Marine adaptations in the Late Mesolithic of the Portuguese southwest coast: use-wear analysis of the lithic industry of Vale Marim I

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Resumo Procede-se a uma primeira análise traceológica da indústria lítica de Vale Marim I e cruzam-se os resultados com a informação faunística dos sítios coevos de Samouqueira I e do Vidigal, após contextualização no Mesolítico regional da Costa Sudoeste. O estudo dos vestígios de uso permite admitir a prática da pesca com recurso a projéteis que integraram geométricos trapezoidais, no final do Mesolítico, transição para o VI milénio cal BC. Assim, salienta-se a importância das adaptações marinhas na economia dos últimos caçadores-recolectores complexos que iriam protagonizar o processo de neolitização regional.

Abstract The results of the lithic assemblage study are discussed in the wider context of the Late Mesolithic of the southwest Portuguese coast in order to shed new light on the subsistence marine adaptations and on the complex hunter gatherer social organization, immediately preceding the food production economy, and the domestic mode of production.

1. The regional context

1.1. Settlement pattern of the Late Mesolithic in the southwest coast

On the southwest Portuguese coast there is evidence of hunter-gatherer societies with a broad spectrum subsistence strategy and a logistical mobility pattern (*sensu* Binford, 1980) at about the middle of the 7th to the middle of the 6th millennia cal BC (6500 to 5500 cal BC) (Soares, 1995, 1996; Soares & Tavares da Silva, 2004; Soares, Tavares da Silva & Canilho, 2005–2007). This settlement system (Fig. 1) is documented by:

1- Large base-camps, such as Vale Marim I, Samouqueira I and Fiais, probably occupied all year round. Samouqueira I and Vale Marim I are located on the Atlantic shore, perched on cliffs of schist from the Carboniferous basement, overhanging the ocean, but at the transition to Middle Holocene (Fig. 1), they faced a large coastal plain with approximately a kilometre width, now submerged by Flandrian transgression (Dias, Rodrigues & Magalhães, 1997; Vanney & Mougenot, 1981). Fiais is located about 10 km away from the modern coastline, on a stream bank tributary of the Mira River, in the innermost fluvial sector of the Mira basin probably with tidal influence. The acidity of sediments had not allowed the preservation of organic remains at Vale Marim I (except charcoal and teeth of *Sparus aurata*), but at the sites of Samouqueira I, Vidigal and Fiais, fauna assemblages were preserved. All of them contained terrestrial mammals, fish and shellfish remains. At Samouqueira I, mammals were represented by *Cervus elaphus*, *Sus scrofa*, *Bos primigenius*, *Lepus capensis*, *Vulpes vulpes*, and *Canis lupus familiaris* (?). Terrestrial mammals constitute about 8,7% by weight of a sample where fish remains comprised 1,3%, and shellfish 90% (Soares, 1996). The marine invertebrate fauna contained in that sample was constituted mainly by mussels (*Mytillus sp*) at 40%, whelks (*Thais haemastoma*) at 28%, limpets (*Patella* spp) at 26% and cockles (*Cerastoderma edule*) at 4%, with a residual representation of small marine gastropods, *Paracentrotus lividus* and *Pollicipes pollicipes* (Soares, 1996, Table 3). The faunal record of Fiais included the same marine molluscs species present at Samouqueira I and also oyster shells, more adapted to estuarine environment; there were also fish bones and a very dense bone dump with several thousand of terrestrial mammals: red deer (*Cervus elaphus*) at 70%, wild boar (*Sus scrofa ferus*) at 14%, roe deer (*Capreolus capreolus*) at 10%, and auroch (*Bos primigenius*) at 6% (González & Arnaud,

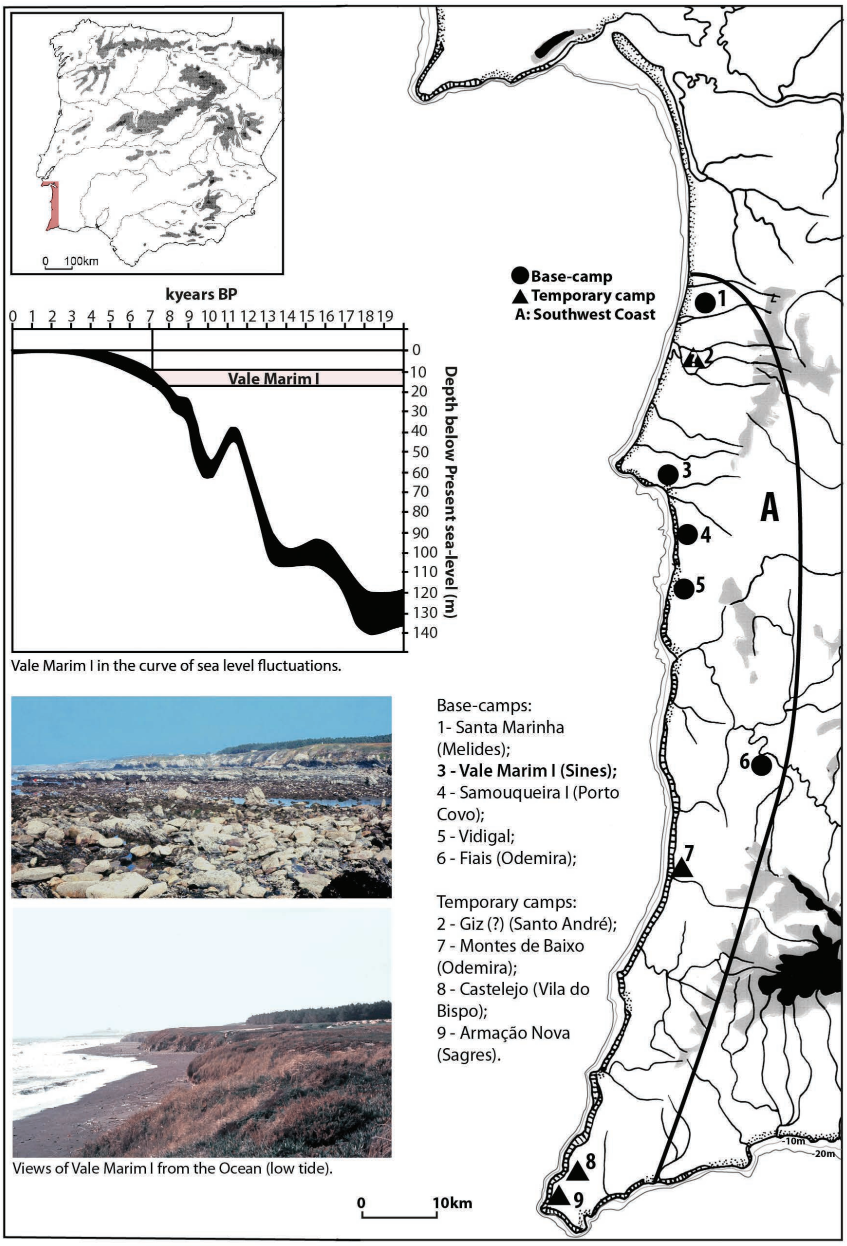


Fig. 1 – Distribution of the main Late Mesolithic sites in the southwest Portuguese coast, and probable sea level during the Mesolithic occupation of Vale Marim I, inferred from the curve of sea level fluctuations proposed for the Portuguese continental shelf over the past 18 000 years by J. M. Alveirinho Dias, Aurora Rodrigues and Fernando Magalhães (1997). Views of Vale Marim from the ocean (low tide), photos by C. Tavares da Silva.

1990; Rowley-Conwy, 2015). These faunal assemblages highlight the practice of hunting (that would occur mainly in autumn and winter, from October to March), fishing and shellfish harvesting, practiced probably at summer, fall and springtime.
2- Small and seasonal multi-layered sites, such as Montes de Baixo (Tavares da Silva & Soares, 1997) and Castelejo (Soares & Tavares da Silva, 2004), with shell-middens of mass captures of shellfish (no mammals, fish or bird remains). In those temporary campsites task groups returned recurrently to exploit resources possibly to be brought back to the base-camp for consumption and/or storage. At Armação Nova (Algarve), an embedded strategy of shellfish gathering and flint exploitation of the Lower Jurasic limestones from the Cabo de São Vicente outcrop has been recognized (Soares, Tavares da Silva & Canilho, 2005–2007; Ribeiro & Terrinha, 2005–2007, 2007).
The Mesolithic broad-spectrum economy, based on a large diversity of food resources, big and small, high-ranked and low-ranked prey items (Soares, 2013, Fig. 4) further enlarged by logistical exploitation of the territory, created a reliable subsistence strategy. Besides, increasing sedentarization and associated demographic increase would be a problem for the economic system stability. Late Mesolithic hunter-gatherers could yet intensify their economic base by means of storage, that could be applied to smoked fish and to other low-risk storable food as acorns of *Quercus ilex* and pine nuts of *Pinus pinea,* available in autumn and winter (October-January). Thus, coastal Late Mesolithic groups reorganized their foraging tactics and technology in association with a supposed increasing reliance on stored foods. They were beginning to think on the advantages of the delayed return of human labour (Testart, 1982).

1.2. Lithic industry

The lithic assemblage composition is connected to the site functional type within the settlement system:
1- The temporary campsites, with a narrow range of exploited resources, display mostly low artifacts density and expediently organized lithic assemblage constituted by cobble tools and flakes on non-siliceous raw materials locally available;
2- In the base-camps, where a broader range of activities was carried out in accordance with a more complex subsistence strategy (i.e. hunting + fishing + shellfish-gathering + storage), more 'curated' procedures to raw material procurement and to lithic artifacts production were applied.
Along the Alentejo littoral the main mineral resources exploited were poor quality cherts from the acid siliceous-volcanic complex of Cercal, and the lower-middle quality flint from the Santiago do Cacém Mesozoic Basin. In this article we have not distinguished chert from flint, both of them are labeled chert. The lithic technology of Vale Marim I corresponds to a laminar knapping method oriented to the manufacture of geometric microlithic tools (mainly trapezes, and rare triangles) by microburin technique.

2. Southwest coast, a diverse marine ecosystem: fishing in the Late Mesolithic

There is a dominant rocky seabed that generates greater diversity of habitats than sandy substrates. The Mira estuary provides shelter and feeding conditions for spawning and first stages of growth of juveniles of many species. Some watercourses, like Ribeiras de Melides, Azinhal, Seixe and Aljezur would have small active estuaries in the Mesolithic (Freitas & *alli*, 2003, 2011) that contributed positively to biodiversity and biological productivity of this littoral. In summer, atmospheric circulation provides the upwelling of cold and nutrient-rich water outcrop system along the coast.
The diversity and year-round availability of fish species of the Southwest coast (Fig. 2), complemented by shellfish was a key factor in subsistence diversification against the declining foraging returns of higher-ranked resources, namely auroch and red deer (Davis & Detry, 2013), and it required complex technologies and composite tools to reduce costs and increase capture rates.
To evaluate fishing (Gabriel, 2015) in the subsistence of the Late Mesolithic coastal groups (Fig. 2), it is useful to observe ichthyological taxa from layer 3 of Samouqueira I (ICEN-729, 7520±60BP, calibrated at 2 sigma =

TAXA	Nº FISH REMAINS	
	N	%
Chondrichthyes class	**139**	**55,6**
Chondrichthyes indeterminate	41	16,4
Lamnidae family	**2**	**0,8**
Atlantic porbeagle (*Lamna nasus*)	1	0,4
Mackerel porbeagle (*Isurus oxyrinchus*)	1	0,4
Triakidae family	**94**	**37,6**
Dogfish (*Galeorhimus galeus*)	62	24,8
Indeterminate triakidae	32	12,8
Sphyrnidae family	**2**	**0,8**
Hammer shark (*Sphyrna zygaena*)	2	0,8
Osteichthyes class	**111**	**44,4**
Muraenidae family	**22**	**8,8**
Moray (*Muraena helena*)	22	8,8
Moronidae family	**1**	**0,4**
Sea bass (*Dicentrarchus labrax*)	1	0,4
Serranidae family	**3**	**1,2**
Blacktip grouper (*Epinephelus fasciatus*)	2	0,8
Indeterminate serranidae	1	0,4
Sciaenidae family	**3**	**1,2**
Meagre (*Argyrosomus regius*)	3	1,2
Sparidae family	**75**	**30,0**
Indeterminate sparidae	19	7,6
Snapper (*Pagrus* spp.)	18	7,2
Gilt-head bream (*Sparus aurata*)	23	9,2
Other species	15	6,0
Mugilidae family	**1**	**0,4**
Thick-lipped grey mullet (*Chelon labrosus*)	1	0,4
Scombridae family	**4**	**1,6**
Mackerel (*Scomber scombrus*)	4	1,6
Soleidae family	**1**	**0,4**
Sole (*Solea sp.)*	1	0,4
Pleuronectidae family	**1**	**0,4**
Flounder *(Platichthys flesus)*	1	0,4
Total	**250**	**100**

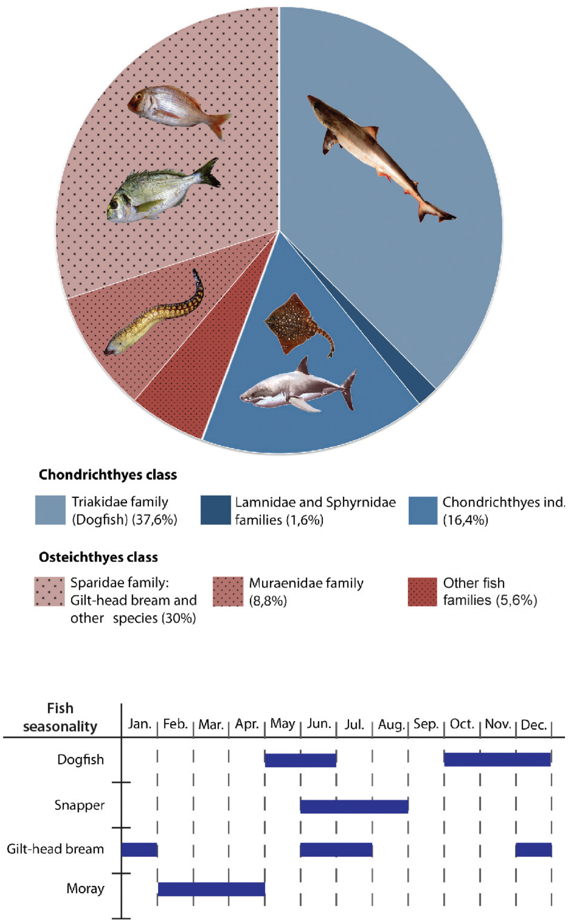


Fig. 2 – Ichthyological fauna from the Late Mesolithic site of Samouqueira I (Sines). Taxonomic classification after Gabriel (2015).

6181–5906 cal BC) (Soares & Tavares da Silva, 2004, Table 3), located in the same ecological setting of Vale Marim I, and far from about 10 km (Fig. 1).

Further south, about 6 km away from Samouqueira I, and 2 km from the seashore, on the left bank of the Queimado stream, the Late Mesolithic open air site of Vidigal also developed a broad spectrum economy where fishing played a very important role. The shell-midden layer had been radiocarbon dated on a bone sample (Ly-4695 - 6640±90BP), that, calibrated to 2 sigma, gave the time span of 5725–5467 (99%) cal BC (Straus & *alii*, 1990), a result that places Vidigal in the transition to the Early Neolithic, between Vale Marim I and Vale Pincel I (Tavares da Silva & Soares, 2015; Soares & *alii*, 2016). A geometric-based lithic industry with trapezes and segments using the microburin technique is fairly representative of that transition.

In the faunal assemblage, the remains of the ichthyological fauna achieved about 1/3 of the total of vertebrates. The general composition obtained by Olivier Le Gall & *alii* (1992, 1994) shows strong similarities with Samouqueira I (Fig. 2). Small sharks and rays (Chondrichthyes class) are dominant. Most of them (dogfish) are attributable to the Triakidae family. There were also bony fishes (Osteichthyes class), mainly gilthead bream (*Sparus aurata*); other species were identified like meagre (*Argyrosomus regius*), from the Sciaenidae family. Osteological remains from Serranidae and scombridae (e. g. Mackerel, *Scomber scombrus*) were also recognized.

According to Olivier Le Gall & *alii* (1992, p. 15), whose main goal was to discuss seasonality based on the ichthyofauna information, the Vidigal inhabitants would practiced fishing in summer and fall, since the majority of the fish identified comes toward the shore in the warmest seasons. Shellfish gathering is also very well represented mainly by limpets (*Patella* sp.), followed by whelks (*Stramonita haemastoma* and *Monodonta lineata*) and mussels (*Mytillus edulis*). Even with low quantities, the presence of *Ostrea edulis* and *Cerastoderma edule* indicates that the lower course of the Queimado stream, adjacent to Vidigal, was at that time a small estuary. Besides gathering shellfish, the Mesolithic group would also hunt terrestrial mammals that supposedly shall come to drink in the Queimado estuary. The mammalian component of the Mesolithic diet at Vidigal included *Oryctolagus cuniculus*, *Cervus elaphus*, *Bos primigenius*, *Sus scrofa*, *Capreolus capreolus*. We consider the diversity of the exploited subsistence resources more adequate to a model of year-round occupation, even in sites located in the outer coast like Vale Marim I, Samouqueira I and Vidigal, with a very probable fishing based economy, which supposes an appreciable investment in specialized gear: small sharks and eagle rays could be caught through lines baited with molluscs like limpets, and harpooned; epipelagic fish, such as scombrids, would be caught in boats, through nets.

3. The site of Vale Marim I

3.1. Ecological setting and chronology

Vale Marim I is a large open-air site (about 1 ha) at Sines Municipality, on the south slope of the igneous hill of Chãos, facing S. Torpes bay (Tavares da Silva & Soares, 1981), at present directly over the ocean, but in the early Middle Holocene, about 1 km away from the ocean (Fig. 1). Several residential units form the site; the excavated area (260 m^2) corresponds to one of them (Fig. 3). The sandy archaeological layer, due to its high acidity, did not preserve organic materials with exception of some charcoal samples and gilthead molar teeth, which highlight the importance of fishing, as already indicated.

The charcoal analysis by Paula Queiroz and José Mateus (unpublished report) revealed the existence of littoral pinewoods (*Pinus pinea*) in the surrounding area of the archaeological site. *Pinus pinea* is the overwhelmingly predominant species, well adapted to warm and dry atmospheric conditions of the Mediterranean climate, confirmed by the presence of *Olea* sp. In more exposed and windy areas there was *Pinus pinaster*. The residual presence of *Pinus sylvestris* has also been reported. This last species was abundant in the region during the Tardiglacial with cooling conditions.

The archaeological layer had been dated by three radiocarbon determinations on charcoal samples (Beta- 417016, 7180±30; Beta-373853, 7170±40; Beta- 417015, 7020±30 yrs. BP) that calibrated to 2 sigma give the time span of 6075–5840 cal BC.

3.2. Lithic industry

A random sample of 1321 artifacts has been analysed (Fig. 6.1) from a total assemblage of 8900 flaked lithics; 7614 of them are from the curated technological subsystem on chert/flint raw materials. The analysed sample is quite representative of the curated technological sub-system; lithic artifacts were widely distributed (Fig. 6.1) all along the excavated area (Sectors F8, F9, G8, G9, G10, H9). The production of lithic tools was concentrated nearby some fireplaces where cores and schist chisels were found. Lithic blanks were being produced on the site by reduction of small non-local chert cores (Fig. 4); all the phases of the production chain are represented; despite that, the low overall cortical/non-cortical ratio indicates an emphasis on the later stages of core-reduction and tool-production at the site.

The origin of this raw material was nodular sources mostly from S. Luis hill (acid siliceous-volcanic complex formation of Cercal) about 37 km (8 h of walking) south from the site (Oliveira, 1984), and from the Mesozoic Santiago Basin, about 25 km north (5 h of walking).

Chert cores are mostly bladelet-cores (Fig. 4). They are, in general, single-platformed, with sub-prismatic shape, mostly reduced to a single-face. Platform types are cortical, non-faceted or finely faceted. Debitage products are mostly bladelets (average width: 7–9 mm; average thickness: 2–3 mm). Standardization in the process of tool blanks production was used to reduce tool production and maintenance costs (Fig. 6.2). It included decreasing variation in bladelet size/shape and increasing investment in core preparation. From a typometric point of view, almost no differences

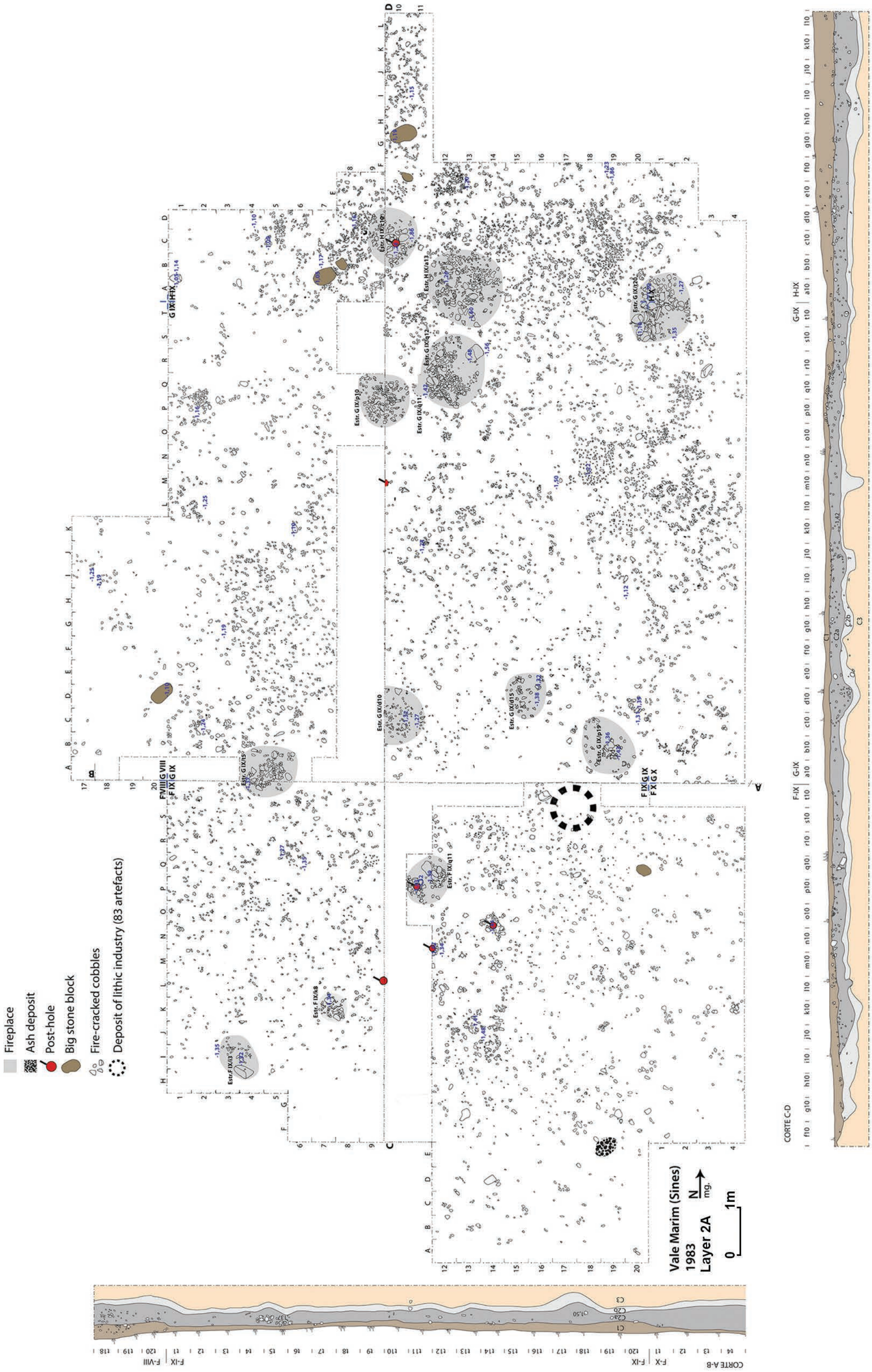


Fig. 3 – Vale Marim I. Stratigraphic profiles and plan of the archaeological layer (C.2A), with a high density of fireplaces (namely for smoking fish) and fire cracked pebbles.

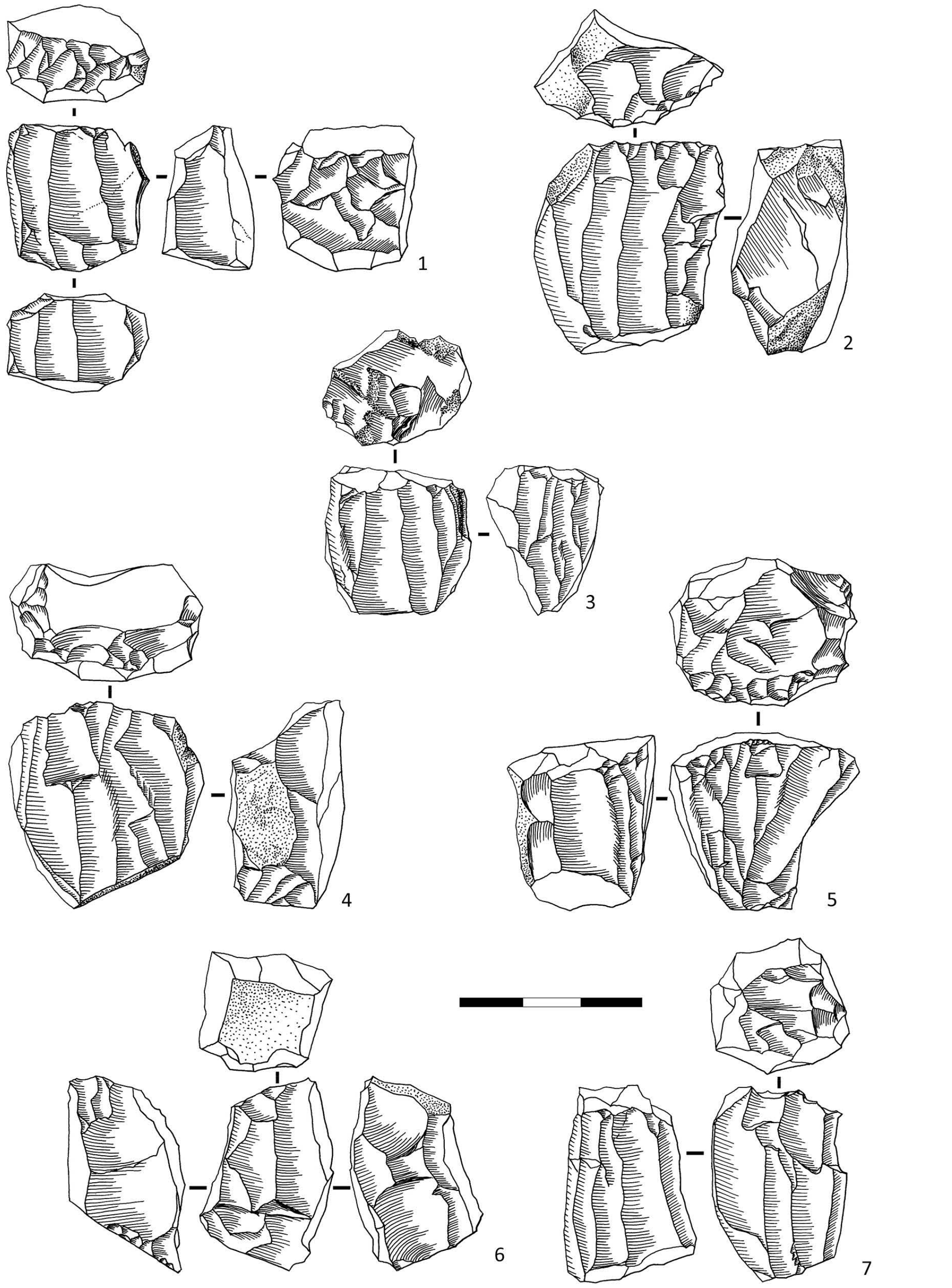


Fig. 4 – Vale Marim I. Cores on chert. Mainly bladelet-cores. Drawing by Fernanda de Sousa.

have been noted between unused and used bladelets; despite that, in what concerns technology, it is clear that the most regular blanks, the parallel-sided bladelets with a straight profile (mostly trapezoidal, but also triangular cross-sections), were preferentially used for trapeze production, while cutting tools were often made on bladelets with more concave profiles, often cortical ones and/or with less regular edges. Flakes showed (Fig. 6.3) no relevant differences between unused (average width: 11,4–16,4 mm; average thickness: 3,4–5,9 mm) and used blanks (average width: 14,8–22,2 mm; average thickness: 5–8,2 mm). Flake blanks were mainly used for scraping activities employing edges with obtuse angles, such as naturally steep edges, fractures and ridges. Edge retouching is always minimal. All but two of the geometrics were made on bladelet blanks. Vale Marim I, like other Late Mesolithic base-camps, produced a geometric-based tool assemblage, dominated by trapezes

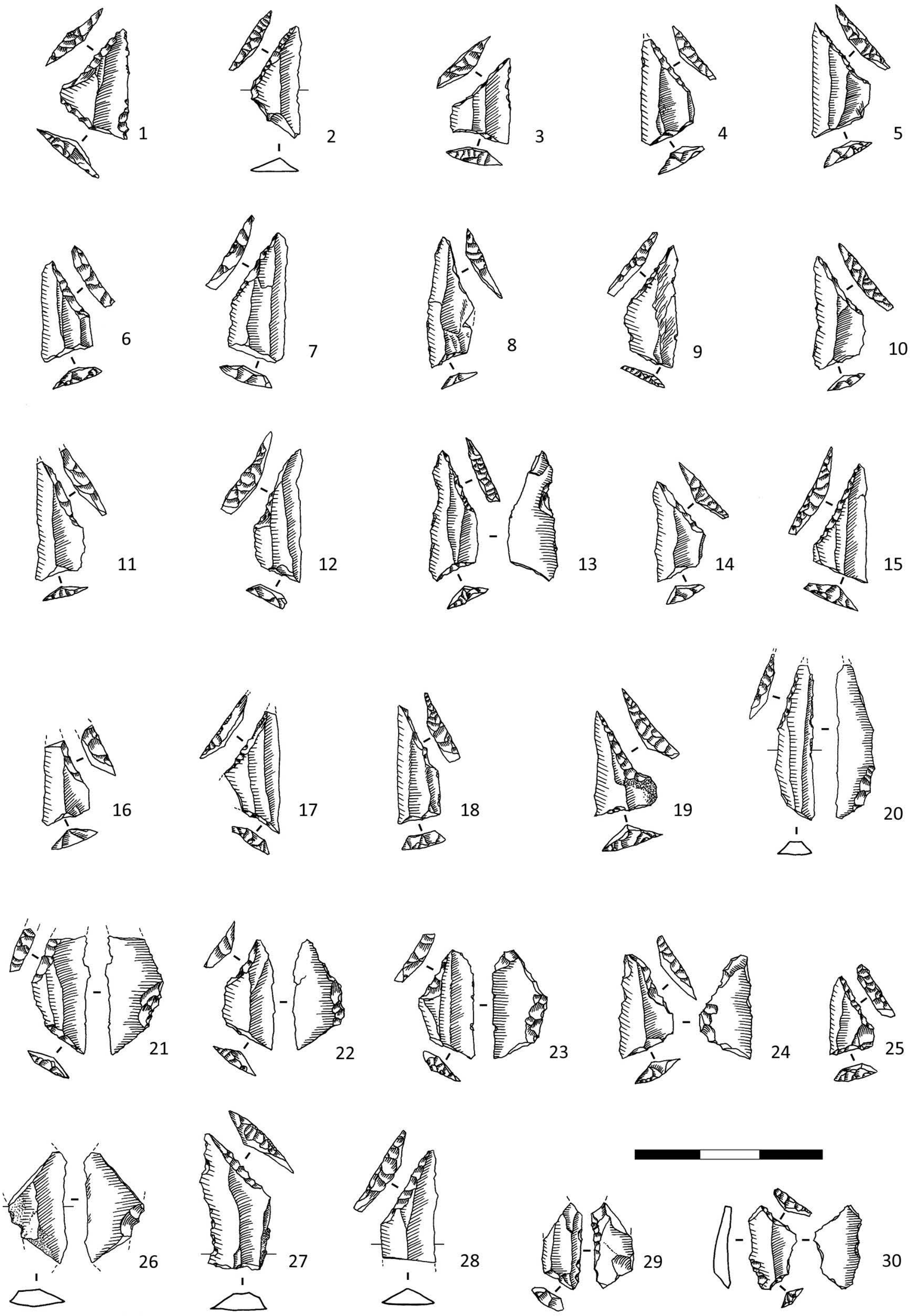
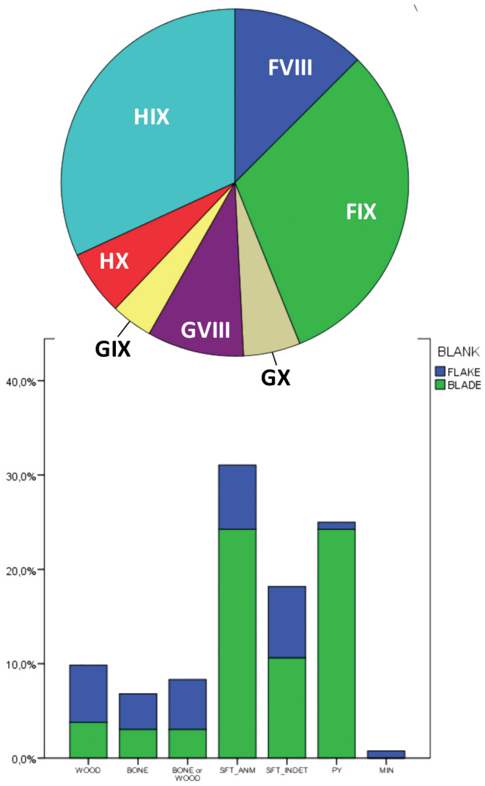


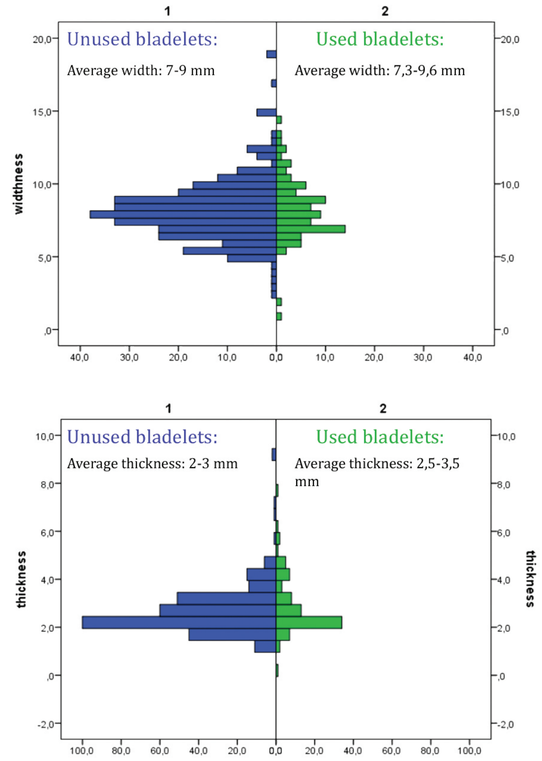
Fig. 5 – Vale Marim I. Geometrics. All but two of the geometrics were made on bladelet blanks. Vale Marim I like other Late Mesolithic base-camps produced a geometric-based tool assemblage, using microburin technique. Drawing by Fernanda de Sousa.

(Fig. 5), using microburin technique (Soares, 1995; Vierra, 1992). Overall, there appears to be very little variation in armatures thickness and weight, with more variation in length and width. Asymmetrical trapezes have in some cases a shape similar to a *trapèze de Vielle* (GEEM, 1969). Another common asymmetrical trapeze type has a concave small truncation and a straight long one; there is also a trapeze type with a small base slightly retouched (Fig. 5, nos. 21–26) which seems to mark the transition to the segment shape, a type that becomes dominant in the Early Neolithic. In fact, a general

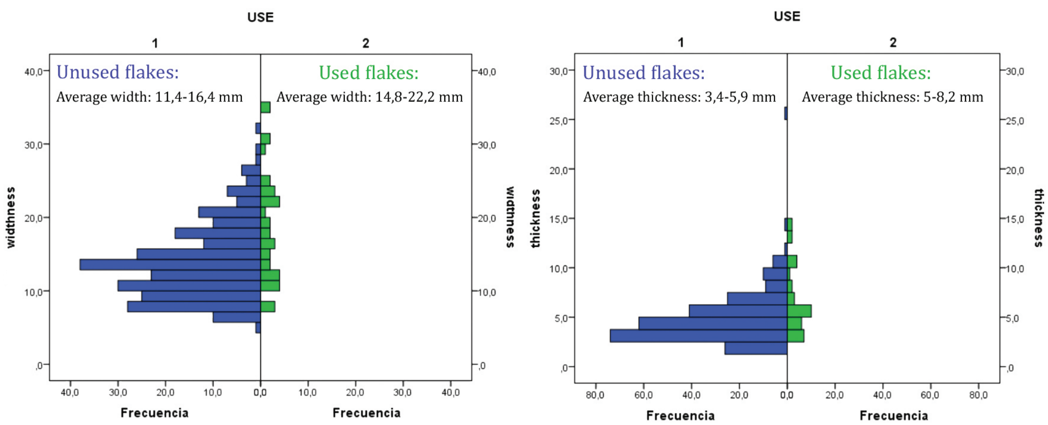
Fig. 6 – Vale Marim I. Lithic assemblage on chert. Typometric aspects of bladelets and flakes.



1 - The analysed sample: 1321 lithic artifacts from sectors F9, F8, G10, G9, H10, H9; 132 active zones were detected.



2 - Bladelet oriented production. Bladelets = 544 (41,2% of the lithic sample). No significant differences were observed between unused and used blanks. It reveals an homogeneous production.



3 - Flakes production. No relevant differences were observed between unused and used flakes. Blanks were selected on the basis of the edge's angle and not on typometrical criteria.

shift from trapeze to segment-oriented tool system by circa 5700 cal BC in the SW coast announces Neolithic times.

3.3. Use-wear analysis

The use-wear analysis has been carried out employing a stereoscopic microscope (from 5x to 40x) for the analysis of the edge-scarring patterns, and a reflected-light microscope (from 50x to 400x) for the analysis of the micro-features (Mazzucco & *alii*, 2015). Of the selected sample (1321 artifacts), 132 used (or active) zones have been detected, which means a high percentage of unused blanks. Even if in some cases the scarce development of the traces could have prevented their recognition through

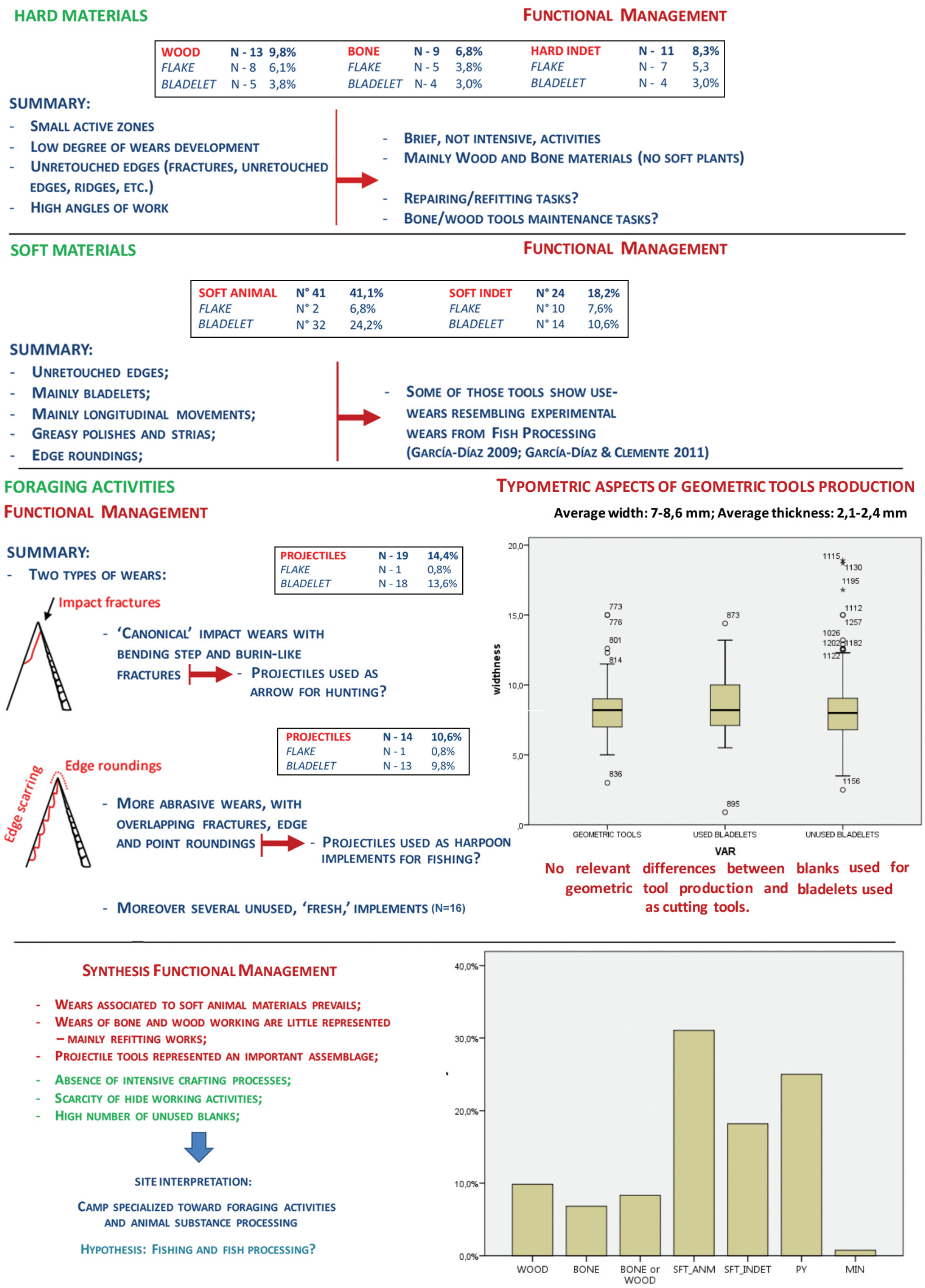


Fig. 7 – Vale Marim I. Lithic assemblage on chert. Use wear analysis. Functional management: wears associated to soft animal materials (SFT_ANIM) prevails; wears of bone and woodworking are little represented — mainly refitting works; projectile tools (PY) were very well represented. They had been used probably for hunting (39%), for fishing (28%) and unused (33%).

microscopic observation, in general terms, items classified as «unused tools» should be considered effectively unused. Indeed, we often underestimate our actual capabilities of use-wear traces detection; at Vale Marim I, most of the detected micro-traces were scarcely developed and clearly recognizable as human-use induced wears only at 400x. This means that lithics were hardly ever used, if considering the overall amount of flaked blanks, but also briefly used, for short working tasks. One possible explanation for this behavior is that flaking activities mainly took place during intervals of downtime in anticipation of specific peak peri-

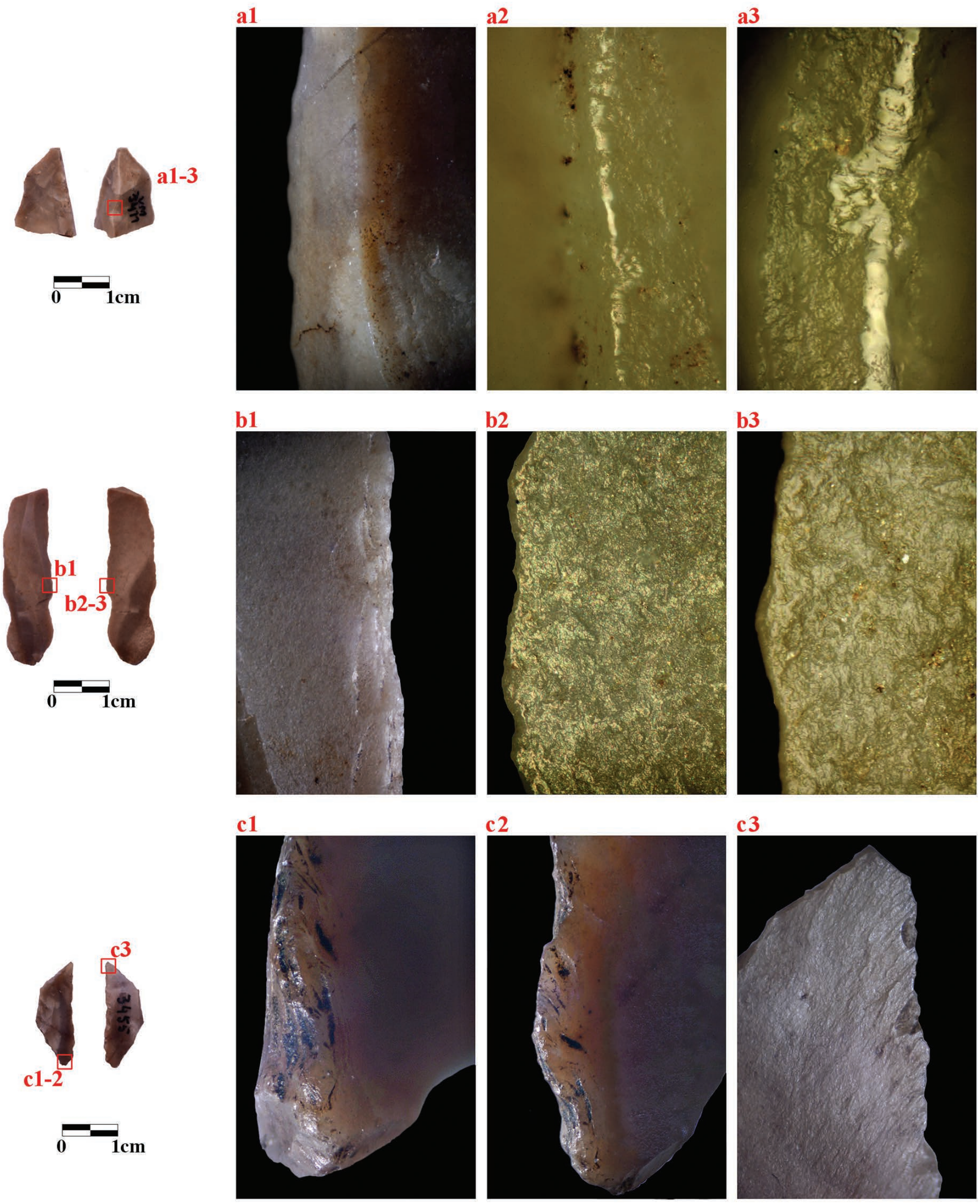


Fig. 8 – Selection of use-wear from the Vale Marim I lithic assemblage. 8a: Flake used for scraping bone/antler materials; a1 - used ridge at 10x, note the absence of macro-scarring; a2 - bone bevel at 200x; a3 - bone bevel at 400x. Note the presence of scratches and pits on the polish. 8b: Bladelet used for cutting soft animal substances, probably fish; b1- used edge at 10x, showing overlapping fractures; b2 - polish at 200x, note the irregular distribution of the polish, which penetrate into the tool's surface; b3 - polish at 400x, note the greasy appearance, with a pronounced edge-rounding. 8c: geometric tools showing edge-rounding and -scarring on one tip; c1-2: bifacial overlapping fractures, with a strong edge-rounding, 10x; c3: opposite tip, much less rounded and damaged, 10x.

ods of resources exploitation, eventually following a *replacement prior to failure* tactic (Kuhn, 1989) that seems well-adapted to a foraging strategy directed toward specific target species; however, this tactic would result in an overproduction of potentially utilizable blanks in respect to the real needs of the group.

Among used tools, there are traces of functional management (Fig. 7) on hard materials (N=33): wood (N=13; 9,8%), bone (N=9; 6,8%), and hard indeterminate (N=11; 8,3%). The blanks used are mainly flakes (N=20; 15,2%); bladelets are represented with N=13; 9,8%. As stated above, use-wear traces are always little developed, suggesting very short tasks, eventually related to bone/wood tools maintenance and resharpening. Natural fractures and ridges are commonly used for those tasks, providing very high-edge angles to work resistant materials (Fig. 8a).

Animal and indeterminate soft materials management (Fig. 7) was also recognized mostly on bladelets (N=46; 34,8%), and on part of the flakes (N=12; 14,4%). Observed traces indicate the processing of animal carcasses; the association of macro edge-rounding and-scarring with greasy micro polish of irregular distribution and longitudinal striations (Fig. 8b) resemble the experimental traces obtained by fish processing (García & Clemente, 2011).

Traces of foraging activities are present on geometric projectiles (Fig. 7), with two different types of use-wears: "canonical" bending/step and burin-like impact fractures, probably related to hunting, observed in 19 cases; edge and point rounding and scarring, probably due to the use of projectiles as harpoons for fishing, observed on 14 geometric artifacts (Fig. 8c). Moreover, several geometric tools (N=16) not showing any wears have been recovered, with fresh, undamaged, edges and points, confirming that the observed edge-rounding and-scarring on the other tools was not due to taphonomic factors, but to human-related uses. More detailed experiments focused on projectile tools functionality are needed to explore the hypothesis of a geometric points use for harpoons; but it could be imagined that, in the lack of more appropriated raw-materials, also lithics were used to manufacture fishing gears.

4. Conclusion

The use-wears associated with soft animal materials management (Fig. 7) are dominant (41,1%), highlighting the importance of animal substance processing (storage?). Traces of bone and woodworking are little represented — mainly refitting works. Projectile tools have played an important role (25%), in accordance with practice of intense foraging activities, apparently balanced between hunting and fishing. Despite that, the scarcity of hide working activities is not compatible with an emphasis on hunting, also considering the use-wear data obtained from other Late Mesolithic assemblages (Philibert, 2002; Perales, 2015). On the contrary, fishing could be the main economic activity, an idea also supported by the fact that the scarce faunal remains preserved in the site were fish teeth (*Sparus aurata*), and we know how mammals bones are much more resistant to taphonomic agents and soil acidity!

Another question concerned with site interpretation is about seasonality (Fig. 7). Could it be a summer fishing camp? Or a basecamp occupied all year-round? Once again, the limited size of the preserved organic materials limits our interpretation; however, the gathering of pine wood and even pine cones of *Pinus pinea* (collection of pine nuts?) might suggest the occupation of the site not only during summer, but also during the late fall.

Combining the zooarchaeological information from Samouqueira I and Vidigal (both sites on the outer coast as Vale Marim I) with the results of lithic use wear analysis of Vale Marim I, it is likely that, on the Alentejo coast, the first communities of true fishermen have developed at the end of the 7th/first half of the 6th millennia cal BC. This hypothesis obviously requires and inspires more research to further knowledge on Late Mesolithic technological and subsistence systems.

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