chalcolithic sites[19]. These particularities associated with the traditional military function of the arrowheads contributed to the idea of Zambujal as a »central place«[20], with a dominant role in the Chalcolithic hierarchic settlement.

9 After the general identification of Zambujal's raw materials by M. Uerpmann[21], a more detailed study was performed. Preliminary analysis began with the arrowheads[22], although the quality of these descriptions was poor compared with the now-standard petroarchaeological protocol[23]. Later studies of Zambujal's lithic raw material[24] allow us to characterize the lithological diversity in the archaeological record as well as their source areas.

10 The first publications of Zambujal's arrowhead techno-typology and functionality (1037 artefacts) focused on the material primarily recovered in the older excavations of Trindade, between 1959–1961 (124), Schubart and Sangmeister, between 1964–1973 (898), and by Kunst (16)[25]. In addition to these materials, the published data from São Mamede's arrowheads[26] and the unpublished artefacts from the Bombarral Museum, recovered in 1991 by J. Ludgero Gonçalves, were also studied[27]. In another paper, the data were complemented by new inventory results from the techno-typological and petrographic study of the archaeological material recovered by Kunst between 1994 and 2012[28].

15 Kunst – Uerpmann 1996; Kunst – Uerpmann 2002; Kunst 2003; Kunst 2007; Müller et al. 2007; Kunst 2010; Kunst – Lutz 2011; Becker 2013; Davis 2013; Görsdorf 2013; Kunst et al. 2013; Becker – Flade-Becker 2017.

16 Sangmeister – Schubart 1981, 226–255; Kunst 2006, 77; Kunst – Arnold 2011.

17 Sangmeister – Schubart 1981, 59–63; Sangmeister – Jiménez Gómez 1995, 32–36; Gauß 2015, 123–130.

18 Uerpmann – Uerpmann 2003.

19 Uerpmann – Uerpmann 2003, 69.

20 Kunst 1995.

21 Uerpmann 1995; Uerpmann – Uerpmann 2003.

22 Jordão – Pimentel 2017.

23 Jordão – Pimentel 2021b.

24 Jordão – Pimentel 2019; Jordão – Pimentel 2021a; Jordão – Pimentel 2021b; Jordão et al. 2022.

25 Jordão 2017.

26 Forenbaher 1999; Jordão 2010; Jordão 2013.

27 Jordão 2017.

28 Jordão 2022.

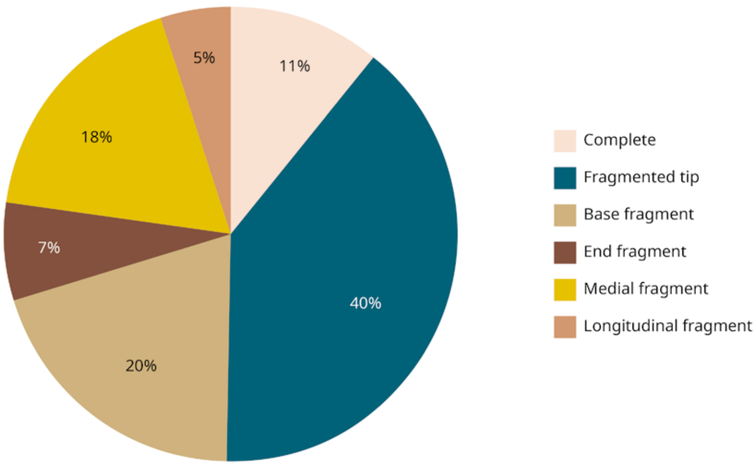

Fig. 2: Zambujal arrowheads conservation status: complete, fragmented tip; proximal; base fragment; medial and longitudinal fragment.

2

11 This paper synthesizes the geoarchaeological analysis of the arrowheads – in their techno-typological and petrographic aspects – to clarify their functionality by revealing how they were introduced in the site.

2 Materials and Methods

12 The present study focuses on the arrowheads from the excavations between 1959–1973[29], and on those recovered in Kunst's interventions, which recovered 37 arrowheads. The total inventoried assemblage therefore comprises 1097 points. Despite the introduction of this new data, the results derived from previous studies remain unchanged.

13 The arrowheads' description follows techno-typological classical categories[30] and its typological classification is based on the proposals of Stašo Forenbaher[31] and M. Uerpmann[32].

14 Evidence of their function was based on a combined analysis of bow-and-arrow technology and their effects provided by the experimental penetration rate index (PRI), as suggested by João Carlos Senna-Martinez[33].

15 The petrographic macroscopic characterization generically followed the principles of rock identification and classification, underlining different criteria such as colour (Munsell Colour System), textural and colour homogeneity, knapping ability, and external general aspects like patina, cortex type, and thickness[34]. These features were followed to determine archaeological microfacies[35]. Both compositional[36] and textural[37] carbonate rocks classifications have been visually applied, regardless of their paleoenvironmental interpretation, taking into account that most flint nodules are a product of the silicification of previously carbonate rocks.

29 Jordão 2017.
30 Tixier et al. 1980; Geneste 1992; Carvalho 1996.
31 Forenbaher 1999.
32 Uerpmann – Uerpmann 2003.
33 Ventura – Senna-Martinez 2000, 11–13.
34 Luedtke 1992.
35 Jordão – Pimentel 2017.
36 Folk 1959.
37 Dunham 1962.

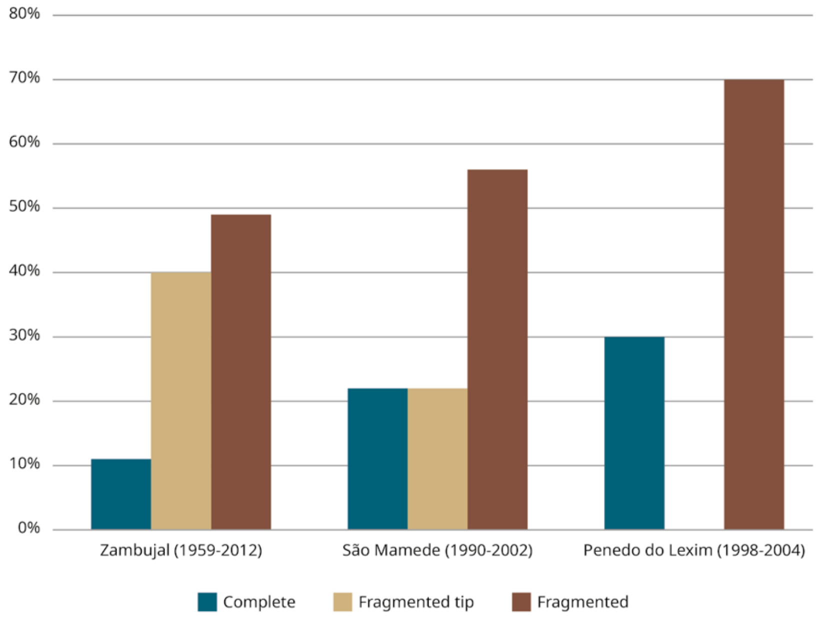

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Fig. 3: Arrow point conservations status: complete; fragmented tip and fragmented – Zambujal, São Mamede e Penedo do Lexim.

16 The flint types were established by a petroarchaeological characterization protocol[38] based on their genesis (genetic type) and provision sites (gitologic type), through a dynamic perspective of an »evolutive chain«[39].

17 A Motic SMZ-140 binocular microscope with LED incident light was used in the mesoscopic observation of the surfaces, with a 40x magnification and, whenever needed, specific images were taken with a digital camera FHD V.2 (Panasonic).

3 Techno-typological Synthesis

18 The arrowheads are the most impressive bifacial flaked artefacts recovered at Zambujal. Of the 1294 bifacial flaked stone objects inventoried from the excavations between 1964–2012, 75 % (973) are arrowheads[40]. A reduced number of projectiles are complete (11 %), but considering those with a fragmented tip or wing, this number increases to 50 %, suggesting that the total could be higher (Fig. 2). Even so, compared to similar Estremadura enclosures recently studied[41], the Zambujal arrowheads have a high percentage of fracturing (Fig. 3).

19 The last phases of the arrowheads' ›chaîne opératoire‹ have primarily been identified so far, although there are six pre-forms. Some were reused as perforation tools (11) or ›encoche‹ (5).

20 This studied set of arrowheads are profusely retouched pieces; mainly bifacial (95 %), invasive (about 40 %), and mostly ›flaky‹ retouching (85 %), as frequently occurs in Portuguese Chalcolithic settlements. Only 10 % of those have a marginal, frequently semi-steep retouch. The edges are predominantly smooth (86 %), although some have serration (14 %). The shape of the edges is mainly straight (65 %), but can also be concavo-convex (14 %), convex (10 %), or sinuous (7 %).

38 Jordão 2022.
39 Fernandes – Raynal 2006; Fernandes 2012.
40 Jordão 2022, 149 f.
41 Sousa 2010; Jordão 2013.

Morphology	Zambujal %	São Mamede %	Pedra de Ouro %	Lexim* %
Tri/conc	37.4	39.9*	49.1	52.3*
Tri/strai	12.2	13	36.8	–
Tri/conv	2.6	1.4	1.8	3.4
Tri/unk-ireg	11.3	17.4	5.8	0.0
Mitriform	14.8	4.3	0.9	11.4
Torre Eiffel	1.4	0.0	0.9	1.3
Alcalar	0.2	0.0	4.7	0.7
Foliate	0.1	1.5	0.0	0.0
Modified	1.3	0.7	0	22.1
Preform	2.5	2.9	0	8.7
Unknown	16.6	18.8	0	22.1
Total	100	100	100	100

4

Fig. 4: Zambujal, S. Mamede, Pedra de Ouro and Penedo do Lexim arrowheads morphology of the edges: Tri/con (triangular/concave base); Tri/strai (triangular/straight base); Tri/conv (triangular/convex base); Tri/unk-ireg (triangular/unknown-irregular base); Mitriform; Torres Eiffel; Foliate; Modified; Preform; Unknown. * Tri/conc and Tri/strai are combined values

21 Longitudinal sections are not very homogeneous, and vary between bi-convex, sinuous, and plano-convex (Fig. 4). Cross-sections are homogeneous; half are bi-convex (50 %), 25 % plano-convex, and the remaining are sinuous, trapezoidal, triangular, plano-sinuous, and convex-sinuous.

22 The profound alteration of the flaking products by retouch makes it difficult to recognize the type of support in 72 % of the projectiles. However, it was possible to identify a preponderance of flakes as support for 26 % of the arrowheads. Thirteen of them were also configured on blade and one on bladelet.

23 The more elongated pieces seem to be associated with a convex/triangular base shape, generally associated to the Late Neolithic/Early Chalcolithic[42]. However, in Zambujal this evidence is not supported by the data.

24 The morphology of the arrowheads was identified in about 85 % of the artefacts. We adopted the criterion that combines »edge *vs*. base shape«, although the boundaries between types are not always clear, particularly at the limit between the concave base and the notched base (›Alcalar type‹), as previously highlighted by M. Uerpmann[43].

25 Following this typology and including the new data from the Kunst excavations, four main groups could be defined, with some variants. The most numerous is the ›triangular type‹ (Type 2) with concave base (Type 2.1), or straight base (Type 2.3), and a deeply concave base (Type 2.2). These are followed by the ›Mitriform‹ type (Type 1), the convex base (triangular or stemmed, Type 4), and the ›Eiffel Tower type‹ (Type 3). Finally, the both ›Unfinished‹ and ›Modified‹ types were also included in the typology (Fig. 5).

26 More than half of the arrowhead assemblage from Zambujal is composed of the triangular type with concave to straight base. These 2.1 and 2.3 types are also dominant in other Chalcolithic settlements and funerary monuments[44]. This type is followed by Estremadura’s characteristic Mitriform points, which occur equally in all of Zambujal’s phases[45]. The percentage of mitriform arrowheads at the Penedo do Lexim settlement is similar to Zambujal’s, but appears residually in Pedra de Ouro (Fig. 6).

42 Forenbaher 1999, 76.
43 Uerpmann – Uerpmann 2003, 77.
44 Forenbaher 1999, 101.
45 Uerpmann – Uerpmann 2003, 93.

27 We assume that the value 3.4 is high in São Mamede considering the restricted area in which these artifacts were collected. In the early 20th century excavations, Bernardo de Sá found an »arrowheads deposit«[46] probably related to the final phase of the arrowhead's manufacturing. The production of arrowheads in domestic contexts at Copper Age sites is actually well documented; examples are known at Los Millares, in the CE 15 hut of Fortim I[47], and Camino de las Yeseras[48]. It should be noted, however, that the early phases of the arrowheads' ›chaîne opératoire‹ were not found in the workshop area of Camino de las Yeseras[49]. Despite the truncated image of the São Mamede's data due to the selectivity of the excavations, it seems plausible that Mitriforms were produced here. At Zambujal there is no direct evidence for the production of arrowheads.

28 The other two types identified – Eiffel Tower and Alcalar – have a reduced occurrence at Zambujal. In Penedo do Lexim, the Alcalar type was produced in a silicified schist, which is a non-local raw material. This fact contributed to the transregional exchange network hypothesis[50]. In Zambujal, however, the Alcalar type is in flint, and those made in schist are triangular with a concave base. Therefore, no correspondence was detected between typology and raw material across different sites[51].

29 Arrowheads have traditionally been considered indicators of periods of social conflict[52]. At Zambujal, the quantity of arrowheads (1097 inventoried pieces) and their concentration within the walled areas (between the 1st and 2nd line of defence and the ›barbican‹)[53] have provided some of the strongest evidence for war at the site. M. Uerpmann[54] points to a more warlike function than a hunting one, as only 13 % of the fauna is derived from hunting.

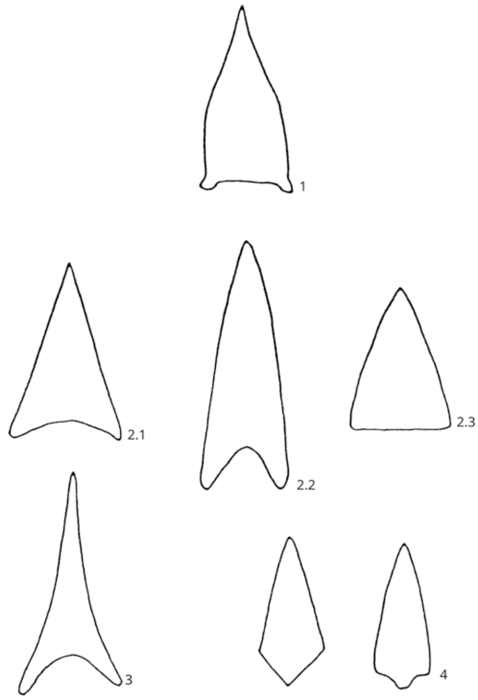

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Fig. 5: Zambujal's arrowheads typology. Type 1 – Mitriform; Type 2 (triangular): 2.1 – concave base; 2.2 – deeply concave base; 2.3 – straight base; Type 3 – Torre Eiffel; Type 4 – convex base (triangular or stemmed).

4 The Penetration Index (PNI)

30 A ballistic analysis was carried out attempting to test the ability of arrowheads to cause physical damage, based on the work developed by Senna-Martinez[55] and José Ventura[56]. This approach combines two main parameters: ›Theoretical Penetration‹ (TP), obtained by the algorithm (0.5 × W × V)/A, where »W« is the weight of the artefact in grams, »V« the velocity in m/s and »A« the area of the cross-section at the point of maximum width; and the ›Penetration Index‹ (PNI), obtained by the algorithm M/A × 100, where »M« is the mass of the point calculated by the formula W × V2/2[57].

31 The PNI is based on the parameters of the arrowhead, the arc, and the effects produced by the projectile on animate and inanimate beings at a particular speed. This last variable –35 m/s – is the minimum value verified in ethnographic and experimental studies[58].

46 Jordão 2013, 70.
47 Molina et al. 1986, 192 f.; Molina – Cámara 2005, 70 f.
48 Liesau et al. 2008.
49 Blasco et al. 2007, 157.
50 Sousa – Gonçalves 2011, 197.
51 Uerpmann – Uerpmann 2003, 102.
52 Kunst 2000, 140.
53 Uerpmann – Uerpmann 2003, 102.
54 Uerpmann – Uerpmann 2003, 102.
55 Senna-Martinez 1989.
56 Ventura – Senna-Martinez 2000.
57 Senna-Martinez 1989 apud Ventura – Senna-Martinez 2000, 11 f.
58 Ventura – Senna-Martinez 2000, 13.

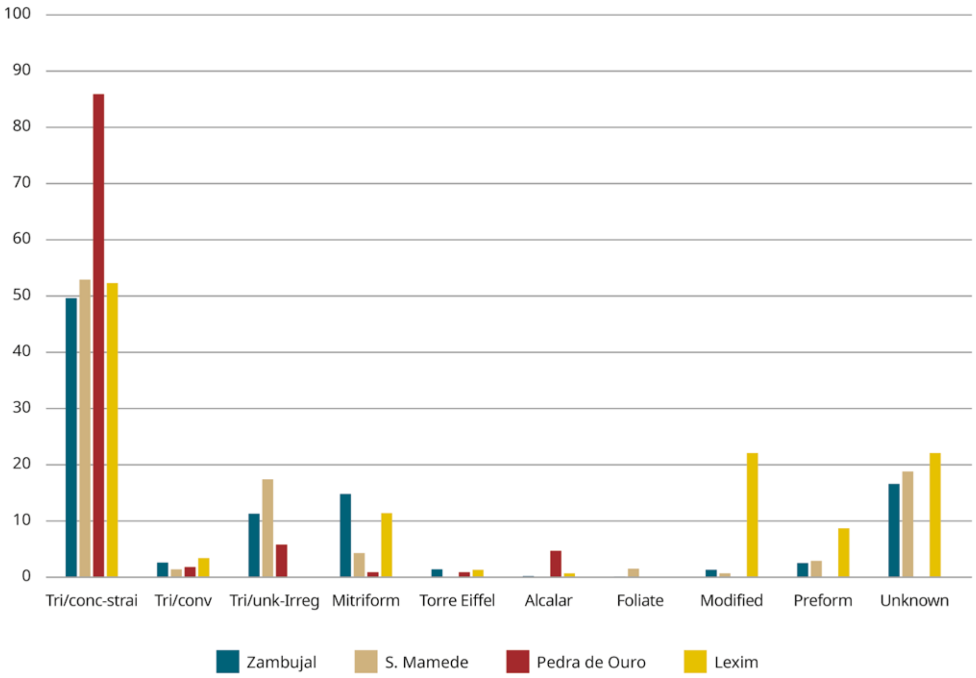

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Fig. 6: Zambujal, São Mamede, Pedra de Ouro and Penedo do Lexim arrowheads morphology of the edges. With »Tri/con« and »Tri/strai« values combined in all sites (%).

32 Four groups of physical damage were determined based on the projectile's PNI:

- Group 1 – PNI <10. No skin penetration occurs.
- Group 2 – PNI between 10 to 30. The penetration and damage occur in the subcutaneous tissues, without deep injury to internal organs. Indicated for targets with a mass of less than 20 kg (rabbits, hares, etc.).
- Group 3 – PNI between 31 to 39. The penetration causes deep internal lesions, which may perforate some bones. Appropriated for medium-sized animals, between 21 and 50 kg (deer, wolves, etc.).
- Group 4 – PNI >40. Corresponds to deep injuries with great penetrative capacity and extensive bone fracture. Indicated to kill big-game hunting, i.e., animals with more than 50 kg. Those points are associated with war.

33 The PNI was determined for 265 whole arrowheads. Surprisingly, ¼ of the projectiles had a PNI <10, which means they are below the minimum level of functionality. Only 6 % of them could be used to kill medium-sized and large animals (Fig. 7). A similar distribution of values was found for the arrowheads of São Mamede (262 whole artefacts). However, the degree of functional use is higher, with fewer arrows (10 %) attributed to Group 1 (Fig. 7). Comparing these PNI data with those obtained from the Pedra de Ouro settlement[59] and the nine necropoleis in the Mondego basin[60], it can be observed that all the projectiles have functional performance values.

34 This means that the majority of the arrowheads studied would have been intended for the hunting of small animals (Fig. 7). The points that could cause damage to medium-sized (± 25 %) and large-sized (± 20 %) animals are less frequent in the Zambujal assemblage – 6 % for both groups – and, in São Mamede, 7 % and 3 %, respectively. No correlation was found between their typology and performance.

35 It is noticeable that in the Zambujal assemblage, the percentage of arrowheads from Groups 3 and 4 is very low when compared with the other functional Group 2, as occurs in the other Chalcolithic assemblages studied. In addition, Group 1 is more nu-

59 Branco 2007.

60 Ventura – Senna-Martinez 2000.

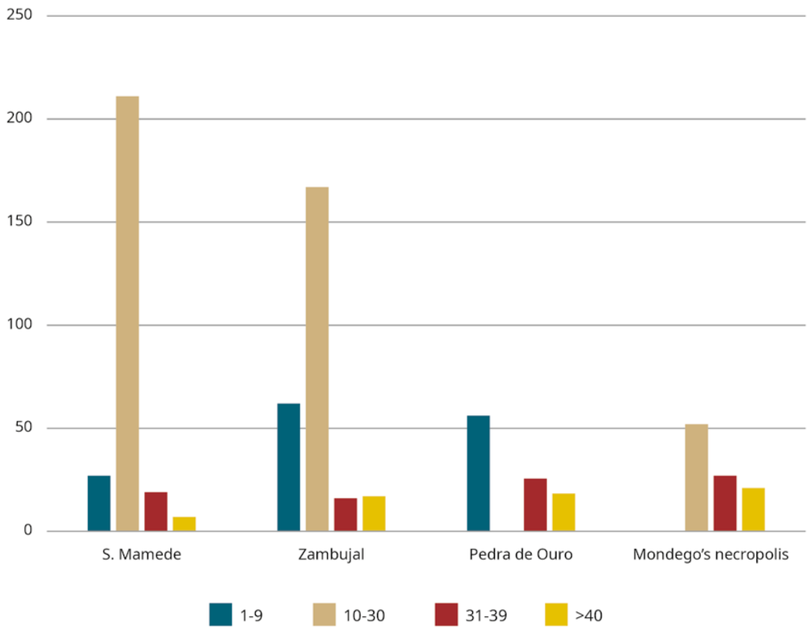

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Fig. 7: PNI values and frequency in percentage of arrowheads by group: São Mamede, Zambujal, Pedra de Ouro and Mondego's necropolis.

merous compared with the other assemblages. However, it is important to point out that the number of whole arrowheads is smaller at Zambujal than in other similar settlements; in São Mamede the percentage is doubled and in Penedo do Lexim it is tripled (Fig. 7).

36 However, we should consider the fact that the arrowheads that were actually used may be the fragmented ones, and therefore were not studied for the ballistic analysis. There is a pattern of fragmentation, at the distal or proximal part, valid for the area of the greatest concentration of these artefacts. This area is known as – ›barbican‹ – located between towers G and E,[61] where 174 were collected (among them two unfinished and four modified), 136 of which were fragmented. To test this hypothesis, it would be important as a future line of research to carry out traceological analyses of the edges to recognize signs of use, in the fracture zones as well, that can be attributed to violent impact.

5 Petrography of the Arrowheads

37 For this project, a sample of 688 arrowheads was studied for a preliminary macro- and mesoscopic analysis of their raw material[62]. The results of the first petroarchaeological study of Zambujal's arrowheads revealed that 55 % of the silicious raw material had its genesis in a marine environment, probably in the Cenomanian, and 15 % correlated with continental flint (silcrete) from Paleogene formations, probably collected in local Quaternary detrital formations[63].

38 Further investigations of the raw material used to produce all the flaked flint objects from the site revealed that only 3 % of those objects made from the local Paleogene flint were arrowheads[64] (Fig. 8 p–r). Initially, the M6 microfacies were associated with silcretes, but this hypothesis was not confirmed after the thin section observation

61 Kunst – Arnold 2011, 439.

62 Jordão – Pimentel 2017.

63 Jordão – Pimentel 2017; Jordão – Pimentel 2019.

64 Jordão 2022, 172.

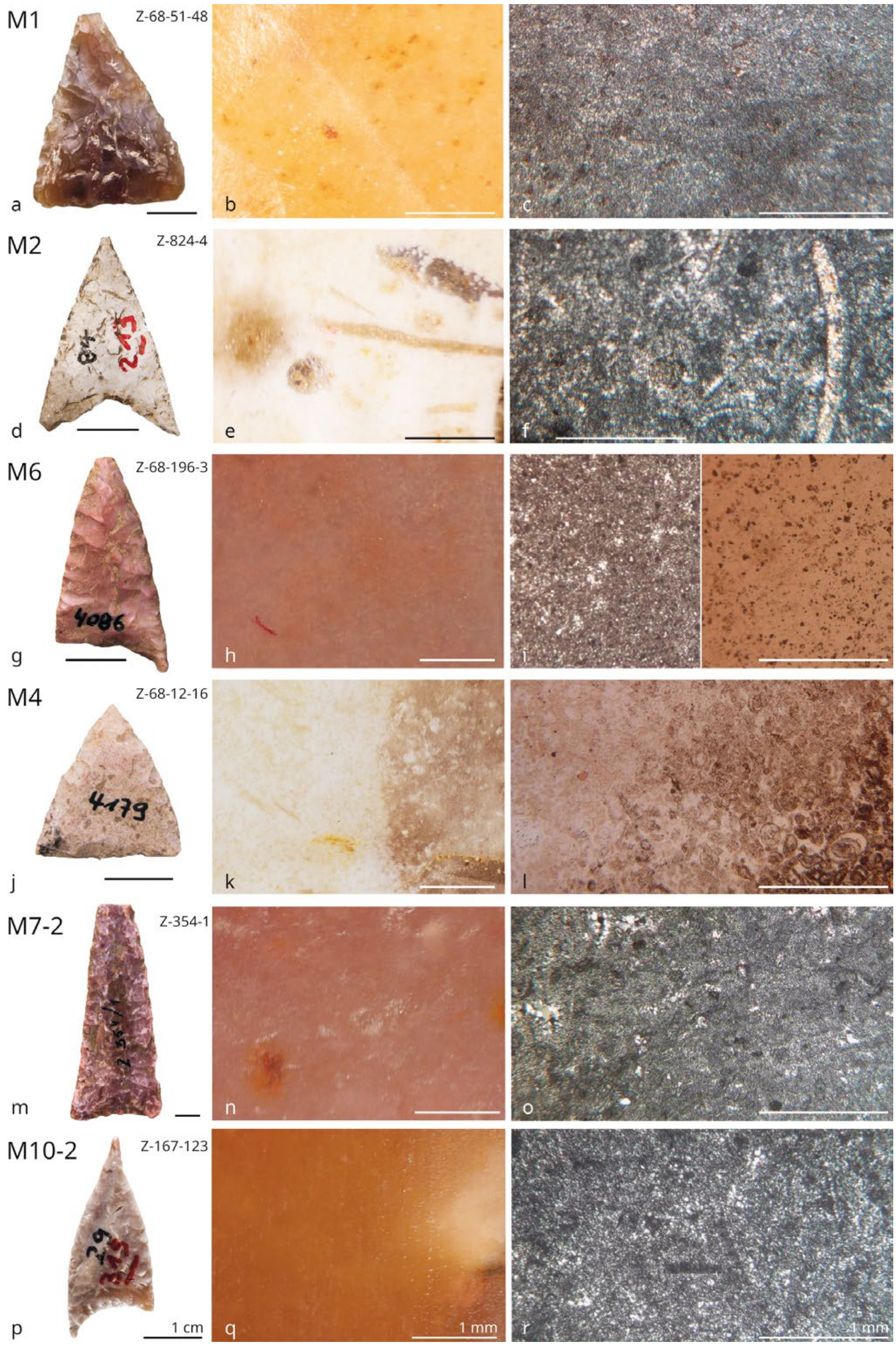

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Fig. 8: Main archaeological microfacies of the Zambujal's arrowheads at three scales (macro-, meso-, microscopic) – M1: triangular straight base arrowhead (a), with a homogeneous reddish surface with iron oxides concentrations (b), quartz microcrystalline structure, mudstone (c); M2: triangular concave base arrowhead (d), grey to white with bioclasts (bivalves, ostracods) and different quartz crystallization (d, e), quartz crypto-microcrystalline structure and wacke-packstone texture with bioclasts (bivalves, ostracods, echinoid spines) (f); M6: triangular concave base arrowhead (g), rosie brown translucent surface (h), with major quartz microcrystalline structure, with some fibrous filling bioclasts (®, right) in mud-wackestone texture with iron oxides (Fe-O) concentrations (®, left); M4: triangular straight base arrowhead (j), brown to white with visible bioclasts (k), quartz cryptocrystalline structure, packstone with foraminifers miliolids (l); M7-2: triangular concave base arrowhead (m), reddish translucent with iron oxides (n), quartz crypto-microcrystalline structure with bioclasts and iron oxides (o); M10-2: mitriform arrowhead (p), brown to reddish translucent surface (q), quartz micro-mesocrystalline structure with microcodium ®.

and more detailed characterization of local flint sources[65]. After all, the M6 in Zambujal – Z6 archaeological microfacies – was correlated with the C3-PPC-Lx flint[66].

39 The microfacies M1 – associated with a non-bioclastic part of a mudstone texture without recognizable elements in macro analysis – was identified in 37 % of the arrowheads, which makes evident the difficulty of classifying flint based on small

65 Jordão – Pimentel 2019; Jordão – Pimentel 2021a; Jordão – Pimentel 2021b.

66 Jordão 2022.

Microfacies of Zambujal's arrowheads		
General microfacies	**Zambujal microfacies**	**Chronology-Provenance**
M1	Z-1	C3-BL
M2	Z-2	C3-PPC-Lx
M4	Z-4	C3-BL
M6	Z-6	C3-PPC-Lx
M7-1	Z-7-1	J3-RM-1
M7-2	Z-7-2	C3-RM-2
M9	Z-9	C3-PPC-Lx
M10-1	Z-10-1	Pg-TV
M10-2	Z-10-2	Pg-TV
M12	Z-12	C3-Our
M13	Z-13	J3
M14	Z-14	C3-Naz

9

Fig. 9: Equivalence between the general microfacies (column 1) and the archaeological microfacies (column 2) identified in Zambujal's arrowheads with correlation with the flint from the geological samples (column 3). BL (Lusitanian Basin); C3 (Cenomanian); J3 (Oxfordian); Lx (Lisbon); Naz (Nazaré); Our (Ourém); Pg (Paleogene); PPC (Pero Pinheiro-Carenque); RM (Rio Maior); TV (Torres Vedras).

pieces, mostly fractured, or sometimes with the surface damaged by exposure to high temperatures[67] (Fig. 8 a–c).

40 Nevertheless, it was possible to identify microfacies M2 as the most often found in arrowheads (38 %). This microfacies is characterized by cryptocrystalline mineralogical structure, ›wacke‹ – to ›packstone‹ (›packstone‹ – M9) texture, with micropaleontological diversified associations with miliolids and textularids foraminifera (Fig. 8 d–f). Both microfacies M2 and M9 correlated with the samples of Pero Pinheiro – Carenque – Lisboa (C3-PPC-Lx)[68]. One additional microfacies associated with the same source area – M6 – is present in 5 % of the flint. In this M6 bioclasts (probably Radiolaria) filled with chalcedony and also dolomite with FeO_3 aggregates were observed (Fig. 8 g–i). Therefore, 43 % of the raw material may be associated with the Pero Pinheiro – Carenque – Lisboa source area (Fig. 9).

41 In the 19 arrowhead preforms (Fig. 9. 10) identified after the complete inventory, both microfacies M2 and M9 are represented. The association of these flint types with intermediate stages of the arrowheads' debitage allows us to note a regional provenance of flint compatible with the C3-PPC-Lx group (Fig. 9).

42 The M7-2 flint associated with the Rio Maior source area is observed in 15 % of the projectiles (Fig. 8 m–o; 9. 10). The residual number of flakes with these microfacies does not allow us to recognize the local debitage of this raw material, so it could have been introduced in the form of finished artefacts in the settlement.

43 The few M12 and M14 microfacies were associated with C3-Our/Naz flint, identified mainly on blades[69]. The residual M13 microfacies are characterized by a heterogeneous ›breccia‹ surface, with colours ranging from dark grey to light grey, with opaque to translucent surfaces, and a texture ›mud‹- to ›packstone‹ with bioclast fragments. Its occurrence, in secondary deposition, has been documented on the right bank of the Nabão River, in the Tomar area[70]. At Zambujal, the microfacies Z-13 has, sometimes, a white patina.

44 The distribution of arrowhead flint types is similar to archaeological material knapped in the site, with a dominance of the C3-PPC-Lx (Fig. 9. 10. 11). However,

67 Jordão – Pimentel 2017; Jordão – Pimentel 2021b.
68 Jordão – Pimentel 2021a; Jordão – Pimentel 2021b; Jordão 2022.
69 Jordão 2022, 173 f.
70 Matias 2012.

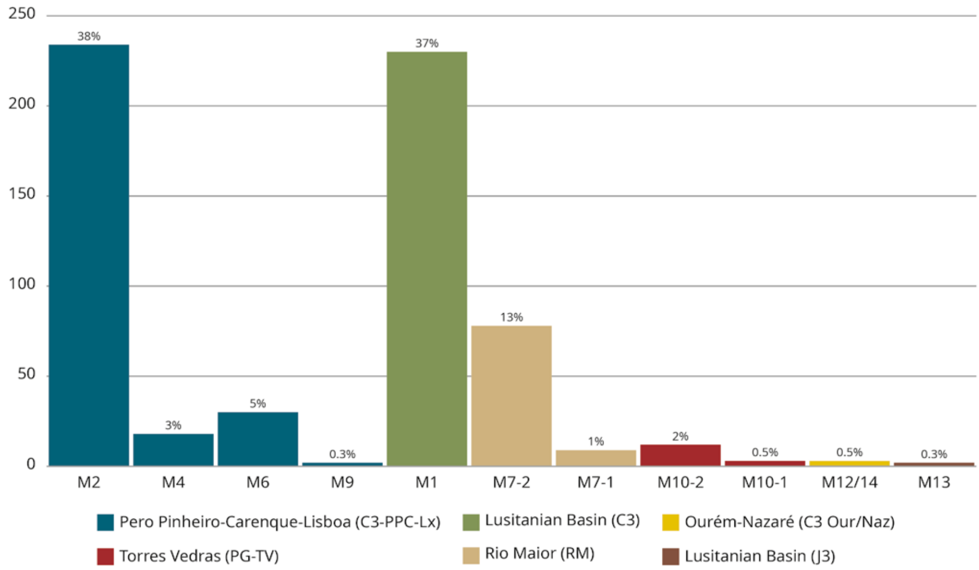

Fig. 10: Siliceous microfacies provenance of the Zambujal's arrowheads: M2, M4, M6, M9 – Pero Pinheiro-Carenque-Lisboa; M1 – Lusitanian Basin; M7-1, M7-2 – Rio Maior; M10-1 – Pg-Torres Vedras; M12/14 Nazaré/Ourém; M13 – Lusitanian Basin.

10

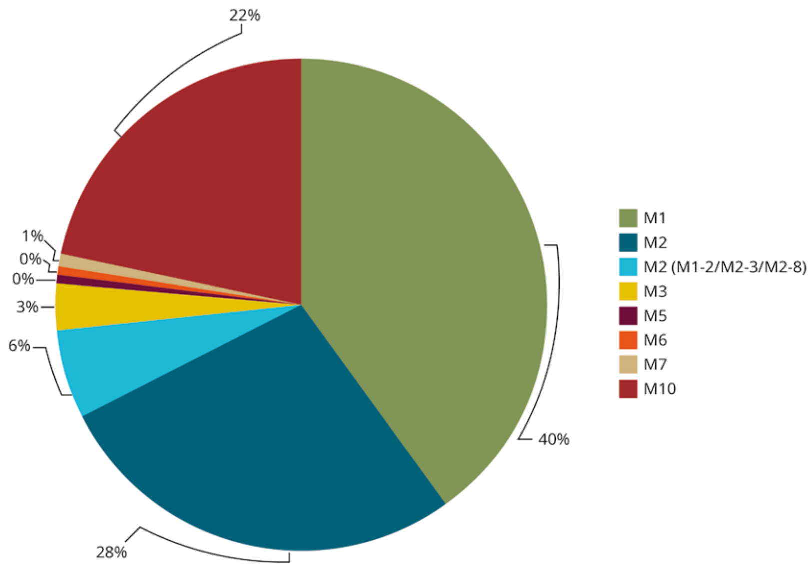

Fig. 11: Microfacies of the archaeological material knapped in Zambujal.

11

the Pg-TV flint was rarely used to produce, among others, projectile points, except the chalcedonic facies for bladelets[71].

45 Finally, other raw materials from different regional contexts were found in the set of arrowheads (Fig. 11): five in jasper, two in hyaline quartz, and one in quartzite and schist. The absence of their corresponding ›chaînes opératoires‹ led to the conclusion that they came into the site as finished artefacts. Although quartz and quartzite may appear in local detrital contexts, the presence of jasper and schist suggests a regional provenance of more than a hundred kilometres.

71 Jordão 2022.

6 The Arrowheads as Part of the ›Central Place‹ Hypothesis

46 The arrowheads recovered in Zambujal have morphologies that are typical of arrowheads found at Chalcolithic sites in the Estremadura. Triangular shapes with concave and straight bases are predominant, followed by the mitriform type.

47 The evaluation of the arrowheads' effectiveness based on ballistic analysis demonstrated that the majority (64 %) would only be able to cause physical damage in small animals (Group 2). A small minority of the arrowheads (6 %) could cause damage to medium-large animals (humans included) (Group 3–4). In addition, the PNI value of non-functional armatures is 24 % (Group 1).

48 First of all, it should be noted that the PNI was applied to whole armatures only, which constitute only 11 % of the assemblage. This point probably means that those that have been used were not likely accounted for. This is valid for settlement evidence, though not necessarily evidence congruent with funerary contexts where the artefacts are frequently complete. The data collected in the domestic domain in different stages of use make the picture more complex. We argue that future traceological analyses of the cutting edges and the study of hunted fauna as well may be useful to detail the function of arrowheads.

49 On the other hand, we must consider the use of poisonous substances on Group 2 arrowheads (with penetration capability) to make them efficient for damage and even killing, as modern hunter-gatherers do[72]. The use of poison arrows was likely a common practice with the most ancient archaeological evidence in the Egyptian predynastic period (2481–2050 BC)[73].

50 Nonetheless, we suggest that PNI analysis[74] is an important test for assessing the preliminary ballistic characteristics of arrowheads.

51 The local production of arrowheads has been identified directly by a few preforms made on flake. In the case of arrowheads where the support can be seen, the majority were also made on flakes, which was an important product knapped on-site. The manufacture of arrowheads has been documented in similar Chalcolithic settlements such as Los Millares[75], Camino de las Yeseras[76] and probably São Mamede[77].

52 The results of the petrographic studies show the dominance of C3-PPC-Lx flint from the Lisbon peninsula (30–40 km), according to the remaining flaked industry knapped in Zambujal. It should be noted that there is less frequent use of raw material from the local Palaeogene (until 10 km), which suggests that it was less significant for arrowhead production. On the contrary, there is a greater use of Rio Maior flint in finished armatures with no operative chain documented at the site, suggesting the arrowheads' regional provenance and production (30–35 km).

53 In addition to a regional axis of circulation from the east, another provenance area to the south-east was documented in Zambujal. These include the jaspers (and schist) from the silicious facies in the Alentejo (South Portuguese Zone), more than a hundred kilometres from the site, thus showing a transregional provenance of some of the arrowheads (Fig. 10. 11).

72 Borgia 2019.
73 Clark et al. 1974.
74 Ventura – Senna-Martinez 2000.
75 Molina et al. 1986; Molina – Cámara 2005.
76 Liesau et al. 2008.
77 Cardoso – Carreira 2003; Jordão 2010.

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RESUMEN

Las puntas de flecha de Zambujal (Torres Vedras, Portugal)

Funcionalidad y procedencia de la materia prima

Patricia Jordão

Zambujal es considerado uno de los yacimientos de referencia más importantes de la Estremadura portuguesa para la comprensión del Calcolítico del suroeste de Iberia. Este estudio combina estudios de procedencia de materias primas y análisis de funcionalidad y tipología para contribuir a nuestra comprensión de la guerra en el Calcolítico. Este trabajo es una síntesis de los estudios tecno-tipológicos y petrográficos de las puntas de flecha halladas en Zambujal durante las excavaciones de Hermanfrid Schubart y Edward Sangmeister (1964–1979) y Michael Kunst (1994–2012). La evaluación de su eficacia se basa en el análisis balístico (índice de penetración) y sugiere que la mayoría de los proyectiles con todos los parámetros necesarios para este estudio sólo causarían daños físicos a los animales pequeños. No obstante, en el futuro deberán realizarse nuevos estudios experimentales. Los resultados de los estudios petrográficos de los útiles de sílex muestran el predominio del sílex de la región de Lisboa (30–40 km). Sin embargo, cabe destacar que hay una menor proporción de materia prima de procedencia local (hasta 10 km) que de Rio Maior, lo que sugiere un origen regional (hasta 30–35 km).

PALABRAS CLAVE

Calcolítico, Estremadura portuguesa, estudios de procedencia, petrografía, tecnotipología, sílex, puntas de flecha, guerra en el Calcolítico

ZUSAMMENFASSUNG

Die Pfeilspitzen von Zambujal (Torres Vedras, Portugal)

Funktionalität und Rohstoffherkunft

Patricia Jordão

Zambujal gilt als einer der wichtigsten Referenzorte in der portugiesischen Estremadura für das Verständnis des Chalkolithikums im Südwesten der Iberischen Halbinsel. Diese Arbeit kombiniert Studien zur Herkunft der Rohstoffe mit Analysen zur Funktionalität und Typologie, um zu unserem Verständnis des Krieges im Chalkolithikum beizutragen. Die vorliegende Arbeit ist eine Synthese der techno-typologischen und petrographischen Untersuchungen der Pfeilspitzen, die in Zambujal während der Ausgrabungen von Hermanfrid Schubart und Edward Sangmeister (1964–1979) und Michael Kunst (1994–2012) gefunden wurden. Die Bewertung ihrer Wirksamkeit beruht auf einer ballistischen Analyse (Penetrationsindex) und lässt darauf schließen, dass die meisten Projektile nach den für diese Studie verwendeten Parametern nur bei kleinen Tieren physische Schäden verursachen würden. Allerdings müssen in Zukunft weitere experimentelle Studien durchgeführt werden. Die Ergebnisse der petrographischen Untersuchungen der Silexindustrie zeigen die Dominanz von Feuerstein aus der Region Lissabon (30–40 km). Es ist jedoch hervorzuheben, dass der Anteil des Rohmaterials aus lokalen Quellen (bis zu 10 km) geringer ist als aus dem Rio Maior, was auf eine regionale Herkunft (bis zu 30–35 km) schließen lässt.

SCHLAGWÖRTER

Chalkolithikum, portugiesische Estremadura, Provenienzstudien, Petrographie, Techno-Typologie, Feuerstein, Pfeilspitzen, Krieg im Chalkolithikum

SOURCES OF ILLUSTRATIONS

Cover: P. Jordão
Fig. 1: P. Jordão, modified from Ventura – Senna-Martinez 2000, 5 figura nº1; map: DAI, USGS, GEBCO (author: D. Blaschta, modifications: C. Comas-Mata)
Fig. 2: Jordão 2017, 5 figura n°2
Fig. 3: Jordão 2017, 6 figura n°3
Fig. 4: Jordão 2017, 6 Tabela n°1
Fig. 5: Adapted from Uerpmann 1995, 40 figura n°3
Fig. 6: Jordão 2017, fig. 7 n° 4
Fig. 7: Jordão 2017, fig. 11 n°8
Fig. 8: P. Jordão
Fig. 9: Adapted from Jordão 2022, 166–167 part. V.7
Fig. 10: P. Jordão
Fig. 11: Jordão – Pimentel 2021b, 17 graph 2

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