

UNIVERSIDADE DE LISBOA

Faculdade de Letras



**Last hunter-gatherers in Eurasia: a comparative approach to shell midden site structure
and function between Atlantic Europe and Japan**

Diana Rita da Graça Nukushina

Orientador(es): Prof. Doutora Mariana Teodósia de Lemos Castelo Branco Diniz

Prof. Doutor Grégor Marchand †

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Tese especialmente elaborada para obtenção do grau de Doutor em Arqueologia e Pré-História

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In memory of Grégor Marchand,
who supported this work with lots of knowledge, enthusiasm and fun.

畑に蛤 (*batake ni hamaguri*)

‘You cannot get clams from a field.’

– Japanese proverb

But sometimes you can.

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Abstract

The construction of shell middens is a common characteristic of several of the last hunter-gatherer groups of Holocene Eurasia that occupied diverse environments, usually with significant aquatic components. In particular, numerous shell middens have been found in the archaeological record of the Late Mesolithic in Atlantic Europe and the Jomon period in the Japanese archipelago, notably the period from the end of the 9th millennium cal BP to the end of the 4th millennium cal BP (Middle and early Late Holocene). However, despite the long history of research and the high quantity of available archaeological data on these sites, systematic comparative approaches to the shell midden phenomenon between these two regions have been lacking. Furthermore, shell middens have often attracted researchers because of the richness of their contents and their frequent funerary nature, while much less attention has been given to the formation, structure and overall function of the sites themselves.

This thesis examines how shell middens were internally structured and used by Middle and early Late Holocene hunter-gatherer groups in Atlantic Europe and Japan, providing the first contribution to a transcultural comparative perspective on the shell midden phenomenon and their builders from these two extremities of Eurasia. It presents a review and analysis of available archaeological data and existing local and regional perspectives on shell midden site structure and function based on several Late Mesolithic and Jomon sites from Atlantic Europe and Japan. Case studies from Portugal, north-west France and western Japan (Okayama region) are further developed through different methodologies that comprise an analysis of the parameters of the archaeological sites, written and graphic documentation from past excavations and intra-site spatial distribution of material remains with a focus on lithic material. Structured comparisons between Atlantic Europe and Japan are established throughout the thesis and integrated into a broader discussion of shell midden research, the meaning of these accumulations and the characteristics of the Holocene hunter-gatherer societies that constructed and left them behind in the two regions.

Keywords:

Shell middens; last hunter-gatherers; site structure and function; Atlantic Europe; Japan

Resumo

A construção de concheiros – depósitos culturais caracterizados por acumulações antropogénicas e intencionais de conchas – é uma característica comum a vários grupos humanos que, em diferentes pontos do mundo, ocuparam ambientes diversificados, tendencialmente com componentes aquáticas relevantes (como costas marítimas, margens de estuários, rios e lagos) e condições propícias à recolha de quantidades significativas de moluscos. A Europa Atlântica e o Arquipélago Japonês, embora se situem em extremos opostos da Eurásia separados por uma longa distância geográfica e cultural, partilham o facto de se destacarem por um elevado número de concheiros conhecidos no registo arqueológico das últimas comunidades de caçadores-recolectores do Holocénico, particularmente em contextos culturais do Mesolítico final, na Europa, e do Jomon, no Japão, sobretudo aqueles que integram o período cronológico compreendido entre o final do 9º milénio cal BP e o final do 4º milénio cal BP (Holocénico Médio e Tardio inicial).

As duas regiões encontram-se maioritariamente na zona temperada e sofreram importantes mudanças ambientais no período pós-glaciar decorrentes do aumento e progressiva estabilização posterior das temperaturas médias e do nível do mar verificados a nível global, designadamente, profundas alterações da flora (com a expansão das florestas temperadas), da fauna (com o desaparecimento ou migração da megafauna típica do Pleistocénico e a expansão de fauna de média ou grande dimensão, como o veado e javali) e das zonas costeiras (fenómenos de acelerada transgressão e posterior estabilização/regressão das linhas de costa). Fruto destas alterações, desenvolveram-se ecossistemas de grande produtividade, sobretudo em associação a ambientes protegidos de águas pouco profundas, entretanto formados, como baías e estuários, onde abundantes e diversificados recursos aquáticos e terrestres (animais e vegetais) passaram a estar disponíveis e mais facilmente acessíveis e previsíveis para as comunidades humanas.

O aparecimento de concheiros, em maior número e dimensão, no registo arqueológico do Mesolítico Final da Europa Atlântica e do Jomon do Japão (sobretudo do período entre o final do *Initial Jomon* e o final do *Late Jomon*), tem sido genericamente associado ao desenvolvimento de uma exploração mais intensa de ambientes e recursos aquáticos por parte das comunidades de caçadores-recolectores nestas fases, relativamente a períodos anteriores. Esta tendência é também sugerida por vários outros indicadores, como os dados arqueozoológicos e de isotópos estáveis de esqueletos humanos provenientes de vários concheiros, que apontam para o desenvolvimento de dietas mais diversificadas e com uma integração significativa (ainda que variável) de recursos aquáticos, a existência (numerosa em várias regiões) de outros tipos de sítios litorais (sem concheiro), ou a identificação de um maior número de equipamentos diversificados de pesca e de evidências de transporte aquático nos contextos arqueológicos deste período. A formação dos concheiros holocénicos, sobretudo os de maior dimensão, tem sido também frequentemente relacionada com o desenvolvimento de estilos de vida mais sedentários e de maiores densidades populacionais entre as comunidades de caçadores-recolectores, características por sua vez associadas ao conceito de “caçadores-recolectores complexos” ou “afluentes” (Yesner et al., 1980; Koyama and Thomas, 1981; Price and Brown, 1985; Arnold, 1996; Rowley-Conwy, 2004).

Os concheiros mesolíticos na Europa Atlântica e Jomon no Japão têm sido amplamente estudados desde o século XIX, existindo hoje uma abundante e diversificada informação arqueológica disponível sobre estes sítios. As influências da arqueologia ocidental na arqueologia japonesa em geral, bem como, especificamente, na investigação de concheiros, são, também, evidentes. Porém, não têm sido desenvolvidas abordagens comparativas detalhadas de concheiros entre a Europa e o Japão, por razões que se podem relacionar com a distância entre as duas regiões, as dificuldades de entendimento linguístico entre investigadores, a enorme heterogeneidade destes sítios, mesmo quando observados a partir de escalas micro-regionais, entre outros factores. Por outro lado, quer na Europa, quer no Japão, os concheiros têm atraído fortemente a atenção dos investigadores, principalmente, pela riqueza dos seus conteúdos arqueológicos, proporcionada pelo bom nível de preservação de material orgânico que habitualmente caracteriza estes sítios. Tal situação tem permitido, em ambas as regiões, o desenvolvimento de numerosas análises específicas direccionadas para o estudo do paleoambiente, paleoeconomia (sobretudo no que se refere às paleodietas) e cultura material. A frequente natureza funerária dos concheiros tem sido igualmente destacada, atestada pelo elevado e excepcional número de esqueletos humanos aí exumados. Porém, a formação, estrutura interna e funcionalidade geral destes sítios (para lá da actividade funerária) têm sido tópicos menos desenvolvidos pela investigação. Os concheiros têm sido, portanto, mais abordados como acumulações e repositórios de informação detalhada sobre aspectos ambientais, económicos e culturais vários, do que como sítios que, em si mesmos, terão tido significado, enquanto palco e parte de actividades humanas no passado. Tais actividades foram, em muitos casos, diversificadas dentro dos mesmos sítios e desenvolvidas de forma prolongada no tempo, por diferentes gerações. O estudo e o debate sobre esta vertente dos concheiros, menos explorada, torna-se, por isso, necessário, e a utilização de uma óptica comparativa transcultural tem o potencial de, entre outros aspectos, auxiliar processos de inferência e de interpretação do registo arqueológico, muitas vezes de difícil entendimento nestes contextos pré-históricos, e promover a crítica de conceitos vulgarmente utilizados.

A presente dissertação constitui, assim, uma primeira abordagem comparativa e transcultural entre a Europa Atlântica e o Japão ao fenómeno dos concheiros e às sociedades que os originaram. Especificamente, procura analisar de que forma os concheiros foram internamente estruturados e utilizados pelos grupos de caçadores-recolectores do Holocénico Médio e Tardio inicial nas duas regiões – Mesolíticos e Jomon - utilizando diferentes escalas e focando-se nas temáticas da organização espacial interna (*site structure*) e funcionalidade dos sítios (*site function*). Procura-se, através da examinação detalhada da diversidade do registo arqueológico, discutir algumas ideias pré-concebidas dos concheiros enquanto acumulações necessariamente caóticas, sem qualquer tipo de organização discernível, com propósitos limitados à acumulação de detritos e, quando aplicável, à actividade funerária, bem como classificações funcionais pouco fundamentadas.

Nesse sentido, é apresentada uma revisão e análise dos dados arqueológicos disponíveis e perspectivas até agora defendidas no que toca à organização espacial interna e funcionalidade dos concheiros, tendo por base a bibliografia existente sobre vários sítios com ocupação no Mesolítico final na Europa Atlântica e Jomon no Japão. São também

desenvolvidos, em maior detalhe, casos de estudo de Portugal, noroeste de França e Japão ocidental (região de Okayama), utilizando diferentes metodologias. No que toca aos grupos de concheiros destas regiões, procede-se ao levantamento e sistematização de dados relativos a aspectos físicos, conteúdos arqueológicos e características funcionais (actividades) documentadas através do registo arqueológico. Posteriormente, são seleccionados e classificados parâmetros quantitativos e qualitativos, procedendo-se à análise regional e inter-regional das principais tendências dos grupos de sítios. Relativamente a alguns dos concheiros do vale do Sado (Portugal), do noroeste de França e de Okayama, no Japão, apresentam-se análises de documentação escrita e gráfica de escavações realizadas no passado, em vários casos, na primeira metade e inícios da segunda metade do século XX, com enfoque nas características e distribuição espacial dos principais elementos que constituem estes sítios (depósitos, estruturas e materiais arqueológicos). São também apresentadas análises espaciais de materiais arqueológicos, nomeadamente de materiais líticos, provenientes das escavações mais recentemente realizadas, no século XXI, nos concheiros de Poças de São Bento (Vale do Sado, Portugal), Beg-er-Vil (Bretanha, França) e Hikozaiki (Okayama, Japão). A análise do material lítico, abundante nestes três sítios, incide maioritariamente sobre material em pedra lascada e combina dados resultantes do seu estudo tecno-tipológico e a abundante informação contextual e espacial disponível, resultante da aplicação de protocolos de trabalho de escavação e de pós-escavação de grande detalhe.

Ao longo da dissertação, são estabelecidas comparações sistemáticas entre dados arqueológicos da Europa Atlântica e Japão, destacando semelhanças e diferenças, as quais são integradas numa discussão final mais alargada sobre os problemas e perspectivas em comum relativas às metodologias de investigação dos concheiros (nomeadamente no que toca à sua escavação), o funcionamento e significado destas acumulações e as características das sociedades caçadoras-recolectoras holocénicas que as construíram e deixaram em ambas as regiões, em especial, no que toca à sua relação com os meios e recursos aquáticos e à sua complexidade social.

Palavras-chave:

Concheiros; últimos caçadores-recolectores; organização espacial interna e funcionalidade dos sítios; Europa Atlântica; Japão

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Diana Nukushina

Introduction

0.1. Comparing shell middens across a large territory: a challenge to scientific barriers

‘Science has no boundaries’ is a recurrent expression. It is evident that globalisation has affected how science, including archaeology, is done today. In the last decades, scientific production has accelerated. Information is now shared at the speed of a click and mobility has become easier and almost (if not totally) compulsory for researchers. Archaeologists, who deal with human culture and evolution, have often faced problems that are common to many different geographic contexts. However, this does not necessarily mean that engaging in comparative research and large-scale approaches is now a widespread practice in archaeology. In fact, science *has* boundaries. Still today, researchers continue to be constrained and conditioned by numerous geographical, linguistic, cultural, economic, political, and scientific barriers, even if many live in a relatively democratic and globalised world.

Comparative archaeological research between Atlantic Europe and Japan, two extreme points of Eurasia separated by more than 9000 km, is not without precedents, but it is still far from being a traditional approach. These two regions, mostly lying in the north temperate zone, have faced similar environmental modifications in the post-glacial period that were mainly caused by an increase in temperature and humidity, as well as sea-level rise. The archaeological record of the hunter-gatherer populations in these regions indicate that several cultural adjustments happened at the time. Among other things, the proliferation of shell middens constructed by hunter-gatherer groups from the Middle Holocene onwards is one of the best documented changes in the littoral zones. However, a systematic comparative approach to this common phenomenon between Europe and Japan is lacking in the archaeological literature for several reasons, including linguistic barriers. This work was thus designed to challenge the still existing difficulties of research between Europe and Japan, providing the first contribution to a macro-scale perspective on shell middens from these two regions in the north temperate zone.

0.2. Research questions and objectives

Despite the distance from each other, Atlantic Europe and the Japanese archipelago shared some environmental and cultural characteristics in the Middle and early Late Holocene (the end of the 9th millennium—the end of the 4th millennium cal BP). The proliferation of shell middens was one of them, being evidenced in the archaeological record of the Late Mesolithic in Atlantic Europe and the Jomon period in the Japanese archipelago, more specifically from the end of the Initial Jomon to the end of the Late Jomon subperiods (roughly between 8200–3300 cal BP). However, despite being two relevant areas of Eurasia regarding the number of known Holocene shell midden sites and the quantity of available archaeological data, a comparative approach to this phenomenon is lacking. Furthermore, in both regions, shell middens have been often attracting the researchers for the amount and richness of their contents and frequent funerary nature, while much less attention has been given to the formation, structure and function of the sites themselves. Perceptions of these

sites as simple discard places and cemeteries have dominated research approaches and perspectives, but the archaeological evidence from the Late Mesolithic and Jomon shell middens is diverse, suggesting that these sites were used for a wider variety of activities and purposes that require a better examination.

The main objective of this thesis is to better understand how shell middens were internally structured and used by the Middle and early Late Holocene hunter-gatherer groups in Atlantic Europe and Japan. The research specifically addresses the following questions:

- 1) *Shell middens as a Holocene global phenomenon*: Why do shell middens systematically appear in the archaeological record of the Middle and early Late Holocene hunter-gatherer groups of Atlantic Europe and Japan, particularly in close association to the ‘climatic optimum’?
- 2) *Shell midden variability*: How different and similar are these shell middens in their general features? How can shell midden variability be explained?
- 3) *Shell midden site structure*: Are these shell middens internally organised? How is shell midden site structure discernible through the archaeological record? How diverse is it? Are the spatial patterns similar between Late Mesolithic and Jomon shell middens?
- 4) *Shell midden site function*: How variable are the functions of shell middens that can be assigned to each site, site cluster and region? Which factors seem to be correlated with the variability of functions? Are shell midden site typologies adequate and useful? What is the role of shell middens in the Late Mesolithic and Jomon littoral settlement systems?
- 5) *From shell midden site structure and function to hunter-gatherer societies and complexity*: Do shell midden formation, site structure and function reflect hunter-gatherer social structure and complexity? How similar or different is social structure and complexity evidenced by Late Mesolithic and Jomon shell middens’ records? Is the concept of ‘maritime hunter-gatherers’ adequate to refer to the communities that left these sites?
- 6) *From shell middens to scientific construction*: What is the impact of different research methodologies and contexts on the available data and the construction of perspectives on shell middens?

The following methodologies are applied and accompanied by structured comparisons between shell middens from the Late Mesolithic of Atlantic Europe and the Jomon of Japan: (1) a review of available archaeological data and perspectives on shell midden site structure and function based on several cases from Europe and Japan; (2) case studies from Portugal, France and western Japan (Okayama region) on an analysis of parameters related to site formal characteristics, contents and function, analysis of written and graphic documentation from past excavations and spatial analysis of material remains with a focus on lithic material.

0.3. Thesis structure

The body of this thesis is divided into three parts, which are composed of several chapters.

Part I corresponds to the background of this thesis and comprises chapters 1, 2 and 3.

Chapter 1 starts with a general introduction to the concept of shell middens, the main object of the research. It explains the richness of shell middens in information of a diverse nature about the past societies that left them and the dimensions of these sites as a global

phenomenon that developed with intensity from the Middle Holocene onwards. The following section addresses the importance of comparative research in archaeology for the study of common problems within past societies. The focus is put on comparative research between Europe and Japan on prehistoric archaeology undertaken so far and the relevance of engaging in comparative investigations of shell middens from these two regions. The text follows with a presentation of the frameworks of this thesis – its geographic framework (Atlantic Europe and the Japanese archipelago), its climatic and chronological framework (Middle Holocene and early Late Holocene) and, finally, its cultural framework (the Mesolithic of Atlantic Europe, notably the Late Mesolithic period, and the Jomon period of the Japanese archipelago, with an emphasis between the end of the Initial Jomon and the end of the Late Jomon period).

Chapter 2 contains a general presentation of Late Mesolithic shell middens in Atlantic Europe, followed by Jomon shell middens in Japan. Each section (Atlantic Europe and Japan) is structured in a similar way, being divided into four topics – history and aims of shell midden research (from the nineteenth century until today), general characteristics of the sites (location, formal characteristics and composition, function, chronology), current methods of excavation and ongoing research problems. The chapter ends with a comparative section that introduces several common matters that can be found between the two regions of Eurasia concerning the characteristics of shell middens and research on these sites.

Chapter 3 addresses the main topics of research on shell middens in this thesis – site structure and function. It starts with a state of the art, which includes a definition and explanation of the two concepts and a presentation of general problems that have been found in the study of these domains. It ends with an introductory approach to the research on site structure and function of shell midden contexts in general, describing some of the problems that often affect these specific sites (visibility of features, stratigraphic complexity, post-depositional processes) and need to be considered in the analyses. The chapter ends with the presentation of the main questions on site structure and function that can be posed concerning Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan.

Part II is dedicated to the exposition and review of available data and perspectives, presentation of the results of the analysis and a comparative discussion. It is composed of two chapters (chapter 4 and 5).

Chapter 4 consists of an extensive review and analysis of the available data and perspectives on shell midden site structure and function in Late Mesolithic Atlantic Europe and the Jomon period of Japan. It is divided into four subchapters. Firstly, the analytical methods are explained in **subchapter 4.1**. Then, case studies from the Late Mesolithic of Atlantic Europe are presented in **subchapter 4.2**, with a focus on those from Portugal and France. It starts with an introduction to shell middens in Portugal, which is followed by a review of data from three regions (the Tejo valley, Sado valley and south-western coast of Alentejo and Algarve), a presentation of results concerning the analysis of general trends of each site group and a discussion of results. A similar approach is made with the shell middens in north-west France. After an introduction to the sites of the region, a review of data is presented for each site, being followed by a presentation of results concerning the analysis of general trends of the sites and then a discussion of results. After these two regional

approaches, the results from the analysis of the general trends of the shell middens from the two countries (Portugal and France) as a set are presented. Additionally, some insights on shell midden site structure and function from two other important regions of Atlantic Europe with abundant sites (Spain and Denmark) are presented.

The chapter continues with the presentation of case studies from the Jomon of the Japanese archipelago, in **subchapter 4.3**, which is centred on sites in western Japan. After an introduction to the shell middens of western Japan, data from the sites of the Okayama region are presented and reviewed. Then the general trends of the site cluster are analysed and discussed. The results of the study of general trends from the shell middens of Okayama are also compared with those from the Portuguese and French sites. In the following section, data from some well-known submerged shell middens in western Japan are also reviewed, considering the relevance of the information provided by these sites on site structure and function, among several other matters. The last section of this subchapter is devoted to eastern Japan. The analyses presented in this study are centred on cases from western Japan, but the highest densities of Jomon shell middens are recorded in eastern Japan, where there is a long tradition of research and larger amounts of available information, and addressing it is inevitable in this work. After a brief overview of shell middens in eastern Japan, some well-known cases from Tokyo Bay are presented and discussed. The chapter ends with **subchapter 4.4**, which contains comparative reflections and conclusions of the review and analyses undertaken on the site structure and function of Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan.

Chapter 5 presents the results of a document analysis (written and graphic documentation) and spatial analysis of archaeological material (centred on lithic remains) from the case study of shell midden sites from the Late Mesolithic of Atlantic Europe (the Sado valley in southern Portugal and the Brittany region in north-west France) and the Jomon period of western Japan (Okayama region). After an explanation of the analytical methods in **subchapter 5.1**, the case study of the Sado valley (Portugal) is approached in **subchapter 5.2**, being centred on the presentation and discussion of the results of a document analysis and spatial analysis of lithic remains from the site of Poças de São Bento. It is followed by the presentation and discussion of results of a document analysis from three other sites (Cabeço do Pez, Vale de Romeiras and Arapouco). In **subchapter 5.3**, the case study of shell middens in Brittany (France) is centred on the presentation and discussion of the results of a document analysis and spatial analysis of material remains from Beg-er-Vil. It also includes the presentation and discussion of results of a document analysis from three other sites (Beg-an-Dorchenn, Téviéc, Höedic). The last case study (**subchapter 5.4**) comprises Okayama prefecture (Japan), being mostly dedicated to the presentation and discussion of the results of a document analysis and spatial analysis of material remains from the Hikozaki shell midden. The results of a document analysis from Tsukumo shell midden are also presented and discussed. The chapter ends with a section on comparative reflections and conclusions about the results of the analyses undertaken on the three regions, in **subchapter 5.5**.

Part III consists of only one chapter (**Chapter 6**) and offers a comparative discussion of the presented data and the results of the analyses undertaken in this thesis, integrating them

into a broader view of the Late Mesolithic and Jomon shell middens and the societies that left these constructions, the last hunter-gatherer groups from Atlantic Europe and Japan. The first section (**subchapter 6.1**) approaches the common problems and perspectives regarding current methodologies of the investigation of shell middens in Europe and Japan, especially concerning the excavation of these sites. In **subchapter 6.2**, the function of shell midden sites is discussed, regarding two main topics: the construction of site typologies/classifications as a response to the variability problem and the relationships between shell middens and other littoral sites. It is followed by **subchapter 6.3**, with a discussion about shell midden site structure concerning the internal elements of the sites (features, materials and activities that were undertaken), their placement and spatial relations between them. Finally, in **subchapter 6.4**, the significance of shell middens in the lifeways of Late Mesolithic and Jomon hunter-gatherer groups is evaluated, notably the relevance of aquatic resources for these communities and the relation of these sites with the development of social complexity.

PART I

Chapter 1 Shell middens as a Holocene global phenomenon: a comparative approach between geographical extremes of Eurasia

'The shell mounds, or deposits, in various parts of the world have many features in common. They also have their distinguishing peculiarities. Their similarity arises from the fact that they are the refuse piles of savage races who came to the shore at certain times of the year, or who occupied the shore permanently and there availed themselves of the food so easily secured from the water, in the shape of mollusks and fishes.'

(Morse, 1879, p. 5)

1.1. Defining shell middens

Shell middens are observed across diverse environments worldwide, usually environments with significant aquatic components (coastlines, rivers, estuaries/marshes and lake shores) that allow conditions for mass harvesting of molluscs (Figure 1). These cultural deposits result from a common global human behaviour and can be broadly defined as the 'intentional anthropogenic accumulations of shells' (Balbo et al., 2011, p. 147). As explained by Gregory Waselkov (1987) and Geoff Bailey and Nicky Milner (2008), the principal *visible* component of these deposits is mollusc shells. However, while the concept of a shell midden can be very inclusive, it does not define a minimal dimension or shell density for considering an accumulation to be a shell midden (Hardy, 2017, p. 259). Indeed, the English term 'shell midden' often encompasses many different realities of shell accumulation such as small deposits in rock shelters or caves, pits filled with dense concentrations or actual mounds. The proliferation of many alternative terms in the literature has been inevitable, in many cases having slightly different meanings regarding the shape and volume of deposits, or the density of shells. 'Kitchen middens' (after the original *Køkkenmøddinger* in Danish), 'shell mounds', 'shell deposits', 'shell-bearing sites' or 'shell matrix-sites' are among the most used terms. This scenario becomes further complicated if languages other than English are introduced into the debate (e.g., Dupont, 2003b; Komiya, 2015). The terminological and conceptual problem can explain the difficulties in quantifying shell middens with precision across different regions of the world because quantification always implies classification, which depends on the perspective on the concept that is adopted. In this work, the term 'shell midden' is applied considering its prevalent use in the literature and referring to intentionally accumulated shell deposits, without any implicit meaning related to their size, form or function.

It is peculiar how a global phenomenon can be so problematic in its definition. However, its dimension is far from being the sole cause of shell midden diversity. The definitions, either more inclusive or restrictive, cannot hide the variety encompassed by these features regarding other aspects such as location, form, composition, function and chronology (e.g., Waselkov, 1987; Larsson, 1993; Balbo et al., 2011; Gutiérrez-Zugasti et al., 2011; Habu et al., 2011; Álvarez et al., 2011; Hardy, 2017). Shell middens are typically littoral sites composed of marine (salt and brackish water) mollusc shells. However, sites composed of freshwater or

terrestrial mollusc shells are also known in inland locations, such as the well-known land snail middens (*‘escargotières’*) of the Capsian cultural complex in Algeria and Tunisia (Lubell et al., 1976). Additionally, shell middens can be associated with very different settlement types from temporary occupations to large permanent settlements, and economies from simple foraging to agriculture-based ones (Bailey and Milner, 2002).

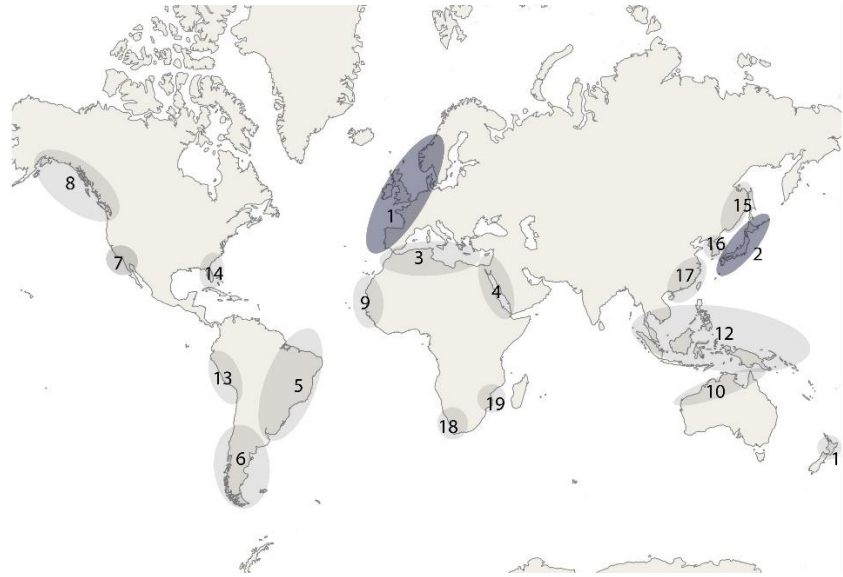


Figure 1: World map showing the distribution of the most investigated regions with shell middens (image by author based on Balbo et al., 2011; Hardy, 2017; Ruiz et al., 2020; Robson et al., 2023 and others): 1) Atlantic Europe (developed in this study); 2) Japanese archipelago (developed in this study); 3) Mediterranean Sea/North Africa; 4) Red Sea; 5) Brazil; 6) Southern South America; 7) California; 8) Northwest Coast of America; 9) Senegal/Mauritania; 10) Northern Australia; 11) Northern New Zealand; 12) Southeast Asia and Pacific islands; 13) Pacific coast of Peru and Chile; 14) Southeast North America; 15) Russian Far East; 16) Korean Peninsula; 17) Coast of China; 18) South Africa; 19) Mozambique.

The accumulation of shell middens usually provides distinctive soil chemistry by creating an alkaline matrix through the calcium carbonate of shells. These conditions allow for a good preservation of other archaeological and organic material, notably shell, bone and antler remains. Thus, although shell middens primarily denote mollusc exploitation (Balbo et al., 2011), these features can also preserve residues of resources other than molluscs (such as terrestrial fauna, fish, etc.), as well as human bones. This characteristic is particularly relevant in environments where organic material rarely survives by other means, such as in most parts of Western Europe and the Japanese archipelago, where acidic soils predominate (Suzuki, 1989; Larsson, 1993; Matsui, 1999). The organic content can provide excellent information on topics such as subsistence, seasonality or funerary behaviour, while it can also allow the acquisition of chronological data through radiocarbon dating. In addition, artefacts and other traces of activities such as combustion, food processing, habitation or ritual are frequently found in shell middens. Shell middens are thus markers of human activity in its various dimensions. At the same time, their components are significant sources of information

concerning past environmental and climate conditions and changes, and human adaptations to them.



Figure 2: Beg-er-Vil shell midden, Morbihan, France (photo by author).

It has been recognised that shell middens developed intensively (in dimension and quantity) in the post-glacial period across the world (Bailey, 1978; Waselkov, 1987; Claassen, 1998), especially from the Middle Holocene onwards (Erlandson, 2013; Hardy, 2017; Astrup et al., 2020). This phenomenon seems to be correlated, particularly in temperate regions, with the establishment of warmer global temperatures and a lower variance in weather, which enabled the formation of highly productive ecosystems with abundant aquatic and terrestrial resources. The inundation of the coastlines and the progressive stabilisation of the sea levels allowed the formation of embayments and estuaries with shallow waters that were suitable for the development and harvesting of molluscs.

In fact, shell middens are known during a wider time-scale starting in the Palaeolithic (Bailey, 1978; Gutiérrez-Zugasti et al., 2011; Álvarez et al., 2011), but early sites that have been found have been fewer and generally smaller. In addition, most of these sites have been found in relatively protected environments such as caves or rock shelters, or in locations in elevated positions in relation to the contemporaneous shoreline (Bailey and Flemming, 2008). It is now well established that the available data on shell middens prior to the Middle Holocene is biased in many regions by the submergence of early coastlines during the rise of post-glacial sea levels (Waselkov, 1987; Claassen, 1998; Álvarez et al., 2011; Bailey, 2013; Erlandson, 2013; Astrup et al., 2020; Hale et al., 2021). Consequently, it can be understood that the large quantity of coastal sites from the Middle Holocene and later that we know today resulted from the survival of this inundation, which has been allowed by the global deceleration of sea-level rise and consequent formation and stabilisation of shorelines and estuaries (Bailey and Milner, 2002; Anderson et al., 2007; Parkington and Brand, 2020). As so, it is uncertain if the archaeological appearance of many shell middens in the Middle Holocene corresponds to an effective historical ‘innovation’ or ‘revolution’ of this period (as discussed by Bailey and Flemming, 2008), or if that was also a significant phenomenon in earlier phases, since datasets indicating aquatic resource exploitation in the Pleistocene have been growing (e.g., Nabais et al., 2023).

Despite the problems in chronologically defining the ‘appearance’ of shell middens in a significant number, the proliferation of shell middens and other littoral sites is not the only

evidence of the intensive use of aquatic environments and resources by post-glacial hunter-gatherers worldwide (Suzuki, 1989; Barnes, 2015c). The development of marine technologies, such as harpoons, fishhooks, nets and boats is also well-attested (Bailey and Milner, 2002; Erlandson, 2013). Innovations in technology and the spread of these items in the archaeological record indicate improvements in fishing and sea mammal hunting, as well as transportation and resource exchanges across water bodies. The intensification of maritime mobility is also indirectly indicated by several lines of evidence, such as the Mesolithic occupation of a number of islands in north-west France (e.g., Höedic) (Marchand, 2003; 2015; 2021), or the large, remote islands in the Mediterranean basin that implied sea-crossings of longer distances (e.g., Corsica and Sardinia) (Leppard et al., 2021). Moreover, the formation of middens can also be related to the development of more sedentary lifeways and higher population densities, producing larger quantities of food waste at this time (Waselkov, 1987; Erlandson, 2013; Dow and Reed, 2015). In many regions, however, shell middens became less important, both in number and size, with the introduction of farming (Abe, 2009; Hardy, 2017), expressing, although not exclusively (Waselkov, 1987), a stronger correlation of these features with hunter-gatherer-fisher societies.



Figure 3: Kasori shell midden, Chiba prefecture, Japan (photo by author).

Shell middens have often been assumed to be waste from food consumption since early investigations. However, archaeological and ethnographic research has described many other activities which can justify shell gathering, such as artefact production, or the collection of shellfish as bait or trade (Stein, 1992; Hardy, 2017). Also, shell middens frequently include evidence of acquisition and consumption of other types of aquatic food (fish and marine mammals), as well as terrestrial food (plant and animal), even if mollusc shell remains are generally overrepresented due to their higher degree of archaeological visibility and preservation (Bailey, 1978). Evidence of other types of activity associated with the accumulation of shell middens is also recurrent, such as habitation, food processing, storage, and funerary and ritual activities, in some cases being related to mollusc gathering while in others apparently not. These activities other than shell gathering could have consumed more time and effort, or represented a greater economic or social significance for the communities, despite resulting in lower quantities of conserved archaeological evidence (Waselkov, 1987, p. 145). Therefore, considering the variety of formation processes, possible functions and

meanings, shell middens cannot be immediately or exclusively seen as markers of reliance on aquatic food sources, even if some dietary analyses of skeletal remains from these sites can suggest so (e.g., Schulting and Richards, 2001; Schulting, 2015).

The diversity that characterises shell middens in several aspects, as well as the costs implied by the investigation of these ‘mines of information’, have led to a tendency for the development of studies at the local and regional scales, while analyses at continental or global scales have been rarer (Milner et al., 2007; Balbo et al., 2011; Álvarez et al., 2011).

1.2. Comparative approaches to common archaeological problems

1.2.1. Transcultural comparative approaches in archaeology

It has been recognised that archaeology is a comparative science by nature (Smith and Peregrine, 2011). Since its origins, archaeological research has been based on the exploitation of significant parallels between different case studies, regardless of the scale of the approach. Comparison is needed to understand the material record, notably to perform seriation; furthermore, archaeology aims to understand cultural variation and change in past human societies for which comparisons among examples from different spatial and temporal contexts are required (Peregrine, 2004; Drennan et al., 2011; Smith and Peregrine, 2011; Weber et al., 2013).

For various reasons (such as limitations on time, funding resources often restricted to small-scale projects or research traditions), many archaeologists have focused on detailed contextual descriptions of individual cases in territorially circumscribed areas, rather than comparative works involving transcultural approaches and longer distances in time and space (Kikuchi, 2010; Drennan et al., 2011). In particular, although wide-scale comparisons in archaeology have some presence among anthropologically-oriented approaches (e.g., North America), they are rare within historically-oriented approaches (e.g., continental Europe) (Trigger, 2007), since the latter tend to consider context as a crucial element and limit comparisons to contiguous chronologies and areas. The resurgence of cultural relativism and historical particularism in archaeology, associated with the influence of post-processualism in the last decades, also contributed to the depreciation of evolutionary perspectives on cultural variation and change, the rejection of regularities and even the decline of belief in objective approaches as valued by processual researchers (Bailey and Milner, 2002; Trigger, 2007; Estévez and Prieto, 2017). However, the recognition of general patterns in long-term cultural evolution through the main sequences of cultural change across the world has been a challenge to relativism and particularism in archaeology (Peregrine, 2004; Trigger, 2007; Jordan and Cummings, 2014).

In fact, generalisations continue to have deep impacts on the interpretations (Bailey and Milner, 2002). Moreover, researchers engaging in comparative archaeology today seem less interested in normative societal types or generalised similarities, and are more concentrated on cultural identity, variation and change lying beneath the material world (Drennan et al., 2011, p. 2). It has becoming a general assumption that strongly localised cultural adjustments, which archaeologically take the form of local contexts and sequences, are at the basis of long-term cultural changes (Jordan and Cummings, 2014). As such, it has been underlined that comparative approaches need to be generated between specific archaeological contexts and

focused on understanding the particular processes, variations and unique features behind cultural regularities (Feinman, 2011; Weber et al., 2013; Jordan and Cummings, 2014; Steinhaus and Knopf, 2018). Balanced views, involving the analysis of archaeological data at multiple scales, are thus considered necessary (Drennan et al., 2011).

Comparative approaches of case studies (objects, settings, practices or events) sharing some similar characteristics can increase the insights gained from the archaeological datasets themselves and contribute to criticising commonly used concepts or preconceptions (Jordan and Weber, 2016). These approaches are a robust way to develop analogical reasoning, which is known to be essential for the construction of inferences and the interpretation of the archaeological record (Smith and Peregrine, 2011; Knutsson, 2014; Lane, 2014; Steinhaus and Knopf, 2018). This is particularly relevant for prehistoric studies since the archaeological record is usually limited in information. Furthermore, considering that a wide range of methods can be applied, comparative research in archaeology also promotes transdisciplinary studies (Drennan et al., 2011). For example, comparative research has been done within past societies, but also with present living groups using the ethnographic record (Peregrine, 2004; Lane, 2014).

However, since archaeology is not innocent (Clarke, 1973; Trigger, 2007), it is important to recognise that comparative approaches are also influenced by their contexts of production. Although the appearance of more and diverse comparative studies can be expected with advances that come with globalisation, it is evident that historical connections between different countries are reflected in the construction of international networks in archaeological research, in which comparative studies are included. For example, the development of research between Europe and elsewhere cannot be disconnected from the history of European colonialism. Clearly, research between Europe and Latin America, Africa or Australia, where European languages dominate, has been relatively frequent; on the contrary, East Asia, notably Korea and Japan, which ‘escaped’ European political control, still often appear today as isolated and dissonant cases in Western international archaeological literature. This historical circumstance, adding to its physical and cultural distance, notably the linguistic barrier, and the formation of specific archaeological research traditions, can explain why these regions have been less studied by Western researchers and less present in international publications (Barnes, 2015a).

The present thesis starts from a non-post-processual assumption that transcultural comparative approaches are useful, especially in prehistoric archaeology, conducting an analysis of archaeological data and interpretations from Europe and Japan at multiple scales, with the aim to obtain a balanced view of general trends and particular contexts, theoretical construction and material evidence.

1.2.2. Comparative archaeological research between Europe and Japan

It is thought that archaeology as a scientific discipline was introduced in Japan by the end of the nineteenth century. At that time, several Western scientists arrived in Japan, under the modernisation and westernisation processes of the country established by the political regime of the Meiji period (1868–1912). Edward Morse (1838–1925), an American zoologist studying marine fauna, is considered to be the ‘father’ of modern archaeology in Japan

(Ikawa-Smith, 1982; Suzuki, 1989). He identified the shell midden of Ōmori, in Tokyo, and developed the first scientific archaeological excavation in Japan at this site in 1877. Interestingly, he soon compared the Ōmori shell midden to the shell deposits he had seen in New England and those reported in Denmark at the time (Morse, 1877; 1879). Morse contributed to the introduction of methods from natural sciences in archaeology, strongly diverging from the already existing antiquarian tradition in Japan (Ikawa-Smith, 1982). However, despite some subsequent important work undertaken by the Japanese students of Morse and other Western researchers, these new approaches took substantial time to be integrated into Japanese archaeology (Suzuki, 1989, p. 11).

Several historical factors contributed to the formation of a very particular and somewhat isolated archaeological research tradition in Japan. The strong permanence of a culture-historical orientation and the related importance of typological approaches, the high quantity of administrative rescue excavations and generated scientific data, and also the involvement with the non-specialised public have been highlighted as specific characteristics of Japanese archaeology (Ikawa-Smith, 1982; Habu, 2004; Habu and Okamura, 2017; Steinhaus and Knopf, 2018). In recent years, numerous advances have been made on the internationalisation of the activity, exemplified by the increasing number of publications in non-Japanese languages (including important syntheses with a wide circulation such as Imamura, 1996; Kobayashi and Nakamura, 2003; Habu, 2004; Barnes, 2015b), international research projects and meetings involving Japanese researchers and archaeological contexts (e.g., several projects directed by the Sainsbury Institute for the Study of Japanese Arts and Cultures and the Nara National Research Institute for Cultural Properties, EU funded projects such as Beyond Archaeology (BE-ARCHAEO), international field schools such as the Rebun International Field School), or initiatives directed to provide open-access archaeological data (e.g., the Comprehensive Database of Archaeological Site Reports in Japan by the Nara National Research Institute for Cultural Properties or the Database of Radiocarbon Dates Published in Japanese Archaeological Research Reports by the National Museum of Japanese History). The latter's actions have been particularly important for allowing direct access to primary data from Japanese archaeological sites, either from Japan or overseas. However, the largest part of archaeological information from Japan is still only available in Japanese, and frequently difficult to access. Moreover, the high amount of generated archaeological data, as well as the idea of the 'uniqueness' of the Japanese material, have led studies to focus on the Japanese islands and the neighbouring regions in East Asia (Steinhaus and Knopf, 2018). This is especially visible in Jomon archaeology, whose voluminous records are mainly published in Japanese and within Japan (Habu, 2004), as reports of archaeological works, articles in local, regional and national journals, monographies, exhibition catalogues or other books for wider audiences. In addition, many Japanese archaeologists have difficulties in communicating in English, which significantly constrains active exchanges of information with Western researchers.

Considering this, it can be argued that doing comparative archaeological research between Europe and Japan is, still today, a challenging task. The presence of Japanese archaeological contexts in international debates is still frequently restricted to the presentation of a few case studies within a symposium or a volume; an effective integration of a comparative analysis

of subjects in common is rare. Nevertheless, a growing number of works have been appearing on diverse themes and chronological periods from the Palaeolithic to modern times, evidencing the need for and interest in the construction of integrative approaches of archaeological phenomena and active scientific exchanges. For example, comparative approaches between European Mesolithic/Neolithic and the Jomon/Yayoi periods in Japan have been developed in various areas, including chronology (Imamura, 2010), settlement and subsistence of hunter-gatherers (Uchiyama, 2016), sedentism and storage (Dow and Reed, 2015), emergence of agriculture and domestication (Rowley-Conwy, 1984; Fujio, 2004), violence and warfare (Nakagawa et al., 2017) and ritual practices (Bailey et al., 2010; Matsumoto, 2011).

Despite being a shared phenomenon, shell middens formed by Holocene hunter-gatherers in Mesolithic Europe and Jomon Japan have not been approached in a comparative way. Some researchers have already underlined the importance of comparing the Jomon record with shell middens overseas (e.g., Suzuki, 1989, p. 27). Also, Jomon shell middens have been frequently highlighted in international publications and conferences where European sites are also discussed (e.g., Akazawa, 1986; Habu et al., 2011; Matsui, 2013). However, analyses and discussions about common aspects and problems concerning these sites have been lacking, a situation that this thesis intends to change.

1.3. Two regions in contrast: Atlantic Europe and Japan

The geographic scope of this work is Atlantic Europe and the Japanese archipelago, corresponding respectively to the Western and Eastern ends of Eurasia (Figure 4). Both regions are in the mid-latitudes of the northern hemisphere, mostly lying in the temperate zone and presenting seasonal variations.



Figure 4: Location of Atlantic Europe and the Japanese archipelago in Eurasia (image by author).

After 11700 cal BP and the end of Pleistocene, the post-glacial period in Atlantic Europe and Japan was characterised by deep environmental modifications caused by the worldwide transition to the Holocene, which included an overall increase in temperatures and rainfall, melting of glaciers, sea-level rise and marine transgression. In both regions, such changes resulted in the formation of new coastal zones (e.g., Japan became an archipelago), the expansion of temperate forests (Figure 5) and modifications to existing fauna (e.g., disappearance and reduction in population of many species of Pleistocene megafauna and

proliferation of large and middle-sized mammals, such as deer, wild boar and smaller mammals). An overall tendency for diversification of the available terrestrial and aquatic food sources has been shown. Holocene hunter-gatherer populations inhabiting these regions had to deal with these environmental changes. Important economic, social and cultural adjustments in this period are suggested by the archaeological record (Cummings, 2014; Dow and Reed, 2015), notably innovations in material culture, intensification of foraging and adaptation to seasonal variation of available food resources, changes in settlement systems, more frequent burial practices, increased sedentism and social complexification. At the same time, regional and diachronic cultural variation grew, demonstrating the existence of diversity in these adaptations (human agency) and an absence of simple trajectories in evolution.

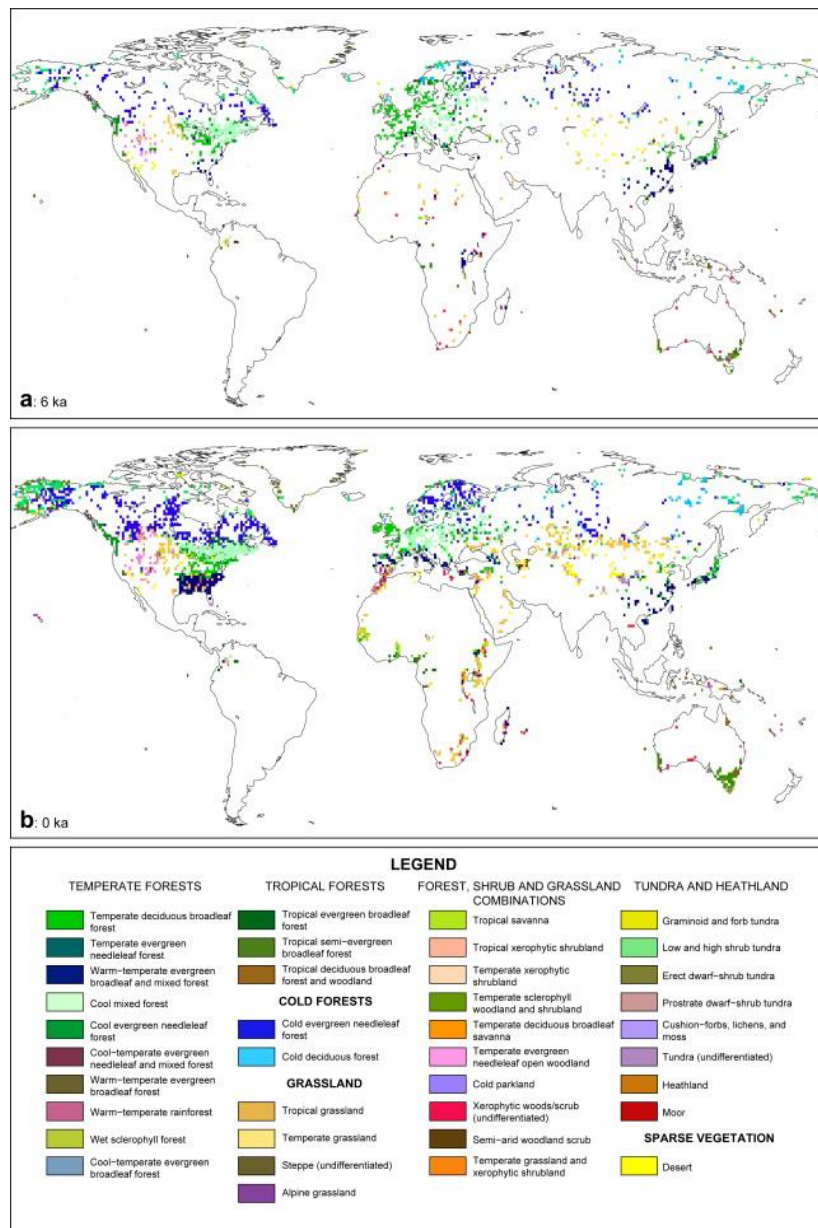


Figure 5: Map showing the biomes at the Middle Holocene and present day, in which the predominance of temperate forests in Atlantic Europe and Japan can be observed (reproduced from Wanner et al., 2008, fig. 10).

1.3.1. Geographic framework

1.3.1.1. Atlantic Europe

Atlantic Europe denotes the coastal fringe of the western portion of Europe. It is located in a marginal position with respect to the Eurasian mainland. The Atlantic Ocean has always been an important geographic constraint in the region, but also a structuring element, giving resource abundance and facilitating mobility to littoral communities (Cunliffe, 2017).

The extension and limits of Atlantic Europe are up for discussion. The most inclusive perspectives comprise the area from the Straits of Gibraltar to the North Cape (e.g., Scarre, 2002; Marchand, 2014), but archaeological publications usually use a smaller extension (e.g., Bradley, 1997; Arias, 1999; Gutiérrez-Zugasti et al., 2011). Considering the main distribution of Mesolithic shell middens and the focus of this study on the north temperate zone, Atlantic Europe is defined here as the Atlantic façade between southern Portugal and southern Scandinavia, covering a territory approximately between 36° and 59° N of latitude (Figure 6). The main regions encompassed are Portugal, northern Spain, north-western France, the British Isles and southern Scandinavia (Denmark, southern Sweden and the Oslo fjord in Norway, corresponding to the region broadly occupied by the Ertebølle culture).



Figure 6: Map of Atlantic Europe with indication of the regions concerned in this work (image by author).

Therefore, Atlantic Europe aggregates a mosaic of landscapes with different characteristics of topography, climate and environment. The Pyrenees and the English Channel can be considered two important elements of internal division in this area (Marchand, 2014, p. 30). On the contrary, the Atlantic Ocean represents a common element and has a huge influence on the climatic conditions of the region, notably through the Gulf Stream. The region is thus characterised by the predominance of a temperate oceanic climate,

with mild temperatures and abundant rainfall in the areas closer to the ocean, while drier conditions occur on inland and southern areas.

The long and varied coastline of Atlantic Europe, with islands of all sizes, is formed by granitic promontories and narrow inlets interrupted by areas of low basins and shallow estuaries (Scarre, 2002). Compared to the Mediterranean, the Atlantic coastline is characterised by a much higher productivity of the waters and tidal amplitude (Figure 7), with a greater frequency of shallow estuaries and embayments providing a high variety of wildlife and easily accessible resources (shellfish and fish). This availability, particularly increased since the start of the Holocene, has been correlated with a greater importance of aquatic food sources and the development of shell middens in Atlantic Europe during the Mesolithic (Arias, 1999; Bailey and Milner, 2008; Schulting, 2015; Lewis et al., 2020). The presence of other littoral sites (non-shell midden sites) has also been increasingly detected in the archaeological record of the region, attesting to diversity in the exploitation of the marine environments in this period (e.g., Marchand, 2014; 2020; 2021).

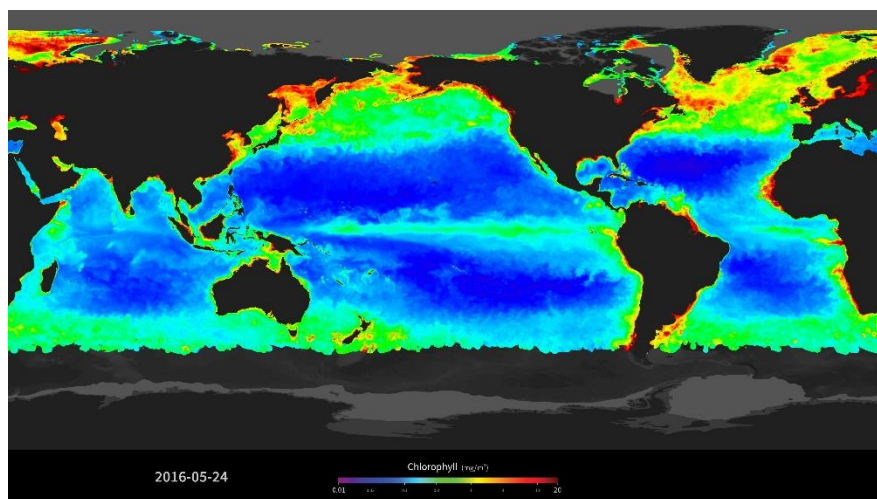


Figure 7: World map of ocean bioproductivity based on sea surface chlorophyll concentration collected with the MODIS sensor (NASA's Goddard Space Flight Center, available on: <https://svs.gsfc.nasa.gov/30786>). The concentration of chlorophyll pigments is often considered as an index of biological productivity. Atlantic Europe and the Japanese archipelago are located in the most productive areas in the map.

However, food sources did not increase exclusively in aquatic environments during the post-glacial in Atlantic Europe. While temperature and humidity levels raised, temperate forests extended across the region, with dense broad-leaf deciduous trees becoming predominant over vast territories. Forests of pine, hazel, oak and elm progressively expanded, replacing tundra landscapes and increasing available food sources (e.g., Clarke, 1976). Nut-bearing trees gained a more heterogenous distribution. Substantial changes also occurred in terrestrial fauna – the large herbivores of the late glacial moved to the far north or became extinct, while forest-adapted animals such as roe deer, red deer, wild boar and smaller animals proliferated (Crombé and Robinson, 2014). This increased diversity and abundance of the overall available food sources is thought to have been a crucial condition for the economic and social developments of the Mesolithic groups in Atlantic Europe.

1.3.1.2. The Japanese archipelago

The Japanese archipelago is located at the easternmost part of Eurasia. It is about 3000 km long, extending from the southernmost point at the Okinawa Islands at 24°–25°N to the northernmost tip of Hokkaido at 45°N. Due to this north–south span, the climate ranges from subtropical in Okinawa to subarctic in northern Hokkaido, although most of the territory falls in the temperate zone. The four main islands are Hokkaido, Honshu, Shikoku and Kyushu, which are located together (Figure 8). Despite the insular character of the archipelago, promoting a certain degree of isolationism, two main historic entry ports of continental influences can be recognized – in northern Hokkaido and northern Kyushu. The latter has a particular importance for enabling contact with the Korean Peninsula and China (Imamura, 1996). The Korea Strait, which separates southern Korea from northern Kyushu, is only about 200 km wide, being interrupted by Tsushima Island.



Figure 8: Map of Japan with indication of the main islands and regions (image by author).

The Japanese archipelago is also characterised by mountainous lands, with coastal plains segmented by mountain ranges in a complex topography (Takahashi et al., 1998). Dense forests are still frequent today, due to the large amount of precipitation, particularly in the summer, which allow the rapid growth of vegetation. In fact, Japan is considered the region with the largest productivity of plant biomass in the temperate zone (Imamura, 1996, p. 3). An important internal division exists today between south-western Japan, where broad-leaf evergreen forests dominate, and north-eastern Japan, populated by deciduous broad-leaf tree forests. The north-eastern Hokkaido zone is dominated by coniferous forests. Aquatic food resources are also abundant in Japan, either from marine or freshwater environments. The warm and cold ocean currents flowing around the Japanese archipelago provide complex and diverse maritime environments, which are among the most productive in the world and represent particularly rich fishing grounds (Imamura, 1996; Toizumi, 2014) (Figure 7).

However, important differences are observable between the Pacific coast and the Sea of Japan coast, the latter being characterised by a lower number of embayments, deeper waters and lower tides (Toizumi, 2014).

The current characteristics of the Japanese archipelago largely reflect the impacts of the climatic and environmental changes that occurred in the final part of the Pleistocene and the first phases of the Holocene. During that period, the sea level rose rapidly, a phenomenon often called the 'Jomon transgression' (e.g., Takahashi et al., 1998). As a result, the Tsushima current, a warm current, began to flow into the Sea of Japan, and Japan was separated from mainland Asia, becoming an archipelago subject to the influence of both warm and cold currents (Aikens and Akazawa, 1996). The coastal zone expanded, being cut by numerous bays and inlets, and important shallow water zones were created. In many areas, extensive tidelands were formed with the subsequent deposition of alluvial soils. It is thought that these changes, together with a general warming trend, resulted in an overall increase in biological productivity in the coastal zones (Aikens and Akazawa, 1996; Takahashi et al., 1998), where a high diversity of marine fauna (fish, shellfish and marine mammals) became present.

The rising of average temperatures and rainfall also caused the retreat of conifer forests from low-lands and the expansion of temperate deciduous forests across the Japanese archipelago. With the Hypsithermal period (between 9 ka BP and 5 ka BP), further expansion of deciduous forests in eastern and northern Japan occurred, while evergreen forests developed in western Japan. These changes generated a greater availability of edible plant foods, such as acorns, chestnuts, walnuts and horse chestnuts, whose remains have been documented in the Jomon archaeological record (Sakaguchi, 2009). Important changes also occurred in terrestrial fauna, with the extinction or reduction in population of large terrestrial mammals typical of the Late Pleistocene (such as Naumann's elephant, elk or bison) and the proliferation of middle-sized mammals such as deer and wild boar (Takahashi et al., 1998; Habu, 2004).

Following Japanese conventions, in this work, the term 'eastern Japan' refers to the north-eastern half of the Japanese archipelago (Hokkaido, Tohoku, Kanto, and Chubu regions), and 'western Japan' corresponds to the south-western part (Kinki, Chugoku, Shikoku and Kyushu regions) (Habu, 2004; Matsumoto et al., 2017). It should be noted, however, that this division can be flexible for some regions located between the two zones, such as the Tokai and Hokuriku regions.

1.3.2. Climatic and chronological framework: Middle and early Late Holocene

As mentioned before, the main chronological framework of this work is the period from the end of the 9th millennium cal BP to the end of the 4th millennium cal BP. Culturally, it is centred on the Late Mesolithic in Atlantic Europe (from the end of 9th millennium to the 7th /6th millennium cal BP) and the Jomon period in Japan, more precisely, the time span between the end of the Initial Jomon and the end of the Late Jomon subperiods (from the end of 9th millennium to the end of 4th millennium cal BP). This time range covers the phase of maximum development of shell middens (in quantity and dimension) from about 8–7 ka BP onwards across the world (Bailey and Flemming, 2008), which is also recorded in Atlantic Europe and the Japanese archipelago.

Regarding climatic periods, and following the definitions from Walker and collaborators (2012), this work is focused on the Middle Holocene (roughly between 8200–4200 cal BP) and the first centuries of the Late Holocene (from about 4200 cal BP). It is mostly coincident with the Holocene Climatic Optimum or Thermal Maximum (Hypsithermal), the period of the warmest and wettest conditions of the Holocene that occurred between 9 ka BP and 5 ka BP (Renssen et al., 2012) (Figure 9). However, it should be noted that the subdivisions of the Holocene and its boundaries do not have consensus, since climatic stratigraphic sequences are not global (Wanner et al., 2008; 2015). Furthermore, the timing of the Holocene Climatic Optimum seems to vary substantially across the regions of the world (Renssen et al., 2012). These chronological variations according to particular zones resulted in inevitable disparities in the use of climatic concepts in the archaeological literature.

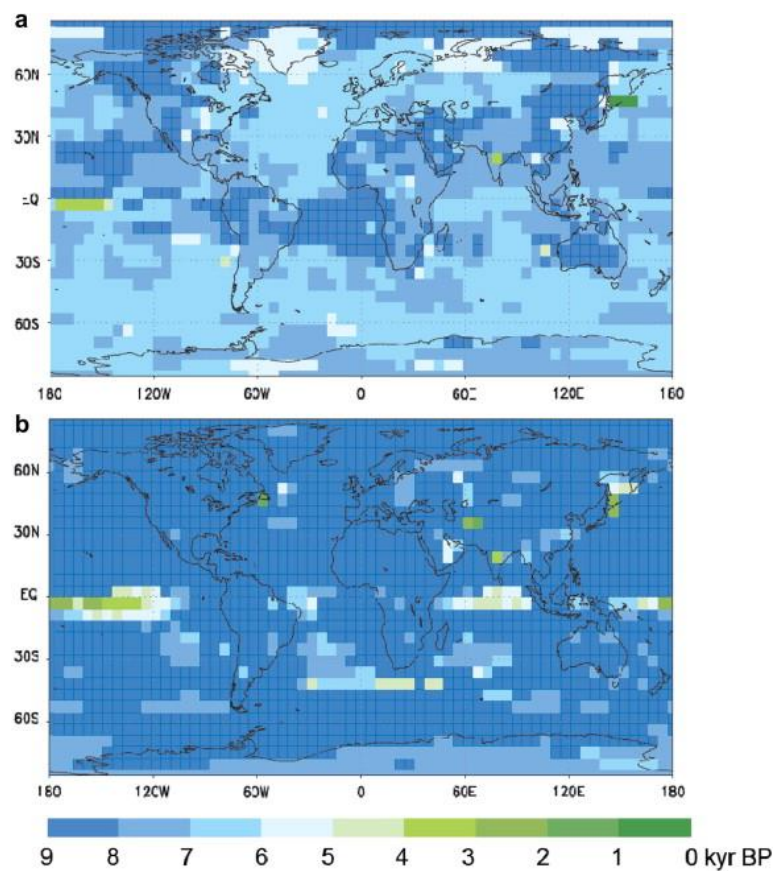


Figure 9: Holocene timing (in ka BP) of the maximum positive temperature anomalies, showing that, almost everywhere, the timing of the warmest conditions falls between 9 ka BP and 5 ka BP (reproduced from Renssen et al., 2012, fig. 4).

During the Middle Holocene, temperatures progressively increased to almost present levels, and a relative stability of the climate was achieved. Despite that, important global oscillations occurred and had considerable impacts on the human communities, as evidenced by some changes in the archaeological record. The so-called 8.2 ka BP event (8200 cal BP) was one of these global oscillations. A proposal by Walker et al. (2012) established this short and abrupt cooling climatic episode as the frontier between the Early and the Middle Holocene, considering that it was detected in proxy climate records in many parts of the

world and apparently had important cultural effects in the northern hemisphere (Walker et al., 2012, p. 652). Atlantic Europe and Japan also seem to have been affected by this event (e.g., Griffiths and Robinson, 2018). For example, in central/southern Portugal, coastal settlement modifications, notably the emergence of large Late Mesolithic shell middens in inner estuaries, have been associated with a drop in the intensity of upwelling and a decrease in coastal resources, as well as rapid sea-level rise caused by the 8.2 ka BP event (Bicho et al., 2010). Although the evidence is still rare, effects of the 8.2 ka BP event in Japan have also been noted. A temporary sea regression was documented during this period, which was apparently followed by a rapid advance of the marine transgression until around 7000 cal BP (Hitoki, 2012). Effects of the 8.2 ka BP event in the southern part of the Korean Peninsula were also noted, with pollen records indicating a rapid drop in arboreal pollen frequency, probably as a result of an abrupt dry and/or cold event that disturbed the vegetation in the area (Park et al., 2018).

Another important climate shift around 4.2 ka BP is also reflected in proxy records worldwide and defined by Walker et al. (2012) as the boundary between the Middle and Late Holocene. According to these authors, cooler and wetter conditions were recorded in some areas of north-western Europe, while in China, a shift to colder and more arid conditions would have occurred. In Japan, it is thought that the sudden decline of the large Jomon settlement site of Sannai Maruyama, Aomori Prefecture, around 4.2–4.1 cal BP, was related to this general climatic cooling and aridification trend, which was recorded in a marine sediment core collected near the site (Kawahata et al., 2009).

Overall, although the warmer and more stable climatic conditions of the Holocene, especially in the Middle Holocene and the first centuries of the Late Holocene, generally provided good environments for post-glacial hunter-gatherers in Eurasia, high-resolution studies have been revealing more details about the occurrence of small fluctuations in temperature/rainfall and probable impacts of these events on human communities.

1.3.3. Cultural framework

The cultural scope of this study is the human societies whose subsistence was primarily based on hunting, gathering and fishing activities and lived in Atlantic Europe and Japan, during the Middle Holocene and the early Late Holocene, in the Mesolithic and Jomon periods respectively.

1.3.3.1. The Mesolithic of Atlantic Europe

With respect to Atlantic Europe, this work approaches the Mesolithic period, more specifically the Late Mesolithic period. In general terms, the Mesolithic has been characterised in Europe by the development of human groups whose subsistence was based on hunting, gathering and fishing activities and had to adapt to changing and diversifying post-glacial environments.

The Mesolithic succeeded the Palaeolithic and preceded the Neolithic period. The beginning of the Mesolithic was marked by the Pleistocene–Holocene transition, around 11700 cal BP (Walker et al., 2012), while the end of the Mesolithic occurred at different times across regions (Price, 1987) and was characterised by the shift from hunting-gathering to

agro-pastoralism (the Neolithic transition). The latest zone to shift to the Neolithic was southern Scandinavia, with the transition recorded at around 6000 cal BP (Karlén and Larsson, 2007). Atlantic Europe has been seen as a ‘tension zone’, considering the delay of the Neolithic transition in relation to other parts of Europe and the formation of Neolithic ‘enclaves’ during this process. This continuity of Mesolithic cultures for a relatively long time has often been explained by the presence of successful, well-adapted hunter-gatherer communities in the region (Price, 1987; Arias, 1999; Thorpe, 2015; Diniz et al., 2021).

The overall amelioration of the climate and consequent increased productivity and diversity of the landscapes were in the background of the Mesolithic in Atlantic Europe (Spikins, 2008; Crombé and Robinson, 2014; Marchand, 2014; Thorpe, 2015). Numerous sociocultural changes have been suggested by the archaeological record of this period. The impacts of the Holocene sea-level rise on the coasts are well documented, notably the creation of new aquatic environments through the flooding and submergence of several areas (e.g., Queiroz and Mateus, 2004). The development of settlement systems with a strong littoral or riverine orientation is one of the archaeologically most visible changes, although inland sites also developed at that time. Numerous shell middens were formed in several regions, some of which reached large dimensions and suggest a higher level of residential stability, particularly in the Late Mesolithic (Price, 1987; Araújo, 2003; Marchand, 2014; 2015; Thorpe, 2015). Several elements indicate the growth of broad spectrum subsistence systems, with an important (although variable) contribution of aquatic food sources on the diets of hunter-gatherer societies (e.g., Umbelino et al., 2007; Marchand, 2015; Schulting, 2015; Peyroteo Stjerna, 2016). The regression of steppe and taiga, in parallel with the expansion and densification of temperate forests, also allowed a greater availability of plant food sources, which were incorporated into diets in larger quantities, although their archaeological remains are usually badly preserved (Crombé and Robinson, 2014; Bishop et al., 2023). Changes in the number of mammalian fauna also occurred, with the disappearance or migration further north of large Pleistocene mammals, the expansion of deer, wild boar, roe and aurochs in large-middle sized fauna, and the proliferation of lagomorphs in some regions (e.g., Rowley-Conwy, 2015). Dogs were the only domesticated animal in this period and strongly associated with the expansion of bow and arrow hunting in new environmental contexts. Concerning material culture, Mesolithic artefacts are predominantly characterised by lithic remains, notably flaked stone tools. Several changes in stone technology have been reported (e.g., the intensification of microlithisation, widespread distribution of arrowheads and development of macrolithic industries in some regions). Furthermore, a growth in the importance of bone, antler, wood and other plant technologies is known. Associated with that, the spread of composite tools has been seen as one of the most relevant changes in this period (Rozoy, 1989; Ghesquière and Marchand, 2010; Marchand, 2014).

Chronologically, the Mesolithic has generally been divided into two phases with substantial environmental and cultural differences: the Early Mesolithic (Preboreal and Boreal periods) and Late Mesolithic (Atlantic period). The Late Mesolithic has been delimited as the time span between 8300/8200 cal BP–6000 cal BP. The 8.2 ka cold event, which was recorded in proxy records from the North Atlantic ocean (Walker et al., 2012), has been correlated with changes in human settlement and culture in Atlantic Europe that occurred

around that time (López de Pablo and Gómez Puche, 2009; Bicho et al., 2010; Wicks and Mithen, 2014; Griffiths and Robinson, 2018). This event is also considered a chronological marker for the beginning of the Late Mesolithic in several regions (Carvalho, 2009; Bailey, 2013; Araújo, 2015; Marchand, 2015), although its cultural impacts are still under discussion (Marchand and Perrin, 2017).

The Late Mesolithic corresponded to the peak of post-glacial temperature and humidity (Hypsithermal) and the expansion of closed and mixed deciduous forests, dominated by lime, oak and elm (Price, 1987; Crombé and Robinson, 2014). The growth of the productivity and diversity of landscapes at that time were the background to several economic and socio-cultural changes. The post-glacial marine transgression continued in this period, but it deaccelerated, allowing the consolidation of coastlines and estuaries (e.g., Costa et al., 2019). The number of known coastal sites increased considerably, and some large sites, with continuous occupations, were developed. Smaller sites with temporary occupations are also known, expressing variability in settlement systems (Marchand, 2014). A number of technological developments are reported, such as the expansion of blade and trapeze industries or the use of indirect percussion in south-western regions, resulting in a greater standardisation of lithic tool production (Marchand and Perrin, 2017). Advances in fishing technologies are also known, notably through the evidence provided by several sites in Scandinavia (e.g., Pickard and Bonsall, 2007). Some cases of pottery use in hunter-gatherer contexts have also been recorded (Courel et al., 2020), although it does not represent the dominant element of artefactual assemblages of Late Mesolithic contexts of Atlantic Europe (contrary to many Jomon assemblages). Other changes include subsistence diversification and cultural regionalisation, and the complexification of funerary and ritual behaviour (Price, 1987; Arias, 1999; Ghesquière and Marchand, 2010; Crombé and Robinson, 2014; Thorpe, 2015). An overall increase in sedentism, population densities, as well as social complexity has been stressed (Price, 1987; Rowley-Conwy, 2004; Kozłowski, 2009; Ghesquière and Marchand, 2010).

However, regional diversity of the archaeological evidence in Atlantic Europe suggests the existence of different and multiple situations in terms of economic and social development in the Late Mesolithic. This heterogeneity can be seen in identified features at archaeological sites. For example, numerous burials have been recorded across several sites (e.g., southern Scandinavia, Portugal, north-west France), in some cases allowing us to talk about cemeteries (e.g., Schulting, 1996; Peyroteo Stjerna, 2016) (Figure 10). However, the identification of dwelling structures has been more restricted outside the Scandinavian region, with evidence being hard to define in many cases (e.g., Roche, 1989; Marchand et al., 2018). While Ertebølle societies, the latest Mesolithic communities of southern Scandinavia, appear to correspond to what is generally considered ‘complex hunter-gatherers’ and the culmination of the development of ‘Mesolithic lifestyles’ (Andersen and Johansen, 1986; Bailey and Milner, 2002; Kozłowski, 2009; Ritchie, 2010; Cummings, 2014; Warren, 2014), archaeological traces from other regions in Atlantic Europe seem much less prominent and very diverse.

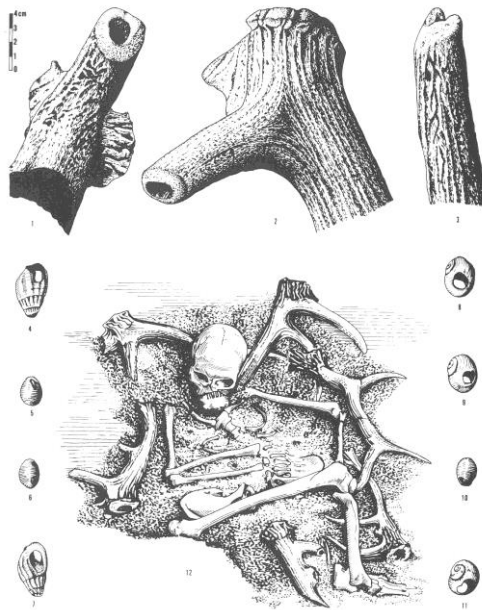


Figure 10: Grave K (from Péquart, 1954), antler tools and shell beads from Hoëdic, Morbihan, France (reproduced from Rozoy, 1978, fig. 221).

1.3.3.2. The Jomon period of Japan

Concerning the Japanese archipelago, this work is focused on the Jomon period. The Jomon is the prehistoric culture (or group of cultures) and period which developed in the Japanese archipelago since the end of the Pleistocene, for more than 10000 years. Chronologically, it followed the Palaeolithic period and preceded the Yayoi period, when full-scale agriculture, notably wet-rice field farming, was introduced. However, the exact starting and ending points of the Jomon period are still controversial. The beginning of the Jomon period has been related to the appearance of pottery in Japan, in the final part of the Pleistocene, at ca. 16000 cal BP, while the transition from the Jomon to the Yayoi period has been placed around 2800–2300 cal BP (Matsumoto et al., 2017).

The Jomon period is generally characterised by the development of groups with pottery use and manufacture, whose subsistence was mainly based on hunting, gathering and fishing (for comprehensive reviews in English, see Akazawa, 1986; Imamura, 1996; Takahashi et al., 1998; Kobayashi and Nakamura, 2003; Habu, 2004; Bleed and Matsui, 2010; Habu, 2014b; Barnes, 2015c; Matsumoto et al., 2017). Apart from pottery, the material culture of Jomon sites often includes flaked, ground and polished stone tools, bone/antler tools for fishing and other activities, basketry and ritual artefacts such as ceramic figurines, stone rods and many other objects, although site contents have a huge variation (Figure 11). Documented features are varied and include dwellings, large-scale buildings, storage pits and funerary structures, among things. Overall, the rich Jomon record provides much evidence of residential stability, diversity of ritual practices and social complexity, although these elements vary according to the subperiods, regions and site types (Habu, 2004; Matsumoto et al., 2017).



Figure 11: Examples of artefacts found at Jomon sites. Left: deep bowl from Naraharamachi, Hachioji city, Tokyo. Top right: clay figurine from Hosakamachi, Nirasaki city, Yamanashi prefecture. Bottom right: fishhooks from Numazuka shell midden, Ishinomaki city, Miyagi prefecture (images adapted from the Tokyo National Museum <https://webarchives.tnm.jp>).

The Jomon has been divided into six sub-periods (approximate boundaries according to Matsumoto et al., 2017): Incipient Jomon (16000–11000 cal BP), Initial Jomon (11000–7000 cal BP), Early Jomon (7000–5300 cal BP), Middle Jomon (5300–4400 cal BP), Late Jomon (4400–3300 cal BP) and Final Jomon (3300–2800/2300 cal BP)¹ (Table 1). Each subperiod has been further divided, usually into three phases (early, middle and late phases). However, the chronological placement of the Jomon data has significant variations according to the concerned regions. Furthermore, the use of relative chronology based on fine-grained pottery typologies has a deep tradition in Japanese archaeology, being still an indispensable tool for the chronological placement of Jomon data, despite the progressive adoption of radiocarbon dating (Habu, 2004).

Table 1: Main chronological divisions of the Jomon period (approximate boundaries according to Matsumoto et al., 2017).

Sub-period	Approximate boundary
Incipient Jomon	16000–11000 cal BP
Initial Jomon	11000–7000 cal BP
Early Jomon	7000–5300 cal BP
Middle Jomon	5300–4400 cal BP
Late Jomon	4400–3300 cal BP
Final Jomon	3300–2800/2300 cal BP

¹ The variations in the end of the Final Jomon sub-period are related to the existence of different perspectives among researchers regarding the start date of the Yayoi period, notably the validity of the chronological framework brought by the most recent AMS dates from the Kyushu region that pushed back the beginning of the Yayoi period to ca. 2.9–2.8 ka cal BP (Fujio et al., 2005), and also to important geographic differences concerning the beginning of agriculture in the Japanese archipelago, with a general gradient from west to east, although it was not linear (e.g., Fujio, 2004; 2021).

As for the Mesolithic, the exploitation of a wide range of environments on the coasts and forests is well attested for the Jomon period. Several lines of evidence indicate the expansion of target resources and the development of a greater reliance on the collection of plant and marine food in this period. The creation of shallow water zones and coastlines and the increase in the biomass of aquatic fauna provided important sources for the exploitation of aquatic food, which is reflected on the formation of abundant shell middens and the development of diversified fishing equipment (Matsui, 1999; Habu et al., 2011; Toizumi, 2014). Hunting was also developed and adapted to forested environments. Deer and wild boar became the main game animals and the use of the bow and arrow expanded, with numerous arrowheads being documented in the archaeological record (Takahashi et al., 1998). The presence of dogs, confirmed through the discovery of bone remains and burials from this period, also indicates their use as a forest hunting technology (Perri, 2016), as observed for Mesolithic contexts in Europe.

The increased reliance on plant food resources, allowed by the expansion of temperate forests and the growth of edible nuts and tubers, is particularly well attested in the Jomon record. Numerous nut storage pits have been found at Jomon sites (Sakaguchi, 2009), as well as plant procurement and processing tools, such as grinding stones (Habu, 2014a). Evidence of management and selection of trees is also known. However, the extent of plant manipulation in the Jomon period has been widely discussed (Crawford, 2008; Bleed and Matsui, 2010; Noshiro and Sasaki, 2014; Kudo and Kokuritsu Rekishi Minzoku Hakubutsukan, 2015; 2017; Fujio, 2021 for recent developments). The authors have generally agreed that the Jomon groups practiced some plant cultivation of indigenous species, notably soybeans (*Glycine soja*) and azuki beans (*Vigna angularis*), but not grains. Some domesticated grains were introduced from the continent, though these would not have acquired a primary role in human diets (Akazawa, 1986; Imamura, 1996; Barnes, 2015c). Therefore, it has been considered that the major breakdown occurred only with the adoption of rice and millet agriculture in the Yayoi period.

Pit-dwellings, indicating labour investment and a prolonged stay at a particular location, are known in Japan since the Incipient Jomon, but it is from the Early Jomon period that large settlements with a higher number of pit-dwellings become relatively common in the archaeological record (Matsumoto et al., 2017). However, while these features are part of the image of the Jomon period in general, their presence in western Japan is relatively rare. In this region, large settlements with pit-dwellings only became more frequent in the Late Jomon period (Seguchi, 2009).

Therefore, while high amounts of archaeological data have been produced in the recent decades, a marked temporal and spatial variability of the Jomon record has becoming more evident. Jomon societies are usually considered sedentary and an archaeological example of complex hunter-gatherers (e.g., Habu, 2004), but their characterisation is far from being so linear. Firstly, Jomon groups developed over regions with varying ecological and social environments, over a long time span. Secondly, research has been clarifying the differences between Jomon groups in western and eastern Japan concerning site density and size, and also social complexity (Akazawa, 1986; Imamura, 1996; Sakaguchi, 2009; Seguchi, 2009;

Matsumoto et al., 2017). Despite recent substantial discoveries in western Japan, such as the wetland shell midden complex of Higashimyo, Saga prefecture (Nishida et al., 2016b), researchers have agreed that higher population densities and a greater residential stability and economic intensification occurred in eastern Japan (Matsumoto et al., 2017). Among other facts, the higher number and dimensions of durable residential structures and village sites has been underlined (Sakaguchi, 2009). As a result, Jomon research has been traditionally focused on eastern Japan, where more abundant data are available. It should be also noted that the stronger economic development of eastern Japan has led to the development of large-scale excavations in the region since the post-war period, which have been less frequent in western Japan (Koizumi, 2016).

This work is centred on the time range between the final part of the Initial Jomon and the end of the Late Jomon, corresponding to the period when shell middens were formed in a larger quantity and size across the Japanese archipelago. Although the available information from western Japan is less abundant and impressive in various aspects in comparison with eastern Japan, this work approaches western Japan as a relevant case study, with the aim to understand the diversity of trajectories traced by Jomon hunter-gatherer societies in their relationship with aquatic environments and their resources.

Chapter 2 Shell middens in contrast: Atlantic Europe and Japan

2.1. Introduction

Shell middens from both sides of Eurasia – Atlantic Europe and Japan – became the subject of archaeological research (carried out with scientific methods) since the nineteenth century. The shells at these sites, which are relatively easy to identify on the terrain when the accumulations are dense, attracted the curiosity of many individuals. Scientific communities at that time were deeply interested in human origins and prehistoric man, as a result of the debates generated between evolutionists and creationists following the publication of *On the Origin of Species* (1859), by Charles Darwin (Morse, 1879; Trigger, 2007). This context can explain the quick development of shell midden research in this period (Claassen, 1998; Komiya, 2015). By the end of the nineteenth century, the existence of prehistoric shell middens in Europe and Japan was already known and the sites started to be compared by several researchers. For example, in the notable work dedicated to the prehistory of the Iberian Peninsula, *Les Âges Préhistoriques de l'Espagne et du Portugal* (1886), Cartailhac spoke of the importance of the discovery of the ‘Køkkenmøddinger’ in Denmark and stressed the existence of similar sites in other parts of Europe (Portugal, England, Belgium and France), and also elsewhere, in Northern and Latin America, as well as in Japan (Cartailhac, 1886, pp. 48–58).

2.2. Late Mesolithic shell middens in Atlantic Europe

2.2.1. History and aims of shell midden research

The archaeological research of shell middens has a long tradition in Atlantic Europe. It goes back to 1828–1837 in Denmark, when the discovery of a shell midden was referred to for the first time in the literature – Krabbesholm, in Jutland – and artefacts from that site started to be studied (Gutiérrez-Zugasti et al., 2011; Peterson, 2015). The successive identification of several mounds of oyster and cockle shells on the coast of Denmark (the so-called *Køkkenmøddinger*, which means kitchen middens in English) gave rise to the discussion about the nature (natural or human origin) and age of these sites (Morlot, 1861; Andersen, 2000; Trigger, 2007). In 1848, a multidisciplinary commission (‘The First Kitchen Midden Commission’), headed by the archaeologist J. Worsaae, the biologist J. Steenstrup and the geologist J. G. Forchhammer, was created to solve these questions (Morlot, 1861; Steenstrup, 1875). Their research, which included the excavation of several middens, demonstrated the anthropogenic nature of these deposits by verifying the presence of artefacts, charcoal and animal bones left by human groups (Figure 12). These sites also played a vital role in the discussions about environmental changes in the past and the existence of an older phase of the Stone Age before the appearance of megalithic monuments (Worsaae, 1875; Andersen and Johansen, 1986). Charles Lyell, on his work *The Geological Evidences of the Antiquity of Man* (Lyell, 1863), emphasized the discovery of shell middens in Denmark as evidence of the antiquity of humanity before agriculture. This was also the starting point of the development of an inter-disciplinary archaeological research tradition in Denmark, which had a deep influence on the rest of Europe. By the final part of the nineteenth century (1893–

1897), a second multidisciplinary commission was created ('The Second Kitchen Midden Commission') and excavated the famous site of Ertebølle, which later gave its name to the 'Ertebølle culture' and became a synonym of the Late Mesolithic in Scandinavia (Andersen and Johansen, 1986).

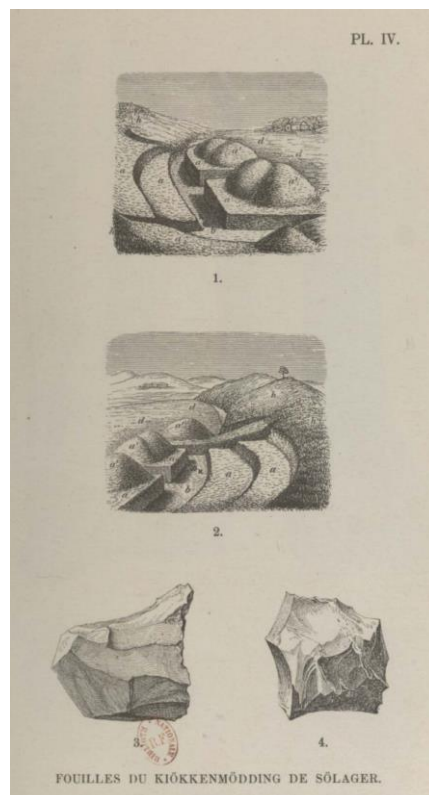


Figure 12: Excavations at Sølager, Denmark, under the direction of Steenstrup, in 1869 (reproduced from Anonymous, 1875, pt. PL.IV).

The Danish 'Kitchen Midden' research quickly spread to other parts of Europe, allowing the successive recognition of numerous shell middens as products of human activity and the organisation of several surveys and excavations. During the second half of the nineteenth century, shell middens were also identified in the British Isles, notably in Scotland (e.g., Grieve, 1872), Ireland (e.g., Atkinson, 1873), France (Du Châtellier, 1881) and Portugal (Costa, 1865; Ribeiro, 1884) (Figure 13). At that time, the main concerns were to answer questions about human origins and adaptations, site formation and palaeoenvironmental changes. In Portugal, the excavations performed in 1864 at the shell midden of Cabeço da Arruda, Muge, under the direction of Carlos Ribeiro, were the first in the country that used scientific methods. In addition, these works resulted in the publication of the book *Da existência do homem em epochas remotas no valle do Tejo. Primeiro opusculo. Notícia sobre os esqueletos humanos descobertos no Cabeço da Arruda* (Costa, 1865), which was the first monograph about a Portuguese prehistoric site (Cardoso, 2018, pp. 22–23). These facts exemplify the contribution of shell midden research to the development of archaeology as a discipline at an international scale. Strong links between different scientific communities were created at that time, debating the similarities and differences between the Danish *Køkkenmøddinger* and the other shell middens in Europe, as well as the antiquity of the Stone Age. For example,

the organisation of the ninth session of the *Congrès International d'Anthropologie et d'Archéologie Préhistoriques* (1880) took place in Lisbon, in which the Muge shell midden complex became a central issue of discussion (Ribeiro, 1884).

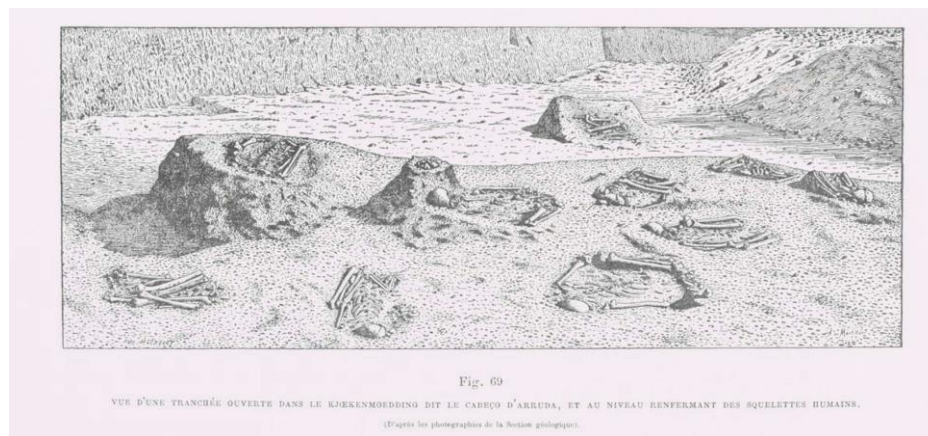


Figure 13: Excavations at the shell midden of Cabeço de Arruda, Muge, Portugal, as highlighted by Cartailhac in *Les Âges Préhistoriques de l'Espagne et du Portugal* (1886) (reproduced from Cartailhac, 1886, fig. 69).

However, the interdisciplinary research tradition that developed in Atlantic Europe (involving naturalists, geologists, and other scientists interested in archaeological themes) suffered a general breakdown at the beginning of the twentieth century. Culture-historical perspectives – characterised by the construction of regional chronological sequences, the definition of cultural areas and the establishment of the origins of cultural groups – became predominant in shell midden studies (Gutiérrez-Zugasti et al., 2011; Marchand, 2015), as exemplified by the relevance given to typology-oriented artefactual analyses in this period. In western Scotland, the ‘Obanian Culture’ was defined in this period on the basis of the presence of shell middens and some types of artefacts found in small caves and rock shelters in Oban Bay and open-air sites in Oronsay (Bonsall, 1996). Similarly, in 1920–1930, in northern Spain, Vega del Sella documented and defined the ‘Asturian culture’ in the Cantabrian region, based on the association between some lithic industries and shell middens (Fano, 2019). Furthermore, as the excavations of shell middens increased across Atlantic Europe, the frequent association between these sites and burials became progressively evident. During the first half of the twentieth century, the focus of research was put on the excavation of human remains in several regions. In France, the well-known sites of Tévéc and Höedic were discovered in this period (Péquart et al., 1937; Péquart and Péquart, 1954) (Figure 14). In Portugal, anthropological studies and excavations in the Tagus valley progressed (Corrêa, 1919; Roche, 1963), while the shell midden cluster of the Sado valley was identified and studied (Barradas, 1936; Heleno, 1956). The discovery of numerous skeletons at these sites gave rise to concerns about racial origins in the shell midden literature. In Portugal, António Mendes Corrêa developed a hypothesis about the formation of the Muge shell middens by African groups, based on the anthropological definition of the famous *Homo afer taganus* (Corrêa, 1919; Cardoso, 2011).



Figure 14: Grave J from the excavations of 1931-1934 at Höedic, Morbihan, France (reproduced from Péquart and Péquart, 1954, fig. 31).

It was only in the second half of the twentieth century, notably in the 1970s and 1980s, that interdisciplinary investigations on Mesolithic shell middens resumed in force, under the new theoretical framework of processualism and a focus on economic and ecological perspectives (Claassen, 1998; Gutiérrez-Zugasti et al., 2011). Several new excavations were carried out in Portugal, Spain, France, Britain and Denmark, using more detailed methods of data recovery in shell middens (e.g., sieving of sediments, three-dimensional recording and controlled sampling procedures). Post-excavation analyses also progressed with the application of new techniques, the development of studies on faunal and archaeobotanical remains and the review of archaeological collections (notably lithic materials) under new paradigms. These studies aimed to widely explore the great amounts of information that shell middens can provide concerning palaeoenvironmental reconstruction, site formation, subsistence, resource exploitation/seasonality or settlement organisation, mainly through ecofacts (e.g., Clark, 1971; Bailey, 1978; Arnaud, 1989). One of the main objectives was to obtain evidence about how Mesolithic hunter-gatherer groups adapted to the changing Holocene environments. In this sense, the exploitation of aquatic resources and the development of social complexity became central themes of discussion in Mesolithic shell midden research (Álvarez et al., 2011). The development of radiocarbon dating methods was also crucial for a better understanding of the formation and chronology of the shell middens (Andersen, 2007). The use of ethnographic information became more valued for the interpretation of the middens in some areas, notably in Denmark (Andersen, 2000). During the following years, the theoretical background of shell midden research remained relatively similar, although historical questions had increased attention, such as those regarding the Mesolithic–Neolithic transition (e.g., Arias, 1999; Marchand, 2000; 2001).

With the beginning of the twenty-first century, a renewed set of scientific projects centred on Mesolithic shell middens appeared, being mainly characterised by new field work (including geophysical surveys), advances on the application of archaeological sciences (e.g., micromorphology, zooarchaeology and archaeobotany) and several research techniques (e.g., GIS, isotope and DNA analysis) to the excavation and post-excavation analyses, notably in Portugal, Spain, France and Denmark (e.g., Diniz and Arias, 2012; Bicho et al., 2013a;

Marchand and Dupont, 2014b; Arias et al., 2015a; 2015b; Schulting, 2015; Arias et al., 2017; Bicho et al., 2017; Marchand et al., 2018; Skriver et al., 2018). Also, the study of submerged shell middens has been advancing, as found in Denmark, where underwater excavations were recently undertaken at the Hjarnø Sund site, eastern Jutland (Skriver et al., 2018). Although the main questions on shell middens continue to be centred on past subsistence, coastal settlement dynamics and environment, approaches focusing on mortuary archaeology and ritual activity have been growing (e.g., Hellewell, 2015; Boulestin, 2016; Peyroteo Stjerna, 2016).

2.2.2. General characteristics of shell middens

Shell middens play a vital role in knowledge about the last hunter-gatherer groups in Atlantic Europe. In many cases, it is known that Mesolithic shell middens were part of wider settlement systems which comprised other site types (Crombé and Robinson, 2014), as observable in Denmark through the Ertebølle record (Andersen, 2000) or in the Brittany region, France (Marchand, 2003). However, the enhanced preservation of organic material and consequent large quantities of data provided by these sites, despite being located in acidic geological contexts, make them unique sources of information when compared with other contemporary Mesolithic sites (Larsson, 1993; Bailey and Milner, 2002).

Mesolithic shell middens are predominantly known from coastal and estuarine contexts across southern Scandinavia (notably in Denmark), the British Isles (especially in Scotland), Ireland, France (the north-western region) and the Iberian Peninsula (the Cantabrian region and littoral region of Portugal) (Bailey and Milner, 2008; Gutiérrez-Zugasti et al., 2011) (Figure 15). Most of these sites correspond to Late Mesolithic occupations (Bailey and Milner, 2008), among which open-air shell middens are the most frequent and largest sites. However, in some areas, other site types are known. For example, in the Cantabrian region, in northern Spain, shell middens occur in rock shelters/caves near the shoreline (Fano, 2019). Similarly, in western Scotland, shell middens typify the ‘Obanian culture’, occurring in open-air sites, but also in rock shelters/caves (Bonsall, 1996).

It is hard to address the exact numbers of Mesolithic shell middens in Atlantic Europe, and those with Late Mesolithic occupations in particular. In a recent publication about the shell middens of Atlantic Europe, 248 Mesolithic sites and 75 sites with Mesolithic/Neolithic occupations were considered for analysis (Dupont, 2016). However, current available information in the literature and archaeological site databases (such as the *Portal do Arqueólogo* from the Directorate-General for Cultural Heritage-DGPC in Portugal) indicate that more than 600 Mesolithic shell middens are identified along the territory of Portugal, Cantabrian Spain, north-western France, Britain/Ireland and Denmark. Only in Denmark, about 400 shell middens are attributed to the Late Mesolithic (Ertebølle) (Bailey and Milner, 2008), while the existence of about 130 Mesolithic shell middens in the western part of Cantabrian Spain (the coast of Asturias) is mentioned (Fano, 2019). However, for most countries or regions, official databases of archaeological sites are not available to search and inventories of shell middens are not organised. Moreover, the criteria used to classify the sites as shell middens are not the same, varying according to the researchers and countries. The accuracy of chronological attributions is also variable. Some shell middens were subject to several

radiocarbon analyses, but, in other cases, published absolute dates are unknown, or the available data are insufficient to characterise the stratigraphic sequence. The quality of the published analyses also depends on the circumstances. In many cases, the radiocarbon dates were obtained a long time ago, the samples were not the most adequate or the contextual information is missing. In addition, chronological characterisations based on archaeological materials depend on the presence of diagnostic artefacts, and some identified shell middens (particularly those located on cliffs) usually provide little material, becoming impossible to make such attributions.



Figure 15: Main concentrations of Mesolithic shell middens in Atlantic Europe (according to Gutiérrez-Zugasti et al., 2011) (image by author).

Shell middens are often considered typical sites of the Mesolithic, especially of the Late Mesolithic period, in Atlantic Europe, but these features also occur in later periods, notably in the Neolithic (Bailey and Milner, 2008). For example, in Denmark, although the majority of shell middens, including the largest ones, are attributed to the Late Mesolithic, many middens also have Neolithic occupations, while some sites are entirely from the Neolithic period (Andersen, 2000). In Portugal, an important group of Middle/Late Neolithic shell middens are known in the Comporta area, in the littoral region of the Sado estuary (Silva et al., 1986), not so far from the Mesolithic shell middens of the Sado valley. However, in Atlantic Europe in general, shell middens seem to have had a reduction in size and quantity after the end of the Mesolithic (Bailey and Milner, 2002; Gutiérrez-Zugasti et al., 2011).

Furthermore, it is widely recognised that Holocene sea-level rise and consequent submergence of shorelines in many areas of Atlantic Europe impacted the early shell midden archaeological record, with the non-preservation of these sites being a probable cause for the lower number of known Palaeolithic and Early Mesolithic shell middens in many regions (Bailey and Milner, 2002; 2008; Milner et al., 2007; Gutiérrez-Zugasti et al., 2011). The ‘appearance’ of shell middens in the Middle Holocene archaeological record at various locations of Atlantic Europe is thus strongly related to the fact that the Mesolithic coastline approached the modern-one and underwent a stabilisation, allowing the accumulation of shell deposits at the same places (Bailey and Milner, 2008). However, other factors are also likely to have influenced the distribution of shell middens, such as geological, ecological and topographical conditions (notably, conditions for localised abundance of molluscs) and the level of residential stability of the populations (Milner et al., 2007).

The environmental conditions achieved during the Mesolithic, especially in the Late Mesolithic, seem to have been decisive for the development of intensive harvesting of molluscs and shell middens in Atlantic Europe, notably the creation of rich aquatic environments in the littoral regions, such as rocky shores and estuaries with extensive intertidal zones (Figure 16).



Figure 16: View of the Sado valley, southern Portugal, with the alluvial plain in the area of the Mesolithic shell middens (photo by author).

Regarding the dimension and shape of these shell deposits, huge differences have been observed – if in some cases, large accumulations over thousands of square meters are known, they are often classified as mounds; in other cases, shell accumulations are limited to smaller deposits or thin layers. However, the terminology and criteria of classification are far from being uniform (Dupont, 2003b; Gutiérrez-Zugasti et al., 2011).

The dominant species of molluscs represented in the Mesolithic shell middens are typical of open rocky coasts (*Patella vulgata* and *intermedia*, *Osilinus lineatus*) and estuaries/brackish waters (*Cerastoderma edule*, *Ostrea edulis*, *Scrobicularia plana*, *Ruditapes decussatus*), showing similarities between different areas of Atlantic Europe (Gutiérrez-Zugasti et al., 2011) (Table 2). In several cases, the exploitation of different aquatic environments can be found at the same sites. Apart from molluscs, shell middens often contain remains of other animals such as mammals, fish, crustaceans, as well as plant remains in some cases.

Table 2: The most common malacological species in the Mesolithic shell middens of Atlantic Europe (according to Gutiérrez-Zugasti et al., 2011).

Scientific name	Common name	Main environment
<i>Patella vulgata</i>	Common limpet	Saltwater (open rocky coasts)
<i>Patella intermedia</i>	Black-footed limpet	
<i>Osilinus lineatus</i>	Lined/thick top shell; Monodont	Saltwater (open rocky coasts)
<i>Mytilus edulis</i>	Common mussel	Saltwater / brackish water (open rocky coasts, rocks of sheltered estuaries/bays)
<i>Mytilus sp.</i>	-	
<i>Littorina littorea</i>	Common periwinkle	Saltwater/brackish water (open rocky coasts, estuaries and mudflats)
<i>Cerastoderma edule</i>	Common cockle	Brackish water (estuaries and sheltered sandy bays)
<i>Ostrea edulis</i>	European flat oyster	Brackish/saltwater (estuaries and shallow coastal habitats with muddy bottoms or rocky coasts)
<i>Scrobicularia plana</i>	Peppery furrow shell	Brackish water (estuaries)
<i>Ruditapes decussatus</i>	Carpet shell clam	Brackish water (estuaries)

Notes: common names and information about the habitat are based on the following resources: <http://www.marinespecies.org/>; <http://species-identification.org/index.php>; <https://www.marlin.ac.uk/>.

Many Late Mesolithic shell middens contain several features (such as fireplaces, postholes, pits, burials), artefacts and tools (notably lithic remains, but also bone and antler tools, shell ornaments and other things). Burials are relatively frequent, especially in the south of Atlantic Europe. Regarding site function, shell middens have been generally divided into residential/year-round sites (relatively large sites with diverse materials and features such as postholes or burials), and temporary/seasonal/specialised sites (smaller sites with few components other than shells and a low diversity of faunal remains) (Bailey and Milner, 2008; Gutiérrez-Zugasti et al., 2011). It is clear, however, that this binomial classification is too simplistic and insufficient to explain all situations. For example, the presence of burials is not necessarily synonymous with long-term occupation or residential function of a site (as pointed out by Peyroteo Stjerna, 2016). Besides this, documented and well-defined habitation areas in shell middens are rare in Atlantic Europe (Andersen, 2000), a situation that poses difficulties to know more about the residential function of these sites.

The chronology of occupation of these shell middens seems variable. The available data are heterogeneous, particularly due to the scarcity of information from older excavations. The obtained radiocarbon dates indicate that many shell middens were used for several hundreds of years – around 1000–1200 years in the case of many Danish middens (Andersen, 2000; Gutiérrez-Zugasti et al., 2011) and Cabeço da Amoreira, in Portugal (Bicho et al.,

2013a). Frequently, the use (or reuse) of these sites in Neolithic times can be observed through the material culture preserved in the archaeological record (e.g., Andersen, 2000; Diniz, 2010). In other cases, however, the occupation seems to have been relatively short, such as in the case of Beg-er-Vil, France, whose more recently obtained radiocarbon data suggest an occupation of approximately 200 years (Marchand et al., 2018).



Figure 17: Shell midden of Beg-an-Dorchenn, Finistère, France (photo by author).

2.2.3. Current methods of shell midden excavation

Contrary to what happens in Japan, in western European countries, the principles for digging shell middens have not been described in publications edited by central archaeological authorities or public agencies. The extent of the excavations has varied according to the conditions and aims of the research projects. If the excavation of sections and small areas has been more frequent, particularly in Denmark, Britain and Ireland (Gutiérrez-Zugasti et al., 2011), the investigation of large areas (including areas without shell accumulations) has been a growing concern, as found recently at Cabeço da Amoreira, Muge, Portugal (Bicho et al., 2017; Taylor et al., 2021), and Beg-er-Vil, France (Marchand et al., 2018). Also, considering the high costs involved in the excavation of shell middens, geophysical methods for previous surveys have been applied in Spain (Arias et al., 2015b), Portugal (Arias et al., 2017) and France (Marchand and Arias, 2018; Lévêque et al., 2023).

Excavation procedures for shell middens have varied according to projects and researchers. The excavations that are integrated in research projects show some similarities, even between different countries. With respect to the recent procedures applied in Portugal and France, the following aspects can be noted (Bicho et al., 2013b; Arias et al., 2015a; Marchand et al., 2018):

- 1) A grid with squares of 1 m is usually established. The excavation follows a sub-square system of 50 cm, such as at Beg-er-Vil, France (Marchand et al., 2018), or the 'bucket shot' system following Dibble (2007), as observed in the most recent excavations in Portugal at the Sado valley shell middens (Arias et al., 2015a) and Cabeço da Amoreira, Muge (Bicho et al., 2013b). Through the latter system, a three-dimensional coordinate is taken for each bucket of ten litres of sediment and the materials from sieving are stored with its reference;

- 2) Sediments are, in general, completely recovered and subject to wet sieving and sorting of artefacts/ecofacts, as at Beg-er-Vil (Marchand et al., 2018) or Poças de São Bento, Portugal (Arias et al., 2015a; López-Doriga, 2016), where field laboratories were implemented during the excavation;
- 3) The position of artefacts is three-dimensionally recorded as a rule, notably using a total station (Bicho et al., 2013b; Arias et al., 2015a; Marchand et al., 2018). Rules for individual georeferencing of the archaeological items can slightly vary, notably the minimal dimension (usually items larger than 1 or 2 cm) or the item types;
- 4) Different stratigraphic approaches have been used. Deposits and features are, as a principle, individually numbered and recorded (e.g., Arias et al., 2015a; Marchand et al., 2018). In some cases, the elaboration of a Harris matrix is used (Arias et al., 2015a). However, artificial levels have been used in other situations (e.g., Bicho et al., 2013b). Stratigraphic profiles are, in general, highly valued as a means of control of the excavation.

Regarding the cases of submerged shell middens in Scandinavia, specific procedures for underwater archaeology for research and excavation have been applied, as found recently in Denmark at the Hjarnø Sund site (Skriver et al., 2017; Astrup et al., 2020).

Overall, the effective integration of archaeological sciences into excavations has been a priority, either through the use of sieving/sorting procedures in field laboratories, adequate sampling strategies or the integration of researchers with multiple backgrounds into field work, such as palaeobotanists and geoarchaeologists (e.g., López-Doriga, 2016; Duarte et al., 2017b).

2.2.4. Current research problems

Extensive information has been provided by Mesolithic shell midden research in Atlantic Europe. However, comparative approaches of shell middens over large areas are still rare (Milner et al., 2007), despite the evident ‘Atlantic connection’ between these sites (Marchand, 2015). The generated data are also disparate among regions. In some cases, this heterogeneity in the research can also be observed inside the regions. For example, in the Cantabrian region in Spain, the number of known Mesolithic shell middens in the western zone (eastern Asturias and western Cantabria) is particularly high compared to the eastern zone (Fano et al., 2013, p. 157). Also, in some areas such as Portugal (Araújo, 2003; 2016), little information concerning non-shell midden sites (inland and littoral sites without shell middens) is available, limiting the functional interpretations about the shell midden sites in settlement systems.

Some of the main concerns of the current research have been the formation and use of shell middens. In this sense, several micro-stratigraphic studies have been developed, providing high-resolution information on shell midden formation that would be impossible to address through a macroscopic analysis of the terrain (Aldeias and Bicho, 2016; Duarte et al., 2017b; Duarte, 2019; Simões and Aldeias, 2022). Unfortunately, these studies are still time-consuming, and their application has been limited to small areas of the sites. The chronological approach, through a high number of radiocarbon dating analyses for each site, has been another relevant way to address questions on site formation and use (e.g., Bicho et al., 2013a; Peyroteo Stjerna, 2016).

Palaeodiets have been a systematically approached topic with respect to Mesolithic shell middens. Palaeodietary data from these sites have contributed to the discussion of the importance of aquatic food sources in diets, but also the economic and social organisation of Late Mesolithic groups (Dupont and Bicho, 2015; Guiry et al., 2015; Schulting, 2015; Cubas et al., 2019). In this sense, malacological studies have been growing and allowing researchers to know more about the exploitation of molluscs as food, and also as raw-materials for other uses (Dupont et al., 2007b; Cuenca Solana, 2013; Rigaud and Gutiérrez-Zugasti, 2016).

Although the funerary record has received much attention since early shell midden research, new studies concerning anthropological materials have been developed in order to understand the funerary and ritual behaviour of hunter-gatherer communities in more detail (e.g., Peyroteo-Stjerna, 2016; Peyroteo-Stjerna, 2021; Peyroteo-Stjerna et al., 2022).

Investigation of the site layout, with the exposure of larger areas in excavation, and research on adjacent zones of the middens themselves, has been a growing concern, notably in Denmark (Andersen, 2000), and more recently in France (Marchand et al., 2018). However, the rarity of excavations of large areas and the scarcity of documented dwelling structures with good definition has limited discussions about the function and organisation of shell middens, as underlined by several researchers (Gutiérrez-Zugasti et al., 2011; Fano and Cubas, 2012).

The preservation of shell middens is also a major issue of concern in Atlantic Europe, since these sites, either in caves or as open-air sites, suffer from the effects of several erosional processes caused by natural elements (e.g., the sea) and human impact (Larsson, 1993). For example, modern agriculture has deeply affected Ertebølle sites in Denmark (Andersen, 2000, p. 383), while the French shell middens in Brittany have been subject to strong marine and anthropic erosion (Marchand et al., 2018).

2.3. Jomon shell middens in Japan

2.3.1. History and aims of shell midden research

The research history on Jomon shell middens is intensely connected with the origins of Japanese scientific archaeology and Jomon studies in the nineteenth century. However, the existence of large shell accumulations was known many centuries before in Japan, being mentioned in local tales. Possibly the oldest record in the world's literature of a prehistoric shell midden is a reference that has been associated with the Ōgushi shell midden (Ibaraki prefecture) in the *Hitachi No Kuni No Fudoki*, an eighth century (Nara period) gazetteer:

'In the remote past, there was a giant with arms so long that while sitting far inland he could reach all the way to the beach and dig clams at the seashore. After eating the clams, the giant would throw the shells in a pile. Eventually so many shells accumulated that the pile became a hill. So the people at this time named the hill [great digging] after the [giant's] monumental feat of clam digging. [The present-day name, Obokushi, derives from Obokujiri (grand digging).]' (Aoki, 1997, pp. 65–66)

The first formal identification of a shell midden as an archaeological site only happened in 1877, with the discovery and excavation of the Ōmori shell midden, in Tokyo, by Edward

S. Morse, an American zoologist and specialist in molluscs and brachiopods. This was also the first scientific excavation in Japan (Figure 18). Interestingly, the original purpose of Morse's stay in Japan was not the excavation of prehistoric sites. The identification of the Ōmori shell midden by Morse was a casual happening, allowed by his knowledge of the shell middens in Florida, New England, Europe and other parts of the world (Morse, 1877; 1879). At the time, Morse was fully conscious of the importance of the discovery of shell middens for the study of human origins:

'The importance of studying deposits of the nature of the Omori Mounds has been fully realized, since the investigations of the Danish shell mounds brought to light so many facts bearing on the habits of the primitive races of Denmark.' (Morse, 1879, p. 2)

Morse's prior research experience of digging shell middens in New England was crucial for the development of his research at the Ōmori shell midden and the publication of the results. The book *Shell Mounds of Omori* (Morse, 1879) is a detailed excavation report of the site and considered to be the mark of the beginning of modern archaeology in Japan (Nishiyama, 1995; Komiya, 2015). Although several Western researchers and diplomats contributed to the development of archaeology in Japan during the second half of the nineteenth century (Abad, 2008), the particular impact of Morse's work, with a deep tradition in natural history, is largely recognised, even if its influences took some time to be effectively incorporated (Suzuki, 1989).

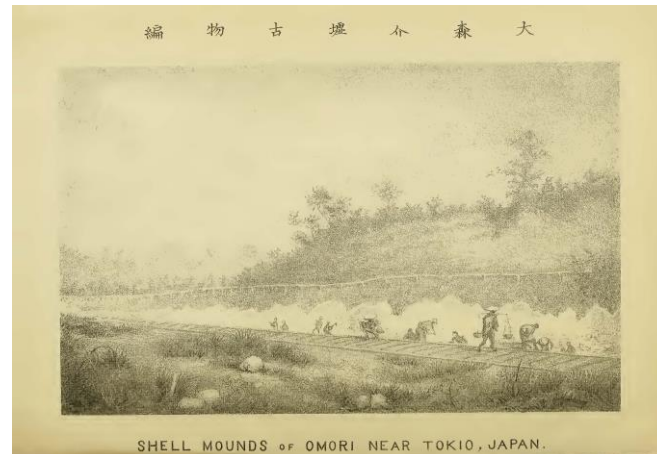


Figure 18: Excavations at the Ōmori shell midden, in Tokyo, according to the publication *Shell Mounds of Omori* (reproduced from Morse, 1879).

Shell midden sites continued to be studied in Japan by the followers of Morse and other Japanese archaeologists. Several excavations were performed and analyses were published, as exemplified by the research on the site of Okadaira, in Ibaraki prefecture, by Morse's students (Iijima and Sasaki, 1882). Some studies on the palaeoenvironment were developed, notably about coastline changes as seen from the distribution of the shell middens (Toki, 1926). However, one of the main purposes of shell midden research in the first half of the twentieth century was the collection of human skeletons and the investigation of the origins of the Japanese people (e.g., Kiyono et al., 1920), while the study of archaeological material

and contexts received less attention (Suzuki, 1989; Nishiyama, 1995; Murata, 2013). Another objective of the excavations of shell middens in this period was to establish detailed chronological sequences through the analysis of shell types and, especially from the beginning of the Showa period in the 1920s, the classification of Jomon pottery types (Tozawa, 1989; Nishiyama, 1995; Matsui, 1999). According to Rokurota Murata (2013), the successive accumulation of shell layers usually allows the ‘packing’ of pottery remains, which, consequently, are preserved in a good state. As so, many shell middens became type sites for the Jomon chronological framework (Habu et al., 2011), giving their name to several pottery styles, such as with Kasori shell middens, in Chiba prefecture (Murata, 2013, p. 10). Furthermore, due to the discovery of many sites with residential features, such as pit-dwellings, shell middens also became a great source of information for settlement research, notably in the Kanto area (Suzuki, 1989; Nishiyama, 1995). The first proposals for a shell midden typology based on site shape and size were made in the first half of the twentieth century by Kingo Tazawa and Nakao Sakazume (Sakazume, 1959). The latter also published the first inventory of shell middens in Japan, containing 1108 sites attributed to the Jomon period (Sakazume, 1959).

After the Second World War, and especially from the 1960s onwards, the focus of shell midden research gradually shifted towards the palaeoenvironment, hunter-gatherer settlement, subsistence studies and social organisation. The impacts of the development of international exchanges, especially the influence of Anglo-American archaeology, became evident in the theoretical approaches and the methods applied in Japanese archaeological research in general (Ikawa-Smith, 1982; 2011; Habu and Okamura, 2017), and in shell midden studies in particular (Habu et al., 2011). Zooarchaeological studies, especially malacological analyses, were more developed, in order to obtain more data on seasonality and site occupation (Komiya, 2015). For example, growth-ring analysis advanced considerably at that time (Koike, 2017). Flotation, water-screening and sampling procedures were also adopted in excavations. Moreover, economic growth and the consequent construction boom that affected numerous archaeological sites led to the establishment of laws and regulations for protection of buried cultural properties and the progressive creation of a government-sponsored, highly systematic cultural resource management system, which resulted in thousands of rescue excavations each year in Japan during and after the 1970s (Ikawa-Smith, 2011; Habu and Okamura, 2017). Excavations of shell middens increased in quantity and extent in this context, especially in the 1980s (Nishiyama, 1995; Habu et al., 2011; Koike, 2017). Integral excavations of numerous shell middens were undertaken, namely in Kanto and Chubu regions, providing diverse data on site location, formation and contents, as well as palaeoenvironment and economy. Although shell midden research was centred on eastern Japan, excavations also increased in western Japan from that time on (Nishiyama, 1995; Koizumi, 2016).

While palaeoenvironment, settlement, economy and social organisation continue to be the main concerns of shell midden research today (Abe, 2007; 2014a; Koizumi, 2016; Koike, 2017), questions about the symbolic aspects of these sites have also been posed, notably in relation to their funerary use and the meaning of the deposition of human, animal and

artefact remains (e.g., Nakamura, 1991; 2005). However, approaches to symbolic aspects are still relatively rare, despite there being wider perspectives on shell middens (Nishiyama, 1995).

Current shell midden research has been conditioned by several factors, including the particularities of archaeological activity in Japan. Since pre-war times, Jomon shell midden research (and Jomon research in general) has been centred in eastern Japan, especially in the Kanto region (Tozawa, 1989; Koizumi, 2016), due to the higher quantities of known sites and archaeological interventions related to urban development. This situation has been generating considerable disparities in the knowledge of these sites between western and eastern Japan. Another aspect to mention is the protection and preservation of shell middens as cultural properties in Japan (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013; Koike, 2017). These sites are often nominated to be (national) historic sites, a situation that poses significant restrictions to new and extensive excavations. There is a general idea about the complexity of excavating shell middens and the need to conserve them for the future, when better techniques would be available to adequately exploit the amount of information provided by these sites (Koike, 2017, p. 150). Considering that, the most recent field work has been developed in the context of conservation measures of the sites undertaken by municipal/prefectural administrative institutions in charge of the protection of the buried cultural properties (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013), such as those found at the Kasori shell middens, in Chiba prefecture (Nishino et al., 2017). At the same time, large rescue excavations from construction works or development projects have led to the discovery of new sites, such as the case of the submerged shell middens of Higashimyo, Saga prefecture (Matsui, 2013; Nishida et al., 2016b), and the acquisition of high quantities of important data that would be difficult to obtain by other means. It is also important to note that, due to the clear dominance of administrative and rescue operations in the Japanese archaeological heritage management system, problem-oriented or research excavation projects – such as those undertaken by universities or research institutes – have been very few (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division], 2018), even compared to western Europe, where rescue excavations also predominate. Nevertheless, public dissemination of shell midden research is extremely well-developed, through the publication of books directed to the general public, or several actions undertaken by institutions and associations to engage local communities in shell midden heritage (exhibitions, guided visits, courses at museums, creation of websites about the sites, among other things). For example, the nomination of the Kasori shell midden as a ‘special historic site’, in 2017, gave rise to a number of activities for the promotion of the site, including new excavations (<https://www.city.chiba.jp/kasori/index.html>).

2.3.2. General characteristics of the shell middens

The Jomon was once characterised as a ‘Shell Midden Culture’ (Tozawa, 1989; Matsui, 1999). Although other site types are also known, shell middens have been largely recognised

as typical sites of the Jomon period. These sites are known in large numbers along the coastal areas of the Japanese archipelago, from Hokkaido to Okinawa.

The estimated numbers of shell middens in Japan have differed according to authors and publications. The first formal database of shell middens in the country was published by Nakao Sakazume (1959), in which 1108 Jomon sites, from a total of 2237 shell middens, are counted. According to the official numbers published by the Agency for Cultural Affairs of the Government of Japan, in 2017, 3955 shell midden sites were known in Japan, from which 2443 sites were attributed to the Jomon period (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division], 2017). With these numbers, the Japanese archipelago can be considered to be one of the areas with the highest densities of shell middens in the world (Toizumi, 2014).

Shell middens in Japan are known from the Initial Jomon period onwards (Toizumi, 1999), but most of them are dated to the Early, Middle and Late Jomon periods. Their formation in the Jomon period has been associated with the Holocene climatic amelioration in the archipelago and the beginning of the sea rising from around 9000 cal BP. However, and similarly to Atlantic Europe, it is probable that many shell middens from earlier periods disappeared with the Jomon Transgression (Toizumi, 2014, p. 67). Most shell middens are open-air sites formed in relatively ‘enclosed’ aquatic environments created by the Holocene transgression, notably shallow bays, estuaries and rias (Takahashi et al., 1998; Matsui, 1999; Toizumi, 2014). The development of shoals and extensive tidal flats enabled the creation of highly productive ecosystems, with abundant molluscs that could be easily gathered. It is considered that these conditions were crucial to the increased reliance of Jomon groups on aquatic food and, consequently, the formation of numerous middens (Akazawa, 1986; Takahashi et al., 1998; Hitoki, 2012; Toizumi, 2014). Contrary to this, shell middens associated with open oceanic coasts are rarer and smaller in general, although some concentrations are known in association with reefs or small inlets (Toizumi, 2014). Shell middens in freshwater environments are also rare in the Jomon record, but some sites are identified in few locations, such as Biwa Lake, Shiga prefecture (Seguchi et al., 2013).

The main concentrations of shell middens in the Japanese archipelago are located in Tokyo Bay, Sendai Bay, Hunka Bay, Ise Bay, Mikawa Bay, Seto Inland Sea and Ariake Bay (Takahashi et al., 1998; Matsui, 1999; Toizumi, 2014), where larger sites are relatively frequent (Figure 19). Tokyo Bay and Sendai Bay, in particular, are two outstanding areas in terms of shell midden density, size and internal structure, a fact that has been related to the high productivity enabled by the meeting of cold and warm currents in the ocean off the middle of Honshu (Matsui, 1999). Overall, Jomon shell middens are more densely distributed along the Pacific coast, while these sites are much less numerous along the Sea of Japan. This discrepancy has often been associated with differences in the formation of tidelands, which are less frequent in the Sea of Japan zone, due to lower tides, deeper waters, and fewer embayments (Takahashi et al., 1998; Toizumi, 2014). Furthermore, Jomon shell middens are more concentrated in eastern Japan, especially in the Kanto region. According to the data compiled by the Agency for Cultural Affairs (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division], 2017), only around 17% of the total recorded shell midden sites (422 from 2443 sites) are located in western Japan (without

considering Aichi and Fukui prefectures) (Figure 20). The denser presence of shell middens in eastern Japan corresponds to a higher density of Jomon sites in general (Habu et al., 2011). Despite these main tendencies, according to Takeji Toizumi (2014, p. 59), the location of Jomon shell middens does not seem to be exclusively determined by geographical factors.

Jomon shell middens are characterised by formal and functional diversity. Variations can be seen in several aspects such as site location, morphology and size, faunal remains (such as the dominant malacological species), material culture and features. Physical factors, such as differences in aquatic environments, have been strongly related to these variations. However, it is thought that other elements, such as the characteristics of the regional settlement and subsistence systems, were also relevant for the formation of these sites.



Figure 19: Map of the Japanese archipelago with the main areas of concentration of Jomon shell middens (following Toizumi, 2014) (image by author).

Some Jomon shell middens are no more than 100 m² in area, while others are much larger, extending several thousands of square meters. The thickness of the shell accumulations is also variable. The highest values were recorded at the Nakazato shell midden, Tokyo, where the accumulations reached a maximum of 4.5 m in thickness (Nakajima et al., 2018). In general, shell middens formed in the Early Jomon or earlier are relatively small, while the sites from the Middle and Late Jomon are larger (Suzuki, 1989; Takahashi et al., 1998; Habu et al., 2011; Ogawa, 2012; Toizumi, 2014). In eastern Japan, particularly in the Kanto region, some of the largest shell middens are found on plateaus and present ring or horseshoe shapes, measuring over 100 m in diameter, as exemplified in the eastern half of Tokyo Bay (Chiba prefecture) by several sites, such as Kasori South (Late Jomon) and Horinouchi (Late Jomon). Numerous pit-dwellings and other features are usually found at these settlement sites.

However, the form and location of the Jomon shell middens are far from being standardised across the Japanese archipelago or each region. Small shell middens are common at several locations as well, such as caves, terraces, sandbars, slopes, plains and plateaus, among other things (e.g., Koizumi, 2016). In some cases, the accumulations were formed inside abandoned pit-dwellings or simple pits, occupying restricted areas of the sites or larger extensions, in a discontinuous way (Ogawa, 2012). In the eastern half of Tokyo Bay, small shell middens are also known in areas where large ring or horseshoe-shaped shell middens are recorded. In addition, large shell middens, without regular shapes, are known at lowland locations closer to the sea in the Kanto region, such as with Nakazato shell midden, Tokyo (Abe, 2014a).

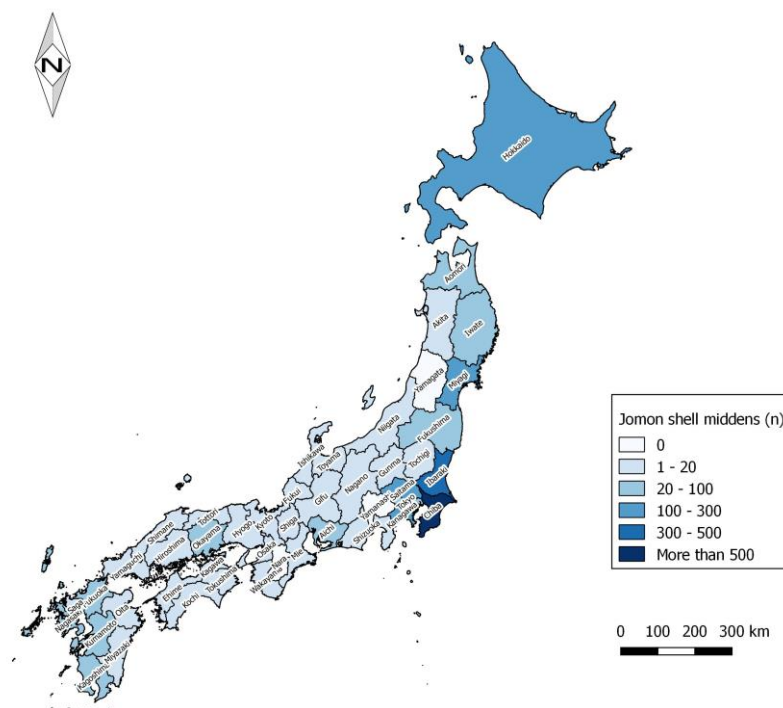


Figure 20: Map of Japan with the number of Jomon shell middens by prefecture (based on numerical data from Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division], 2017) (image by author).

Most shell middens are formed by salt and/or brackish water mollusc species (Tozawa, 1989; Takahashi et al., 1998; Toizumi, 2014), whose variation has been closely (although not exclusively) related to temporal and spatial changes in aquatic environments. The most common marine species at the sites are *Crassostrea gigas* (Pacific oyster) and *Tegillarca granosa* (blood cockle, known as *haigai*), which are frequent in muddy tidelands, as well as *Meretrix lusoria* (common orient clam) and *Ruditapes philippinarum* (Japanese cockle, known as *asari*), which are typical of sandy tidelands. Among the brackish water species, the *Corbicula japonica* (Japanese blue clam, known as *yamatoshibijimi*) is the most frequent (Table 3, Figure 21).

Table 3: The most frequent malacological species in Jomon shell middens (according to Takahashi et al., 1998; Toizumi, 2014).

Scientific name	Common name (Japanese name)	Main environment
<i>Crassostrea gigas</i>	Pacific oyster, Japanese oyster (<i>magaki</i>)	Saltwater (muddy tidelands)
<i>Tegillarca granosa</i>	Blood cockle, blood clam (<i>haigai</i>)	Saltwater (muddy tidelands)
<i>Meretrix lusoria</i>	Common orient clam (<i>hamaguri</i>)	Saltwater (sandy tidelands)
<i>Ruditapes philippinarum</i>	Japanese cockle (<i>asari</i>)	Saltwater (sandy tidelands)
<i>Umbonium moniliferum</i>	(<i>ibokisago</i>)	Saltwater (sandy tidelands)
<i>Corbicula japonica</i>	Japanese basket clam or Japanese blue clam (<i>yamatoshijimi</i>)	Brackish water (soft bottoms of shallow waters near estuaries, lagoons and lakes connected to the sea)

Notes: common names and information about the habitat are based on the following resources:
<http://www.marinespecies.org/>; <http://www.fao.org>; <https://www.sealifebase.org/>;
<https://www.marlin.ac.uk/>.



Figure 21: Banzu tideland, Tokyo Bay (Chiba prefecture, Japan) and examples of shell species that can be easily found today, notably the *Umbonium moniliferum* (ibokisago snails) and the Japanese cockle (*asari*) (photos by author).

A wide variety of ecofacts (e.g., faunal, macrobotanical and other remains), artefacts (e.g., lithic tools, pottery, bone/antler tools, adornments, figurines) and features (e.g., stone concentrations, hearths, storage pits, postholes, pit-dwellings, burials) have been found, indicating the practice of several activities such as hunting, fishing, food gathering and processing, artefact production, storage, habitation and rituals at these sites. As observed for the Late Mesolithic shell middens, human and dog burials are well-documented in Jomon shell middens (e.g., Yamada, 2009; Perri, 2016). Since acidic soils (volcanic ash) are prevalent in the Japanese archipelago, shell middens have been crucial in the Jomon record for allowing the preservation of bones, and consequently, the acquisition of information on subsistence and funerary activities. In addition, submerged shell middens such as Awazu, Shiga

prefecture (Iba, 2005; Seguchi et al., 2013), or Higashimyo, Saga prefecture (Matsui, 2013; Nishida et al., 2016a), have provided contexts with an exceptional preservation of organic material, including wooden artefacts and macrobotanical remains.

It has been observed that many Jomon shell middens were formed in settlement sites with pit-dwellings and burials, while other sites, with few artefacts and no signs of habitation, seem to have been used as specialised sites focused on intensive mollusc gathering and processing (Takahashi et al., 1998; Habu et al., 2011; Abe, 2014a). However, the archaeological record of Jomon shell middens is diverse, even within each region (e.g., Koizumi, 2016). A division between residential and specialised sites seems to be insufficient to summarise all the functions performed by these sites in the different settlement systems.

The chronology of the formation of Jomon shell middens is a topic that still needs to be further investigated. It is likely that many large sites, such as the circular and horseshoe-shaped shell middens of Tokyo Bay and some lowland sites (such as the Nakazato shell midden), are a result of relatively long occupations and continuous exploitation of shellfish at the same location over several centuries or even millennia (Nishino, 2007; Habu et al., 2011; Nakajima et al., 2018). Concerning the large circular and horseshoe-shaped shell middens, the continuity of the occupations are often indicated by the presence of several pottery types and other elements, such as numerous pit-dwellings (Nishino, 2007; Toizumi, 2014). Contrary to this, many smaller shell middens seem to result from relatively short periods of formation. In the case of the Higashimyo site complex, radiocarbon data indicate that the shell middens were formed over 100–200 years, which seems consistent with chronology of the pottery, since only two pottery types were found at the site (Nakamura et al., 2013). In general, however, shell middens with radiocarbon-dated stratigraphic sequences are rare. The use of pottery typology to estimate the age and the accumulation time of the middens has been more frequent, although it can be less reliable (Nakamura et al., 2013, p. 680).

2.3.3. Current methods of shell midden excavation

Currently in Japan, most excavations on shell middens result from rescue operations performed in the context of urban development or site conservation measures undertaken by heritage management authorities. Therefore, the excavation and research procedures at these sites depend on the conditions of the interventions, available resources and time, as well as the institutions that are involved in these works.

The manual *Hakkutsu no Tebiki* (Guidance for Archaeological Excavations) edited by the Agency for Cultural Affairs, Monuments and Sites Division and Nara National Research Institute for Cultural Properties (2013, pp. 298–303) includes a relatively extensive section with guidelines for the excavation of shell middens. Recommended procedures are also described in several shell midden-related publications (e.g., Suzuki, 1989; Okazaki, 2006; Komiya, 2015; Koike, 2017). The main principles and methods that have been pointed out can be summarised as follows:

- 1) *Works prior to the excavation* – due to the high costs of a shell midden excavation, a prior survey is considered to be important to determine the extent and form of the midden. In addition to a pedestrian survey, the use of drilling and test pits is frequent.

Geophysical methods are also applied. Moreover, the examination of the immediate surroundings of the shell midden is considered necessary to understand the settlement system associated with the site (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013; Komiya, 2015). Surface plans of the distribution of shells have been often produced for comparison between different sites (Suzuki, 1989).

- 2) *Excavation procedures* – it is considered that all sediments and shells should be recovered as a principle. Usually, artefacts and other ecofacts are also completely recovered, for which finds washing and sorting of sediments need to be completed. A grid of 2 m–4 m sq. is established for the excavation (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013).
- 3) *Stratigraphic record* – if the identification is possible, different deposits composing the shell midden should be individually numbered, recorded and stored (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013; Koike, 2017). The stratigraphic position of the deposits should be recorded through the observation of sections and horizontal stratigraphy. Matrix schemas are sometimes presented. If individual deposits cannot be identified, artificial levels should be established and recorded (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013). The application of ‘microstratigraphic excavation’ is also suggested by Hiroko Koike, with a focus on the different positions through which shells are deposited (Koike, 2017, p. 153). It should be also highlighted that the extraction of stratigraphic profiles is a technique that is often applied in Japanese archaeology, notably in shell middens. It allows the direct preservation of information for post-excavation analysis, and also for public exhibition (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013; Koike, 2017).
- 4) *Three-dimensional recording of the position of excavated items* – the position of inhumations and intentionally deposited artefacts should be recorded. Rules for recording the position of artefacts should be established (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013; Komiya, 2015).
- 5) *Sampling* – it is stressed that the dimension of the excavated areas should be carefully defined according to time and funding limits. Depending on the circumstances, sampling can be used for the analysis of artefacts/ecofacts. The use of column sampling is common and should be representative of the site (Okazaki, 2006; Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments

and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013; Komiya, 2015).

- 6) *Post-excavation phase* – after the recovery of sediments from the shell midden, the post-excavation phase should include the sorting of small artefacts and ecofacts. Dry sieving (10–5 mm) is usually performed at the site and followed by wet sieving in the laboratory (9.25; 4; 2; 1 or 0.5 mm) (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division] and Nara Bunkazai Kenkyujo [Nara National Research Institute for Cultural Properties], 2013). After, the recovered elements should be ready for specialised analysis (as described in Komiya, 2015).

It should be noted that the abovementioned aspects are only general procedures. Depending on the situation, more specific measurements have been adopted, as in the excavation of submerged shell middens (e.g., Iba, 2005; Matsui, 2013; Seguchi et al., 2013; Nishida et al., 2016b).

2.3.4. Current research problems

Numerous shell middens from the Jomon period are known. Excavations have been undertaken at these sites since the beginnings of the modern archaeology in Japan, generating a high quantity of data about Jomon groups, particularly subsistence, palaeoenvironment, settlement and funerary practices. However, since the excavation of a shell midden requires a large amount of time and investment for post-excavation analyses, the quantity and quality of available data (excavation reports and articles) have been conditioned by the circumstances of the study of these sites. In recent years, several research reports with a general synthesis integrating old and new analyses on well-known Jomon shell middens have been published, such as for the Kasori shell midden, Chiba prefecture (Nishino et al., 2017), the Nakazato shell midden, Tokyo (Nakajima et al., 2018) or the Tsukumo shell midden, Okayama prefecture (Ando et al., 2020). Moreover, important syntheses at a regional or national level concerning Jomon shell midden phenomena have been published (e.g., Habu et al., 2011; Koizumi, 2015; 2016; Komiya, 2015), although individual site studies continue to be predominant.

Past subsistence is still a central issue in Jomon shell midden research. Recently, an increase in stable isotopic analyses in human remains has been observed, in order to obtain detailed data on Jomon diets (Kusaka et al., 2010). Another method of research has been developed through chemical analysis of pottery contents from artefacts recovered from shell middens (e.g., Lucquin et al., 2016). Studies on environmental changes have also been progressed, either through malacological analyses (e.g., Toizumi, 1999) or coastline regional studies (e.g., Hitoki, 2012; Yamamoto et al., 2018).

Shell middens have also been largely contributing to the development of settlement studies. Several texts about the shell middens types and their place on the Jomon settlement systems have been published, notably in relation to the Kanto area (e.g., Abe, 2014a), but also concerning other regions in Japan (e.g., Yamamoto, 2004; Koizumi, 2016).

The discovery and advances on the study of submerged shell middens, such as Higashimyo (Matsui, 2013; Nishida et al., 2016b) and Awazu (Iba, 2005; Seguchi et al., 2013),

have provided a large variety of new data concerning Jomon lifeways, due to the exceptional conditions of conservation of organic material at these sites. Large amounts of data have been obtained about diets, notably through the recovery of aquatic and terrestrial food remains (including plant remains), but also about non-food uses of plants (such as basket and lacquerware production). These discoveries in western Japan also contributed to mitigating the existing disparity of shell midden data between eastern and western Japan.

2.4. Common research trends between shell middens from Late Mesolithic Atlantic Europe and Jomon Japan

Since the nineteenth century, shell middens have been abundantly found in Atlantic Europe and Japan and have attracted the attention of numerous researchers, raising questions on the origins of their formation, the nature of their constructors and past environmental changes. The progressive influence of Western archaeology on Japanese archaeology explains some similar trends that can be found between the two regions regarding the history of shell midden research, such as the importance given to the investigation of human skeletons in the first half of the twentieth century, or the development of approaches centred on palaeoenvironment, settlement and subsistence from the 1960s onwards. It also includes the adoption of certain methodological procedures in the excavations to retrieve large amounts of information (e.g., the application of wet sieving and sorting of sediments). Shell middens have been crucial in both regions for the development of prehistoric studies, notably on Holocene hunter-gatherers, since these sites have been provided large, and often exceptional, datasets. The high level of preservation of organic remains that typically characterises these sites has been particularly valued, since acidic soils predominate in both regions.

The image of profuse occurrence of shell middens from the Middle Holocene onwards in Atlantic Europe and Japan has been influenced, at least partially, by the scarcity of preserved littoral archaeological contexts from earlier periods. Yet, it seems clear that the formation of shell middens was a relevant phenomenon of many Late Mesolithic and Jomon groups. In both regions, the archaeological record indicates that there was an effective tendency in this period to develop settlement systems close to aquatic environments with abundant resources, and to accumulate mollusc shells in concentrated deposits, which often acquired a high visibility. In addition, shell middens are not the only evidence of a marked use of aquatic resources in this period. Non-shell midden littoral sites are also known, and technological improvements on fishing and watercraft that enabled the better exploitation of the aquatic ecosystems and resources are attested in both regions.

However, and despite several studies that have been undertaken on this matter, the importance of aquatic food resources for Late Mesolithic and Jomon peoples that left shell middens is still a huge topic of discussion. The formation of these shell middens results from the exploitation of areas with a high availability of aquatic food, notably molluscs. Accumulated shells are mostly from edible mollusc species. However, the archaeological record from numerous Late Mesolithic and Jomon shell middens has been revealing that access to other resources would also be vital, notably terrestrial food. The diversification of food resources (a broad spectrum economy) seems to have been a common trend for the

development of the Late Mesolithic and Jomon populations and is well-documented at several shell middens. The investigation of large shell middens has also been revealing that the accumulations of shells often resulted from long periods of occupation.

Late Mesolithic and Jomon shell middens are characterised by a strong variability in terms of site location, dimensions, formation processes, contents, activities, duration of occupation, and other aspects. Significant differences between sites can be observed not only between countries, but also at a regional scale. Although interesting, the diversity of the shell midden phenomenon represents an additional challenge in the investigation of these sites. Regarding site function, for example, shell middens in Europe and Japan have usually been divided into long-term residential occupations and logistical/specialised/temporary sites, following the Binford forager-collector model (Binford, 1980). Larger sites with a wide variety of artefacts, features and ecofacts, have tended to be considered long-term residential sites. However, the heterogeneity of these sites shows that the scenario would be more complex, and the functional classifications should be discussed.

Overall, in Atlantic Europe and Japan, Late Mesolithic and Jomon shell middens have been primarily regarded as a reflection of subsistence and human burial activities of the hunter-gatherer groups. However, the rich and varied evidence provided by these sites can reveal more than about food and death. In this regard, further analyses on shell middens are necessary on both sides of Eurasia, at several scales, concerning less approached topics, such as site formation, organisation, function and symbolism.

Chapter 3 Addressing site structure and function of shell middens

3.1. State of the art

The richness of the Mesolithic and Jomon shell midden records has been crucial to address several topics such as palaeoenvironment, human diets and funerary behaviour of Holocene hunter-gatherer groups. However, approaches concerning shell middens themselves – notably, those aimed to understand how these sites were used, maintained, internally organised, and how they worked in settlement systems – have been relatively rare. In this sense, site structure and function are both fundamental issues to explore in detail in order to better understand these sites.

3.1.1. About site structure

Site structure can be broadly defined as the distribution of artefacts/tools, features, faunal remains and other archaeological material that can be found in the space of a site (Binford, 1983; Gargett and Hayden, 1991; Wandsnider, 1996). The analysis of site structure aims to better understand the human activities carried out on the site (past behaviour) and the spatial dimension behind them. It approaches the relationship between the use of space and the spatial patterns evidenced by the archaeological assemblages. This type of analysis can also provide important information beyond the scale of a site, notably about the settlement system or the social structure of the group (Figure 22).

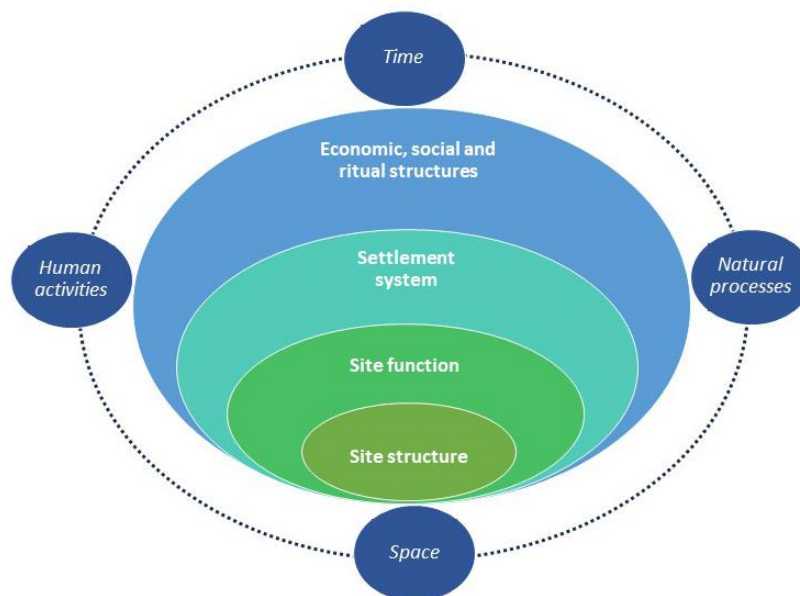


Figure 22: From site structure to economic, social and ritual structures – levels of analysis and important related elements (image by author).

Numerous elements can influence site structure, such as: (1) dimension of the site; (2) location/environmental conditions; (3) presence, types and arrangement of archaeological objects and features; (4) types of activities that were undertaken; (5) intensity and chronology

of site use; (6) population density, mobility and social structure; (7) site formation and post-depositional processes; (8) conditions of archaeological research, such as the dimension of the excavated area or excavation methods used (Binford, 1983; Bartram et al., 1991; Gargett and Hayden, 1991; Keeley, 1991; Kent, 1991; Rigaud and Simek, 1991; Stucki, 1993; Séara, 2014). In general, a greater residential stability of the groups can be related to a higher complexity of site spatial patterning, with increased evidence of physical demarcation of residential spaces and a higher quantity of features, although several elements, including post-depositional processes, can mask the evidence and change this relation (Lane, 2014, p. 116).

Studies on site structure were particularly developed between the 1970s and the early 1990s along with the increase of processual archaeology and an interest in reconstructing past lifeways/behaviours, notably through ethnoarchaeological research (e.g., Binford, 1978; 1983; Carr, 1984; Gargett and Hayden, 1991; Kent, 1991). At that time, much attention was given to the spatial arrangement of activities through the identification of *activity areas*, which were defined by Binford as ‘... places, facilities, or surfaces where technological, social, or ritual activities occur’ (Binford, 1983, p. 148). Traditional perspectives regarding this concept assume that the objects are organised in space according to the particular tasks performed at the site (Binford, 1992), an idea that implies that the activities are fixed in time and space (Clark, 2017, p. 1301). However, after substantial research progress, notably on the interpretation of spatial data and the methods of pattern recognition (Kroll and Price, 1991), the use of space by hunter-gatherer groups and the concept of an ‘activity area’ are now generally seen in a more complex and dynamic way. In fact, several activities can be performed in the same area, the same activity can be undertaken at different places and activities can change their location at the site for a large variety of reasons (e.g., O’Connell et al., 1991; Rigaud and Simek, 1991; Stucki, 1993; Clark, 2017).

Moreover, researchers have become increasingly aware of the fact that many sites contain evidence of several occupations that occurred at different times, and thus objects found near to each other cannot always be assumed to have been used or abandoned at the same time (Clark, 2017, p. 1302). An adequate integration of the effects of time/chronology into studies of site structure is thus crucial to deal with ‘apparent’ archaeological contexts. It has also been widely recognized that humans are only one of several elements that can generate patterns in archaeological deposits; in fact, archaeological patterns are often a result of several site formation processes of cultural and natural origins (Wandsnider, 1996, p. 321). Cultural and natural post-depositional processes have been assumed to modify the ‘original’ spatial organisation of material remains and cultural deposits at sites in several ways (Schiffer, 1975; 1983; Binford, 1981). Consequently, acquiring information on site formation processes is important to analyse site structure and reconstruct human behaviour from its archaeological context. As said by Binford, ‘... the challenge of interpreting site structure is no different from the challenge of archaeology in general.’ (Binford, 1983, p. 149). It is important to understand how that structure was formed, by distinguishing anthropogenic from natural processes, and intentional from unintentional components (Wandsnider, 1996). In fact, it can be considered that, in most cases, the spatial patterns that are observable from the archaeological record are predominantly a reflection of patterns of discard and their subsequent modification by post-depositional processes, rather than an immediate result of

patterns of primary use or individual activities (Clark, 2017, p. 1302). That means, for example, that high-density zones of archaeological objects do not necessarily mean a high intensity of primary activity at these zones (Binford, 1978).

Given the variety of elements that are implicated, site structure can be studied using various methods and techniques, such as visual analysis of the distributions of archaeological objects and features (e.g., the production of distribution maps by categories) and quantitative spatial analysis, often using geographical information systems (e.g., Morgan et al., 2013; Gonçalves et al., 2018; Magnin et al., 2020), feature analysis (e.g., Domingo et al., 2018; Sousa et al., 2018), refitting of archaeological material (e.g., Vandendriessche et al., 2023), geoarchaeological analysis (e.g., Duarte et al., 2017b) and ethnoarchaeological and experimental studies (e.g., Carrer, 2017; García-Piquer and Estévez-Escalera, 2018). There is no single preferable technique for analysing site structure. Instead, and considering the difficulties in interpreting the archaeological spatial patterns that have already been mentioned, the use of multiple approaches has been encouraged (Rigaud and Simek, 1991; Wandsnider, 1996). Also, different scales of analysis can be applied, ranging, for example, from the dwelling-space level to the site-level.

3.1.2. About site function

The analysis of site function is deeply connected with the study of site structure, since the identification of the activities performed at the site and the way those are organised determine the interpretation of site function in the settlement system. Considering that, it is difficult to establish a strict division between site structure and site function as a subject of analysis. Moreover, it seems clear that an analysis of site function cannot be limited to the scale of an individual site. Inter-site comparisons are required, integrating the wider context of the settlement system and the economic and social structure of the considered groups (e.g., Hausmann et al., 2019). Mobility, social organisation, subsistence patterns and technological systems are thus topics that are strongly associated with site function (Burke, 2006, p. 406).

Site function and settlement system analysis in hunter-gatherer contexts has usually resulted in the definition of site types and the creation of functional site taxonomies. However, researchers are increasingly aware of the fact that the archaeological record often presents variability (characteristics of the sites, mobility strategies and time of occupation), which is difficult to classify (Burke, 2006, p. 403; Preston and Kador, 2018, p. 326). In reality, several roles can be assumed by the same site at a certain moment of occupation. Also, site function can change across over time, particularly if the same place was occupied for a long time. In addition, not all sites in the settlement system can be archaeologically recognised, such as those that were destroyed or submerged, or temporary stations that left few traces (Habu, 1996). Thus, it becomes evident that site function needs to be analysed beyond categorical classifications and considering the limitations of the archaeological record and research.

Several elements have been taken into consideration to analyse site function. The archaeological materials and features, the location and the extent of the site are the most common aspects. Artefact types and faunal evidence have been more frequently used for analysing site type and mobility in hunter-gatherer contexts (Burke, 2006; Preston and Kador,

2018). In addition, stratigraphy/site formation and chronology have also been increasingly regarded as fundamental issues to better understand site function and its dynamics (Burke, 2006, p. 404). Despite the criticisms against its simplistic use (Preston and Kador, 2018), ethnographic data still have a strong influence on the interpretation of site function in hunter-gatherer contexts, as exemplified by the use of Binford's ethnographic and ethnoarchaeological observations about the Nunamiut (Binford, 1978; 1983), as well as his forager-collector model (Binford, 1980) by many different scholars in distinct contexts (Arnaud, 1989; Habu, 1996; Habu and Fitzhugh, 2002; Habu, 2004; Dupont et al., 2007b; Uchiyama, 2016 and many other examples from the Mesolithic and Jomon research can be referred). Binford's model characterises hunter-gatherer system variability into a continuum between residentially mobile foragers (movement of the entire group from one locality to another) and logistically mobile collectors (temporary movement of small task groups to and from residential base camps to activity camps) (Binford, 1980, pp. 5–12). Although other proposals have been suggested (many being very similar to Binford's model), the forager-collector model is so far considered by several authors as the most influential in hunter-gatherer archaeology (e.g., Habu and Fitzhugh, 2002; Lane, 2014).

3.1.3. Approaching site structure and function of shell midden contexts

Throughout the history of its research, shell middens have been frequently assumed and approached as refuse deposits. This preconception and the apparent similarity between the sites have conditioned the formulation of functional perspectives. The studies of internal spatial patterning of shell middens have also been affected by the recurrent assumption that the accumulation of the midden/refuse is an occurrence without any kind of discernible organisation.

In Atlantic Europe and Japan, the function of shell middens has been mostly analysed through the study of evidence of activities provided by these sites – particularly of economic and funerary activities (e.g., Arnaud, 1989; Abe, 2014a; Dupont and Bicho, 2015; Koizumi, 2016; Peyroteo Stjerna, 2016). Economic activities have been mainly approached through the analysis of artefacts (either through techno-typological and functional analysis) and archaeozoological materials. The enhanced conservation of faunal remains enabled by these sites has supported the development of studies on seasonality (e.g., Arnaud, 1989; Koike, 2017; Nakajima et al., 2018; Dias et al., 2019), which have strong relevance for the determination of site function, notably through the evaluation of the intensity of site frequentation (year-round or temporary/seasonal use) and the type of activities that were carried out (hunting, gathering and fishing).

Due to the complexity of studying the contents of shell middens, the use of sampling procedures has been common to analyse economic activities and seasonality at these sites (Komiya, 2015). However, in many cases, the contents of the site have been assumed to be homogenous, without an appropriate analysis of its chronological dimension (Stucki, 1993). Thus, an adequate establishment of the chronology of site use is crucial, by undertaking series of radiocarbon dates from different features, areas and sequences, and using other methods, such as artefact typology (for example, pottery styles of the Jomon period) and stratigraphic analysis (Stucki, 1993, p. 125; Koike, 2017, p. 153).

Concerning the site structure of shell middens, the analyses in Atlantic Europe (e.g., Alvim, 2009; Cascalheira and Gonçalves, 2011; Dias et al., 2012; Gonçalves et al., 2018; Marchand et al., 2018) and Japan (e.g., Nakamura, 2005; Tajima et al., 2013; Koizumi, 2016; Nishida et al., 2016b; Nishino et al., 2017; Nakajima et al., 2018) have been mainly focused on the distribution of material remains, the characteristics and spatial arrangement of features and the layout of the shell accumulations. In general, the analyses on site structure of shell middens have been generally less developed than those centred on site function. That is especially noticeable for the Late Mesolithic record in Europe, as already mentioned by several scholars (e.g., Gutiérrez-Zugasti et al., 2011; Cascalheira et al., 2015). The avoidance of this topic can be considered as a general tendency of shell midden studies (Stucki, 1993, p. 123), although some additional reasons can be suggested for the regions and periods concerned in this study. Firstly, extensive excavations of Mesolithic, and also of Jomon, shell middens have been rare in recent times. As a consequence, for many sites, datasets are spatially limited, being often restricted to the shell concentrations, without including adjacent areas, as pointed out by several researchers (Gutiérrez-Zugasti et al., 2011; Fano and Cubas, 2012; Dupont and Bicho, 2015; Koizumi, 2016). This aspect becomes an important limitation to approach intra-site arrangement, and also to obtain a more complete picture of the functional aspects of shell middens. Secondly, the identification of intra-site activity areas is not an obvious task for many shell middens. A number of reasons can be referred, notably the lack of archaeological visibility of some activities, features and materials (e.g., organic materials other than bones which are particularly perishable), the stratigraphic complexity and the high susceptibility to post-depositional processes of many of these sites.

The problem of visibility

In hunter-gatherer contexts in general, some activities can be of limited visibility within the archaeological record, depending on the degree of mobility of the groups (Waselkov, 1987, p. 116). In this sense, it is evident that the features found in the Late Mesolithic shell middens in Europe are generally much less frequent and archaeologically visible compared to those from many Jomon sites. The quantity and visibility of features are also considerably different between the Jomon shell middens in western and eastern Japan (see Chapter 4). In addition, certain types of features, such as pits and surface dwellings, can be difficult to identify if placed in middens, due to the continuing accumulation and recycling of materials that can occur at these sites (Rowley-Conwy, 2013; Hardy et al., 2016).

Stratigraphic complexity

Many shell midden sites are characterised by complex stratigraphies that pose problems to archaeologists when differentiating different units to make their interpretation (Stucki, 1993; Aldeias and Bicho, 2016). According to Vila and collaborators (2009, p. 109), the stratigraphic complexity of these sites is caused by several factors, notably: the high-speed accumulation of volume that typically occurs (with large amounts of shellfish remains often appearing in the field as multiple, juxtaposed shell layers, or a single homogeneous massive layer); the limited extent of circumscribed deposits; the scarcity of soil matrix in many

deposits and the frequent use of the site for trash accumulation and reuse for occupation, increasing the possibility of anthropogenic post-depositional alterations.

Frequently, shell middens are considered to be *palimpsests*. This concept highlights the formation of these sites by successive depositional and post-depositional processes and the consequent difficulties in establishing correlations of items in time and space, and to identify individual occupations or activities (Gargett and Hayden, 1991; Stucki, 1993; Bailey, 2007; García-Piquer and Estévez-Escalera, 2018). These difficulties are particularly felt in case of long occupations, being discussed in detail by Geoff Bailey (Bailey, 2007, p. 204):

'We know that the many millions of shells that make up a sizeable midden must represent a multitude of separate shellgathering episodes, but resolving the mass of shells into these separate episodes except at a very gross level of stratigraphic or chronological resolution is rarely possible. The full range of variability represented by the individual episodes buried within these palimpsests is usually inaccessible and we can only observe the average tendencies represented by the palimpsest as a whole.'

However, for Bailey, shell middens are *cumulative palimpsests*, a specific type of palimpsests in which '... the successive episodes of deposition, or layers of activity, remain superimposed one upon the other without loss of evidence, but are so re-worked and mixed together that it is difficult or impossible to separate them out into their original constituents' (Bailey, 2007, p. 204). According to the researcher, cumulative palimpsests are characterised by a loss of resolution, instead of material. In this sense, it is still possible to detect average tendencies in the archaeological sequences and, occasionally, to find preserved individual episodes, as revealed by some recent micromorphological analyses at shell midden sites (Duarte et al., 2017b; Duarte, 2019).

Usually, and considering the richness and complexity of these sites, the excavations of shell middens in Atlantic Europe and Japan are meticulous and use careful sieving procedures, recovering of sediments and sorting of artefacts/ecofacts. The individual record of the position of artefacts has been largely applied, as observed in the most recent excavations of Mesolithic shell middens, where the use of a total station was generalised and applied to the plotting of small lithic tools (Casalheira and Gonçalves, 2011; Arias et al., 2015a; Gonçalves et al., 2018; Marchand et al., 2018).

Post-depositional processes

Shell middens are particularly susceptible to numerous post-depositional processes of natural and anthropogenic origin, which can completely destroy or significantly change the sites, by affecting the original spatial distribution of materials and causing movement, mixture and destruction of deposits and features. This vulnerability increases the difficulties in interpreting these sites and their distribution.

Bioturbation and erosion caused by several elements, such as water or wind, can significantly affect shell middens (Duarte et al., 2017b; Szabó, 2017). In addition, sites located on the immediate shoreline or riverfront can be strongly disturbed by marine/riverine erosion, redeposition, accumulation of sediment and even burial and complete destruction caused by changes in sea-level (Waselkov, 1987; Hausmann et al., 2022). The high frequency

of shell middens in open-air locations, with sandy contexts, as observed in Atlantic Europe and Japan, also increases the possibilities of being affected by natural post-depositional processes (Claassen, 1998; Duarte et al., 2017a; 2017b; Hardy, 2017; Szabó, 2017). In addition, shell fragments can also suffer partial dissolution, decalcification and natural redeposition of carbonates in other strata (Aldeias and Bicho, 2016, p. 10).

Since shell midden formation is largely controlled by anthropogenic processes (Duarte et al., 2017b), post-depositional processes of human origin are also common at these sites. Deposits can be transformed by a wide variety of actions, including the construction of features, burning, trampling and site maintenance. Although some authors consider that shell layers are relatively resistant to the effects of trampling (Stucki, 1993, p. 123), several geoarchaeological studies have detected evidence of this activity in shell middens. These studies have demonstrated that the phenomenon can significantly impact the deposits, notably causing the dispersal and fragmentation of shells (Aldeias and Bicho, 2016; Duarte et al., 2017a; Szabó, 2017). Additionally, fragmentation is likely to affect the most fragile mollusc species with a greater intensity (Szabó, 2017, p. 776). At the same time, the identification of trampling in shell middens can also be useful to detect intra-site areas of intensive occupation (Duarte et al., 2017b). Site maintenance also seems to considerably affect these sites, through clean-up operations/displacement of material and redeposition of sediments (Keeley, 1991; Rowley-Conwy, 2013; Aldeias and Bicho, 2016; Hardy et al., 2016; Duarte et al., 2017b). On the one hand, according to Lawrence Keeley (1991, p. 258), cleanup material tends to accumulate in special disposal areas such as middens. On the other hand, it is recognised that cleanup operations are conducted with more frequency and investment in sites with an intensive and/or prolonged use, notably for domestic purposes (Binford, 1983; Keeley, 1991), which is the case at several Mesolithic and Jomon shell middens. Peter Rowley-Conwy considered that ‘smearing and blending’ and recycling of materials are typical, active processes in shell middens, which could explain, for example, the scarcity of documented dwellings in Mesolithic shell middens (Rowley-Conwy, 2013, p. 149). Constant changes to the sites caused by ongoing accumulation and successive on-site activities were directly observed by Karen Hardy and collaborators at recently formed shell middens in the Saloum Delta, Senegal (Hardy et al., 2016). Overall, maintenance and successive occupational activities at the sites can lead to the dismantling of existent features and the mixture of previously deposited materials, generating a homogeneous image of the archaeological evidence (Keeley, 1991, p. 258) (Figure 23).

Too many problems?

It becomes clear through the description above that approaching shell middens, and especially the structure and function of these sites, is not an easy task. However, it can also be stated that avoiding difficult topics does not recover any additional information about the past. For example, concerning site structure, LuAnn Wandsnider (1996, p. 321) recognised that limiting its analysis to sites which exhibit an obvious or evident structure / organisation does not contribute to a more correct perspective. Contrary to this, these options can only lead the researchers to have more restricted views and preconceptions of the past.

In fact, any archaeological record provides a complete and immediate image of past activities at a site. Palimpsests, in general, are seen negatively in the archaeological literature, but many archaeological sites, other than shell middens (if not all), can be considered to be palimpsests. In addition, several researchers have stated that the positive aspects of the palimpsest nature of shell middens should be more valued, notably their accumulative and transforming properties, which are behind the formation and good preservation of these deposits, and in many cases, the acquisition of their prominent form on the landscape and social/symbolic significance among communities (Bailey, 2007; Vila et al., 2009). The different patterns introduced by natural or cultural post-depositional processes can also be seen in a less negative way, since these elements are a part of the sites and essential to know about their site history, organisation and function (Wandsnider, 1996, p. 321).

Overall, and despite all the difficulties and limitations, approaching site structure and function can be considered to be a necessary effort to better understand shell midden sites in terms of past human behaviour.



Figure 23: Reconstruction of activities carried out at a shell midden. Illustration by Gyldendal published c. 1907 (National Museum of Denmark, license: CC-BY-SA 4.0).

3.2. Main questions about shell midden site structure and function in Late Mesolithic Atlantic Europe and Jomon Japan

Atlantic Europe and Japan are certainly among the most investigated areas in Eurasia concerning Holocene shell middens. However, the large quantities of available data in these regions have been hard to process and compare. Moreover, most investigations of these sites have been directed towards the study of the palaeoenvironment, subsistence and funerary practices of the hunter-gatherer communities. Approaches to site structure and function have been less common, particularly in what concerns the Late Mesolithic in Atlantic Europe and the Jomon period of western Japan. Despite several differences in the contexts and research traditions between Europe and Japan, the following common questions can be asked regarding the structure and function of the Late Mesolithic and Jomon shell middens:

- 1) Is *site structure* discernible through the archaeological record of these shell middens? How can it be understood and interpreted, considering the problems of visibility of features, stratigraphic complexity and post-depositional processes that often occur at

these sites? How diverse is the structure of shell middens? Are the spatial patterns similar in any aspect between the Late Mesolithic and Jomon shell middens?

- 2) What *types of activities* are undertaken at these shell middens or associated with them? Are some activities (e.g., deposition of shells, food processing, food consumption, artefact production and funerary activities) more relevant than others at certain sites, areas of the sites or periods of occupation? How variable are the *functions of shell middens* that can be assigned to each site, site cluster and region, and which factors seem to be correlated with this variability? Are shell midden site typologies adequate and useful?
- 3) Can *intra-site organisation* reflect specific *site functions*? Is there a relation between certain formal characteristics of the sites and specific characteristics of site structure or function?
- 4) Regarding the relation between shell midden site structure/function and the nature of the hunter-gatherer groups that constructed these sites, how is the *social structure* and *complexity* of Mesolithic and Jomon communities reflected in shell midden site structure and function? Is a higher social complexity reflected in a higher complexity of shell midden site structure and function?
- 5) What is the role of shell middens in Mesolithic and Jomon *littoral settlement systems*?
- 6) How can *research methodologies and contexts of research* (e.g., cultural background) affect the interpretations about site structure and function of shell middens?

PART II

Chapter 4 Review and analysis of data and perspectives on shell midden site structure and function: case studies from the Late Mesolithic of Atlantic Europe and the Jomon period of Japan

4.1. Analytical methods

In order to approach the questions presented in the previous chapter in a comparative way, a critical review and analysis of available archaeological data and perspectives on shell midden site structure and function was undertaken, based on cases from the Late Mesolithic of Atlantic Europe and Jomon period of Japan.

A literature review on shell midden groups from both regions was carried out with a focus on the main characteristics, structure and function of the sites. Regarding the Jomon sites, this work presents some well-known cases from Tokyo Bay in eastern Japan, although the research was centred on cases from western Japan between the end of the Initial Jomon and the end of the Late Jomon (end of the 9th millennium–end of the 4th millennium cal BP). Available information is rare in western Japan compared to the east, but this study intends to approach a less investigated region, and to contribute to the construction of a broader view of Jomon shell midden use that includes areas described as having a lower degree of social complexity, and thus closer to what is observed in Mesolithic sites in Europe.

Two regions in two Atlantic Europe countries – Portugal and France – and one region in western Japan – Okayama prefecture – were selected as case studies for detailed analysis of the sites. A site database was constructed in an attempt to systematise the available information about the physical traits, contents and functional characteristics of the shell middens from these regions. Several elements were included, notably those related to site location (altitude, environmental setting, distance to the main water source in the past, and the main aquatic environment it was associated with or exploited), chronology (radiocarbon data, estimated period of site occupation and shell midden accumulation), formal aspects of the site (estimated area of distribution of shells, total area of the site, estimated volume, shell midden type, form, thickness of the shell deposit), contents (associated materials and features, number and main categories of animal classes, number and main categories of malacological species, etc.) and site function (number and types of activities undertaken at the site or associated with the site, functional characterisation of the site). Then, some quantitative and qualitative parameters were selected for analysis and comparison of the main tendencies of the shell midden groups (Table 4). Parameters were classified according to a limited number of general categories (*Appendices – Table A1*). In addition, the available evidence of intra-site spatial organisation and the site functional classifications attributed in the settlement systems were reviewed and discussed.

Table 4: List of selected parameters for comparative analysis of shell middens.

Parameter	Classification categories
Altitude (<i>in meters</i>)	-
Distance to the main water source in the past (<i>river, coast or lake</i>)	▪ Less than 2 km ▪ Between 2 and 5 km ▪ More than 5 km
Main aquatic environment (associated with the shell midden or exploited)	▪ Saltwater (open rocky coast) ▪ Saltwater (inner bay) ▪ Brackish water and saltwater ▪ Brackish water (estuary or lagoon) ▪ Freshwater
Shell midden type	▪ Mound (shell accumulations totalling more than 1.5 m of thickness) ▪ Layer (shell accumulations totalling less than 1.5 m in thickness) ▪ Spot (shell accumulation in a limited area of less than 10 m² in a larger site) ▪ Unknown
Area of distribution of shells (<i>minimum estimate in square meters</i>)	-
Total thickness of the shell deposit (<i>minimum estimate in meters</i>)	-
Animal classes <i>Considered classes: 1) invertebrates, 2) fish, 3) amphibians, 4) reptiles, 5) birds, 6) mammals</i>	▪ Diverse (four or more classes) ▪ Limited (less than four classes) ▪ Unknown
Malacological species	▪ Diverse (five or more species) ▪ Limited (less than five species) ▪ Unknown
Artefacts (<i>main occupation</i>) <i>Considered classes: 1) lithic artefacts, 2) pottery and other clay artefacts, 3) bone and antler artefacts, 4) shell artefacts, 5) other artefacts</i>	▪ Diverse (more than one class of artefacts*) ▪ Limited (one class of artefacts) ▪ Unknown or absent
Chipped stone tools (<i>main occupation</i>)	▪ Diverse (presence of all categories of the lithic chaîne opératoire**) ▪ Limited (absence of some categories of the lithic chaîne opératoire) ▪ Unknown or absent
Presence of human burials	▪ Yes ▪ No ▪ Possible (scattered human remains)
Number of human burials	▪ Abundant (eight or more features)

	▪ Rare (less than eight features)
Presence of non-burial features	▪ Yes ▪ No ▪ Possible
Number of non-burial features	▪ Abundant (eight or more features) ▪ Rare (less than eight features) ▪ Unknown
Presence of dwelling features	▪ Yes ▪ No ▪ Possible
Activities (undertaken at the shell midden or associated with the shell midden) <i>Considered types of activities: 1) food or other resource acquisition activities, such as hunting, gathering, fishing or raw-material acquisition, 2) food or other resource processing activities, such as combustion*** and storage, 3) tool production, 4) funerary or other ritual activity, 5) residential or other activity</i>	▪ Diverse (three or more types; minimum estimate) ▪ Limited (less than three types)
Estimated period of shell midden accumulation	▪ 200 years or less ▪ Between 200 and 1000 years ▪ More than 1000 years
Estimated period of site occupation	▪ 200 years or less ▪ Between 200 and 1000 years ▪ More than 1000 years

Notes:

* The presence of few pottery sherds was not considered in this count.

** Sites with the presence of all categories of the lithic *chaîne opératoire* excepting the category of debris were also included in this count.

*** Although combustion can also be part of ritual activities, it was only counted as a processing activity in this analysis.

4.2. Case studies from the Late Mesolithic of Atlantic Europe

4.2.1. Shell middens in Portugal

4.2.1.1. Overview

In the current territory of Portugal, in south-western Europe, a significant number of Mesolithic shell middens have been identified. In fact, the Mesolithic in Portugal is mostly known through the shell midden record, which is concentrated in the central and south-western littoral regions (Price, 1987; Arias, 1999; Carvalho, 2009; Araújo, 2016). According to the Portuguese national archaeological site database (*Portal do Arqueólogo*) and the available literature, around 38 sites correspond to shell middens with occupations that are dated or attributable to the Late Mesolithic² (Figure 24). Most of these shell middens are open-air sites

² However, in some cases, it is not clear if the site had a Late Mesolithic or Early Neolithic occupation, or both. For 13 sites, radiocarbon dates are not available.

and located in estuarine or estuarine and open coastal environments. The shell midden clusters of the Tejo and Sado valleys, in particular, became internationally well-known, mainly due to the funerary nature of the sites – a total of more than 400 human skeletons have been found so far (Ribeiro, 1884; Roche, 1972; Arnaud, 1989; Cunha and Umbelino, 2001; Jackes and Lubell, 2012; Peyroteo Stjerna, 2016). Some shell middens in the Tejo valley are also known for their large dimensions and mounded form (Costa, 1865; Ribeiro, 1884; Roche, 1972; Bicho et al., 2010).



Figure 24: The Iberian Peninsula and location of Late Mesolithic shell middens in Portugal (according to the data from *Portal do Arqueólogo* database and available literature), with indication of the main site groups mentioned in this text (image by author).

The available chronological data indicate that the formation of some sites in the Tejo and Sado valleys started around 8300–8200 cal BP (Araújo, 2016; Peyroteo Stjerna, 2016; Peyroteo-Stjerna, 2021). The development of shell middens in these estuaries has been considered to be a consequence of the reorganisation of human settlement at that time (Araújo, 2009; 2015; 2016; Bicho et al., 2010). The Early Mesolithic shell middens that are known in what is currently Portugal are distributed over the central-southern coasts (Estremadura, littoral Alentejo and western Algarve regions), while most of the Late Mesolithic shell middens are concentrated in the inner parts of the estuaries formed during the Holocene transgression, notably in the Tejo, Sado and Mira valleys. These changes to coastal settlements have been fundamentally attributed to environmental and ecological causes. Sea-level rise has been associated with the submergence of early coastal ecosystems, the advance of estuaries inland and, together with climatic amelioration, the creation of attractive ecotones with abundant aquatic and terrestrial food resources (Araújo, 2009; 2015; 2016; Carvalho, 2009; Bicho et al., 2010). The impacts of the 8.2 ka BP event have also been highlighted by several authors, notably its contribution to a decrease in the intensity of upwelling and coastal resources, a rapid sea-level rise and consequent changes to coastal

morphology (Zilhão, 2003; Bicho et al., 2010). However, some researchers have been reluctant to consider this event as the primary cause of settlement changes (Araújo, 2016).

Several similarities and differences have been reported between the shell middens of the Tejo and Sado valleys in aspects such as site location, palaeoenvironment, chronology, stratigraphy, funerary rituals or material culture (Arnaud, 1987a). Both complexes are located in inner areas of the estuaries, with a preponderance of estuarine molluscs *Scrobicularia plana* and *Cerastoderma edule* among the malacological species. However, the shell middens of the Tejo valley were formed in the mesial part of the large Tejo palaeoestuary, where mollusc and fish resources were abundant, while the Sado shell middens were located near or beyond the upstream end of the Sado palaeoestuary, at a relatively higher distance to aquatic resources. This detail on site location has been related by some authors to the differences observed between the two complexes in terms of site morphology (Diniz and Arias, 2012; Duarte et al., 2017a). The shell middens in the Tejo valley are known by their prominence on the terrain due to their vertical development and large dimensions, with some of the sites reaching up to 4–5 m thick of superimposed shell-rich layers (Roche, 1963). Contrary to this, the Sado shell middens are more discrete and do not present a mounded form, having little topographic visibility on the terrain. The excavations so far at the Sado shell middens have revealed a maximum stratigraphic depth of 1–1.5 m, with shell layers (usually no more than 0.60–0.80 m in thickness) lying on the Pleistocene sands (Arnaud, 1987a; 1989; 2000; Diniz and Arias, 2012). According to the observations of José Arnaud, the Sado shell middens would have been mostly formed by lateral juxtaposition rather than vertical accumulation of deposits (Arnaud, 1987a; 2000). However, recent geoarchaeological studies indicate that similar anthropic activities occurred in the sites of Tejo and Sado valleys and the accumulation of deposits took place by superposition and juxtaposition in both complexes (Duarte et al., 2017a; Duarte, 2019).

It has been assumed that the shell midden complexes in the Tejo and Sado valleys were used more or less synchronously during the Late Mesolithic (Arnaud, 1987a; Martins et al., 2008; Peyroteo Stjerna, 2016; Peyroteo-Stjerna, 2021). In both valleys, a large number of human burials was found, leading several researchers to consider the sites to be cemeteries or necropolises (e.g., Arnaud, 1989; 2000; Carvalho, 2009; Peyroteo Stjerna, 2016). Frequently, these burials seem to be organised in clusters and located in specific areas of the sites (Arnaud, 2000; Peyroteo Stjerna, 2016). Considering the high presence of burials, a more permanent character of Late Mesolithic sites compared to those from the preceding period has been generally assumed (Arnaud, 1989; 2000; Roche, 1989; Marchand, 2005; van der Schriek et al., 2007; Soares, 2013; Araújo, 2015). In addition to burial features, the presence of other structures has also been noted, such as postholes, pits, pavements and combustion features (Roche, 1989; Arnaud, 2000; Bicho et al., 2017). So far, possible dwelling features were only found at Moita do Sebastião, Muge (Roche, 1963; 1989), although their function are open to debate (Alvim, 2009). Regarding the archaeological material, lithic remains have been abundantly detected and characterised by the importance of microlithic industries with abundant production of bladelets and geometric microliths (Arnaud, 1989; Araújo, 1995–1997; Marchand, 2001; 2005; Cascallheira et al., 2015; Nukushina, 2015; Paixão et al., 2019). Body adornments, mostly made on shells, stones and red deer teeth, have also been identified

(Arnaud, 1989; André and Bicho, 2016). Moreover, a large quantity of faunal remains has been found, which, together with the isotope analyses undertaken on human remains, have suggested that these groups had a mixed-diet of terrestrial/aquatic food resources, but show important intra and inter-regional variations (Umbelino et al., 2007; Fontanals-Coll et al., 2014; Rowley-Conwy, 2015; Diniz, 2016; Peyroteo Stjerna, 2016).

Despite the attention given in the literature to the largest shell middens of the estuaries, coastal shell middens, mainly of small or very small dimensions, are also known in the Late Mesolithic, notably in the littoral area of Estremadura (Sousa et al., 2016) and the south-western Alentejo Coast/western Algarve regions (Soares, 1996a; Zilhão, 1998; Lubell et al., 2007; Reis, 2014; Valente et al., 2014).

Fundamentally, Late Mesolithic shell middens have been divided into two functional categories: specialised sites, characterised by accumulations that would have been formed during short stays for specialised activities (notably the gathering and consumption of molluscs), and base camps/residential sites, characterised by larger dimensions, longer occupation and the practice of several subsistence, domestic and funerary activities (Arnaud, 1989; Soares, 1996a; Arnaud, 2000; Marchand, 2001; Carvalho, 2009; Araújo, 2016). While many estuarine sites have been classified as residential sites, most coastal sites have been considered to be temporary/specialised sites (Soares, 1996a). However, in the case of the Sado valley, it has been considered that residential and specialised sites would have coexisted as part of the same estuarine settlement system, with seasonal movements between base camps and logistical movements to smaller specialised/temporary camps (e.g., Arnaud, 1989; 2000; 2002). The available data on seasonality from several analyses of faunal remains from the Tejo and Sado complexes are somewhat contradictory, although most studies propose a seasonal use of the sites and the practice of strategies of logistical mobility by these hunter-gatherer groups (Arnaud, 2000; Rowley-Conwy, 2015; Dias et al., 2019). At the same time, the residential character of larger shell middens has been discussed, since the identification of clear dwelling features in the archaeological record has been lacking (Alvim, 2009; Peyroteo Stjerna, 2016).

4.2.1.2. Tejo valley

4.2.1.2.1. Introduction

The shell middens of the Tejo (or Tagus) valley (also referred to in the literature as Muge shell middens) are located in southern-central Portugal, in the Ribatejo region, about 60 km upstream of the current estuary in Lisbon. The 13 known sites are located on low–medium height terraces and distributed along the three tributaries of the Tejo River left bank – Fonte da Moça, Muge and Magos (Figure 25, Figure 26). Some sites are very large and comprise long and complex stratigraphic sequences 4–5 m thick. Usually, shell middens present a circular or semi-circular shape and a mound-type formation with a dense shell-filled matrix (Roche, 1963; Bicho et al., 2013a; Aldeias and Bicho, 2016). However, except for the sites of Cabeço da Amoreira and Cabeço da Arruda, the other middens were destroyed by agricultural works or completely excavated during early research. As a result, the information about many of these sites is little, dispersed, or even lost.

Research on these sites started in the middle of the nineteenth century, when the first shell middens were discovered, excavated by Carlos Ribeiro, the first director of the Geological Commission of Portugal, and presented to the Ninth International Congress of Anthropology and Prehistoric Archaeology held in Lisbon (Costa, 1865; Ribeiro, 1884). The investigation continued in the 1930s under the direction of António Mendes Corrêa (Corrêa, 1933; Cardoso, 2011). In the 1950s and 1960s, more important field work was conducted, notably at Moita do Sebastião, located at the left margin of the Muge River, by Jean Roche and Veiga Ferreira (Roche, 1952; 1963; 1989). More recently, excavations were undertaken between 1999 and 2003 at Cabeço da Amoreira, Cabeço da Arruda and Cabeço dos Morros by José Rolão's research team (Rolão et al., 2006), and, since 2008, under the interdisciplinary projects directed by Nuno Bicho and collaborators (Bicho et al., 2013b; 2017). Several analyses have been published concerning these shell middens on varied topics such as history of archaeology (Cardoso and Rolão, 2000; Cardoso, 2011; 2018), funerary/ritual behaviour (Jackes and Meiklejohn, 2004; Alvim, 2009; Jackes and Lubell, 2012; Peyroteo Stjerna, 2016), chronology (Martins et al., 2008; Bicho et al., 2013a), zooarchaeology (Detry, 2007; Detry and Cardoso, 2010; Dias et al., 2019), palaeoenvironment and archaeobotany (van der Schriek et al., 2007; Monteiro et al., 2017), geoarchaeology (Aldeias and Bicho, 2016), palaeodiet (Lubell et al., 1994; Umbelino et al., 2007), visibility studies (Gonçalves et al., 2014) and material culture (Paixão et al., 2019). Overall, the excavations of the shell middens provided a high number of artefactual remains (lithic and bone tools, shell ornaments and other remains), faunal assemblages, human remains, and other archaeological material. Several features were also discovered. In the largest sites (Moita do Sebastião, Cabeço da Amoreira and Cabeço da Arruda), numerous burials and other features (pits, postholes and hearths) were identified, mostly at the bottom of the stratigraphy.

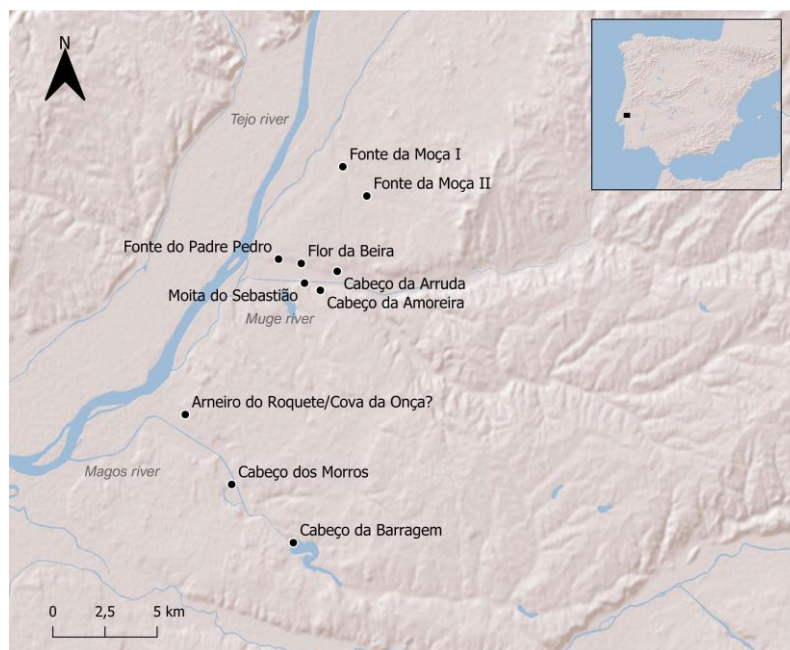


Figure 25: Location of the shell middens of the Tejo valley, Portugal (according to *Portal do Arqueólogo* database and Gonçalves, 2014) (image by author).

Despite the importance given to the excavation of graves, the early researchers, such as Francisco Pereira da Costa and Jean Roche, assumed that the shell middens of the Tejo valley were residential sites, based on the presence of a high quantity of material remains and features (Costa, 1865; Roche, 1963). Roche believed that the communities lived on the middens, considering the absence of residential features in the immediate surroundings of the sites, the type of features that were found at Moita do Sebastião and some stratigraphic indicators, such as the abundance of crushed shells and evidence of the movement of deposited sediments (Roche, 1966, p. 40; 1980). The residential function of these sites continued to be generally accepted by subsequent researchers. For example, through a lithic analysis, José Rolão (1999a) established a division between residential base camps (sites with domestic features and a high quantity of lithic remains, and occupied year-round, such as Cabeço da Amoreira, Cabeço da Arruda and Moita do Sebastião), and shell middens ‘for support’, characterised as temporary/specialised sites (Vale Fonte da Moça I and II, Cabeço dos Morros and Cova da Onça). Also, Grégor Marchand argued that the Muge shell middens correspond to large residential sites with a high degree of sedentism or, at least, with several occupations over a long period (Marchand, 2001; 2015). However, other works around the Tejo valley considered the residential nature of these sites to be unclear, giving a greater relevance to the funerary and ritual component of these shell middens (Alvim, 2009; Jackes et al., 2014; Peyroteo Stjerna, 2016). According to the most recent perspectives from Nuno Bicho’s team, the function of these sites could have changed during the time of occupation (Dupont and Bicho, 2015). It was also proposed that these sites were not residential in nature most of the time, as would be the case at Cabeço da Amoreira (Gonçalves et al., 2018).



Figure 26: Muge area, Portugal (view from Moita do Sebastião) (photo by author).

Recently, the existence of some functional, and possibly social, variability between the sites in the Tejo valley has been suggested, based on the differences observed in the artefacts, stratigraphy and other elements (Gonçalves et al., 2014, p. 131). This view contrasts with chronological variability models presented before by other authors (Roche, 1966; Marchand, 2005) and is in accordance with the radiocarbon data that indicate that most sites were in use at the same time (Bicho et al., 2013a; Peyroteo-Stjerna, 2021). However, several aspects require further investigation, including the causes of the inter-site differences on lithic

remains, notably the dominant geometric microliths types (Arnaud, 1987a; Paixão et al., 2019). In addition, trace element and isotopic data obtained from the individuals buried at these sites are indicative of a balanced intake of marine-estuarine and terrestrial food, suggesting an overall inter-site homogeneity in the diets of these groups (Umbelino et al., 2007; Peyroteo Stjerna, 2016). Therefore, at the current stage of knowledge, elements of inter-site homogeneity and heterogeneity can both be indicated concerning these shell middens.

4.2.1.2.2. Moita do Sebastião

Important data on shell midden site structure in the Tejo valley come from the excavations carried out at Moita do Sebastião (Salvaterra de Magos, Santarém), located on the left bank of the Muge tributary, at 20 m of altitude (*Appendices – Table A2*). According to the first descriptions from the end of the nineteenth century, the site presented an ellipsoidal form with 90–100 m length and 75 m width and a stratigraphic depth of about 2.5 m (Arnaud, 1987a). It was excavated for the first time by the Geological Commission, which found about 80 skeletons (Ribeiro, 1884). Between 1952 and 1954, another set of excavations were undertaken by Jean Roche and Octávio da Veiga Ferreira, in order to investigate the areas of the site that survived after the destruction caused by construction works (Roche, 1963; 1972; 1989) (Figure 27). It was the first time that such a large area of a shell midden had been excavated in Portugal (Arnaud, 2002, p. 60). Unfortunately, only the bottom of the stratigraphic sequence escaped the destruction and was excavated. As a consequence, most of the discovered archaeological materials and skeletons came from the lower layers of the site and few stratigraphic details are available about the site.



Figure 27: General view of the shell midden of Moita do Sebastião, Tejo valley, in the 1950s (reproduced from Roche, 1972, fig. P1:1).

In total, 34 human graves were identified at the site (26 with adult individuals and eight with child remains, some of them containing more than one individual). In addition, 86 negative features (pits and postholes) were detected and interpreted as domestic structures. According to the perspective of Roche (1963; 1989), the site was divided into two main parts: a residential area (which included a feature interpreted as hut and other non-burial features) and burial zones (Figure 28). Adults were buried in two zones outside the residential area,

while children were buried in a specific zone, arranged in semi-circle, inside the residential area and close to the other features. It was also observed that the grave pits were dug in the basal terrace sands, and some were filled with deposits of closed mollusc shells. Adornments and ochre were also identified and associated with the funerary ritual (Roche, 1972, p. 132). Negative features other than graves included 61 postholes and 20 pits that were concentrated in the residential area (Figure 29). A sub-rectangular pit was identified among them, measuring 11.60 m in length, 3.20 m in width and 0.80 m in depth. The pit seemed to have been opened at the bottom of the shell midden (calcareous rock), filled with a dark sediment and partially bordered by pebbles in the north-west area. At the base of the pit, a surface of pebbles was identified. This feature was interpreted as a dwelling surface by Roche. According to the author, the feature was cut by a second dwelling or a wind-cutting structure, which was defined by a series of postholes of different dimensions that delimited a semi-circular area of about 36 m² and opened to the south (Roche, 1963; 1989). Under this perspective, the two features would have been part of a residential phase of the site, before its funerary use. The presence of two pits filled with closed shells of *Scrobicularia plana* was also highlighted and interpreted as storage features. However, this hypothesis – strongly embraced by some authors (Soares, 1996b) – was rejected by other researchers (Arnaud, 1987a; Alvim, 2009), considering the quick deterioration that the molluscs suffer soon after their collection. According to Arnaud, these deposits could simply correspond to shells destined to be opened through fire (Arnaud, 1987a, p. 58). In addition, some pits with evidence of combustion activities (ash and fire-cracked rocks) were identified (Roche, 1972; 1989), probably corresponding to hearth-pits and surface hearths.

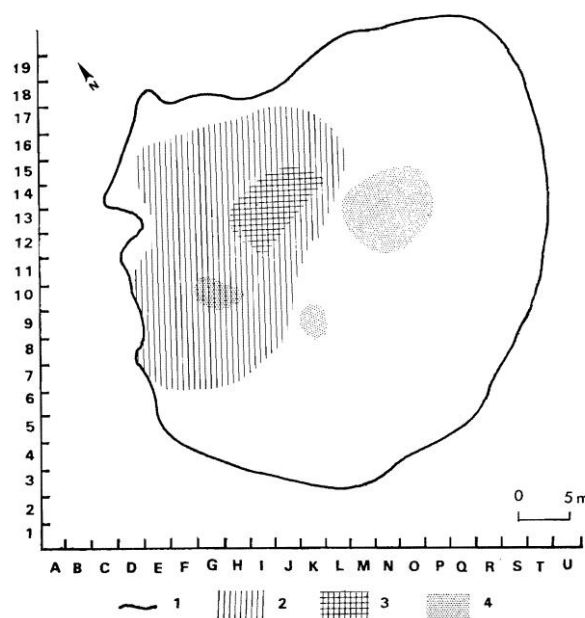


Figure 28: Moita do Sebastião, Tejo valley – intra-site spatial organisation according to the interpretation of Roche: 1) limit of the shell midden, 2) zone of rearrangement of the living space, 3) hut emplacement, 4) burial zones (reproduced from Roche, 1989, fig. 2).



Figure 29: Moita do Sebastião, Tejo valley – some negative features found at the site (reproduced from Roche, 1972, fig. P8:2).

After undertaking a spatial analysis of the available data, Pedro Alvim (2009) suggested that the features identified in the 1950s were not residential, but ritual features connected with the funerary activity. Concerning the feature defined by postholes, the author argued that the irregularity of the position and dimensions of the postholes, the absence of pits or combustion features inside the delineated space, the large dimensions of the area, the opening of the feature to the winds, among other things, are inconsistent with the hypothesis of it being a residential feature. Alternatively, the presence of a horseshoe-shaped, non-covered ritual feature of posts, separating the funerary area from the pit zone, was proposed (Figure 30). It was also stressed that the main cluster of adult skeletons were organised in a horseshoe layout opened towards the north-west. Concerning the rectangular pit, the author suggested that it possibly resulted from the destruction of a structure made of pebbles that could have been related to the feature of posts. In addition, the shell pits were interpreted as possible votive deposits, considering that one of the skeletons was found over a deposit of closed shells and the high frequency of lithic remains that was detected inside the pits. Overall, the researcher refuted the perspective of the original residential use of the site, suggesting, instead, that the formation and occupation of the site would have started with its funerary use. He also stressed that the graves and other features were spatially related and organised as a necropolis, indicating an incipient monumentalisation of the space.

The most recent work concerning the Muge shell middens presented by Mary Jackes, Pedro Alvim and others reinforced the abovementioned perspective against a residential use of Moita do Sebastião. It considered that the large quantity of burials recorded at the site is not concomitant with residential use. It also highlighted the fact that the large amounts of food debris that were found could be part of ritual purposes, and not a result of ‘normal’ meals (Jackes et al., 2014, p. 148). The recent study by Rita Stjerna also stressed the importance of funerary activities for the formation of the shell midden. According to the researcher, the radiocarbon data indicate that the burial activity at the site started at the beginning of the Late Mesolithic (the end of 9th millennium cal BP) and continued in the 8th millennium cal BP. The author also argued that the different clusters of burials seem to have been used at the same time, without chronological differentiation (Peyroteo Stjerna, 2016, pp. 371–372; Peyroteo-Stjerna, 2021).

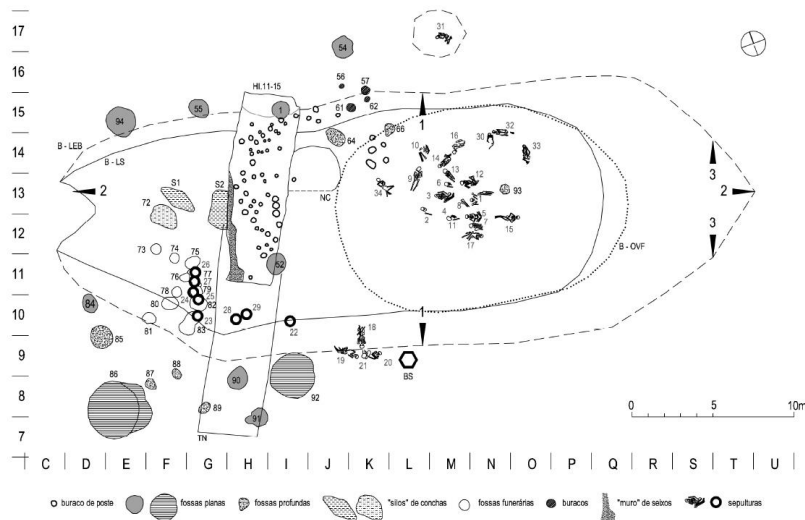


Figure 30: Moita do Sebastião, Tejo valley – human graves (clusters in the eastern and south-western areas) and other features found at the site (reproduced from Alvim, 2009, fig. 6 after Roche, 1972).

In fact, when compared to the data obtained from the excavations at Beg-er-Vil site, Morbihan, in France (see Chapter 5), the dwelling character of the features found by Roche at Moita do Sebastião seem dubious. At the Beg-er-Vil site, vertical blocks and structured postholes were found defining an area of 3.5 m of diameter with a large, structured hearth-pit inside, suggesting the existence of a circular hut (Marchand et al., 2018). A second, similar hearth-pit was found during the last field season in 2018, also located inside an apparently circular area with similar dimensions and defined by some post holes (Marchand and Dupont, 2018). Such a level of regularity and structure was not described for the features found at Moita do Sebastião, more than 50 years before.

Despite the evident importance of the funerary activity at Moita do Sebastião, it seems that the most recent perspectives are centred on a ritual view of the material evidence, sometimes leading to assumptions about its functionality that are debatable. For example, the presence of high concentrations of lithic materials inside the shell pits and among the material collected in the excavations at Moita do Sebastião in general was considered by Alvim as an indicator that lithic tools had a high importance and were used for ritual activity (Alvim, 2009, p. 28). However, several studies have demonstrated that the presence of significant quantities of lithic artefacts and evidence of local lithic production are recurrent in Late Mesolithic shell middens with relatively large dimensions in Portugal and other parts of Atlantic Europe. In France, lithic artefacts have been recovered in abundance from sites without a documented funerary component, such as Beg-er-Vil and Beg-en-Dorchenn (Finistère) (Rault, 1992; Marchand et al., 2018) (see Chapter 5). Moreover, the lithic assemblages found at Moita do Sebastião (Roche, 1972) do not seem to reveal any particular characteristic that suggests a ritual character, including those in the shell pits, which were characterised by the predominance of waste debris and the presence of cores, flakes and tools (Roche, 1960 apud Alvim, 2009, p. 35). In fact, the presence of all stages of lithic production are consistent with local production and does not suggest a special selection for certain lithic tools for deposition.

In summary, the formation of a shell midden can be considered to be a ritualised behaviour, particularly when funerary activities were practiced from its first occupation and over a long period, as seems to be the case at Moita do Sebastião. However, it is difficult to agree with the idea that the practice of certain activities – such as artefact production – could have assumed a stronger ritual character at Moita do Sebastião compared to other sites of the same chronology. A rigid dichotomy between residential and symbolic roles does not seem to explain the function(s) of Moita do Sebastião and other shell middens.

4.2.1.2.3. Cabeço da Arruda

Located on a low terrace on the right bank of the Muge River, Cabeço da Arruda (Salvaterra de Magos, Santarém) is probably the largest shell midden of the Tejo complex. The site is 10 m above sea level and has a good visibility of the marshes (*Appendices – Table A3*). However, its position on the edge of the flood plain would have made it vulnerable to flooding in the region (Corrêa, 1933; Roche, 1980; Roksandic, 2006).

The site was discovered in 1863, and excavated in 1864 and 1880 by Carlos Ribeiro (Costa, 1865; Ribeiro, 1884; Cardoso and Rolão, 2000) (Figure 31). It was described at that time as the most important mound of the Muge complex, presenting an elliptical form 100 m in length and 60 m in width and a maximum height of 7 m (Ribeiro, 1884, p. 282). However, the excavations were conducted by a cut section, and not in area (Costa, 1865). As a consequence, limited data are available. The excavations continued in 1884–85 by Francisco de Paula e Oliveira (Paula e Oliveira, 1884; Jackes et al., 2015). The majority of the human skeletons from the site (about 80 individuals) was identified in the nineteenth century (Peyroteo Stjerna, 2016), but following excavations also enabled the discovery of additional burials. In the twentieth century, field work occurred in the 1930s under the direction of Mendes Corrêa (Cardoso and Rolão, 2000; Jackes et al., 2015). Also, in 1964–65, excavations were undertaken by Roche and Ferreira, who described the complexity of the stratigraphy of the site (with at least 88 levels) and the presence of pits (Roche and Ferreira, 1967; Roche, 1980; 1989; Cardoso and Rolão, 2000) (Figure 32). Survey field work to assess the state of preservation of the site was carried out in 2000 by José Rolão, Mirjana Roksandic and Eugénia Cunha (Roksandic, 2006). Finally, short emergency works were undertaken in 2012 (Monteiro et al., 2017).

Overall, limited data are available concerning the characteristics of the Cabeço da Arruda shell midden and the excavations undertaken at the site. Research in general was concentrated on the study of the anthropological and faunal remains, providing little information about other components and the site itself. It is known that the stratigraphy was complex and composed of several layers of shells with different characteristics, notably shell density (Ribeiro, 1884; Roche, 1989). A high quantity of shell fragments, notably of *Cerastoderma edule* (Lentacker, 1986), mammal faunal remains, lithic material (including geometric microliths), fire-cracked rocks, ash and charcoal, bone tools and human skeletons (more than one hundred) were detected at the site (Costa, 1865; Ribeiro, 1884; Roche, 1966; Roksandic, 2006; Peyroteo Stjerna, 2016; Monteiro et al., 2017).



Figure 31: Cabeço da Arruda, Tejo valley – skeletons found in 1880 (reproduced from Ribeiro, 1884, fig. Pl.1).

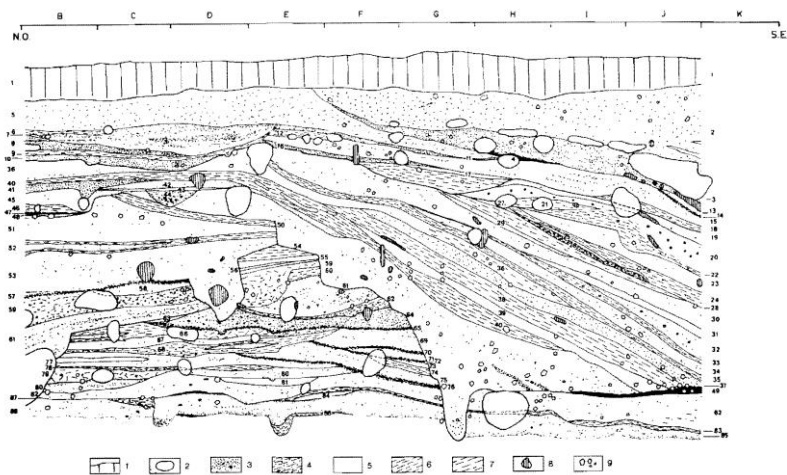


Figure 32: Cabeço da Arruda, Tejo valley – stratigraphic section from the excavations in the 1960s by Roche and Ferreira (reproduced from Roche, 1989, fig. 4).

The inhumations, which mostly correspond to individual and primary burials with little disturbance (Peyroteo Stjerna, 2016), were mainly found at the bottom of the stratigraphy above the basal sands and underlying a layer of fire-cracked rocks, mammal bones, charcoal and some shells, but some burials were also found in the upper levels (Figure 33). The skeletons were put in natural depressions or shallow pits in relatively restricted areas of the site (Costa, 1865, p. 5; Roche, 1966; Cardoso and Rolão, 2000; Jackes et al., 2015). Remains of an articulated and almost complete dog (*Canis familiaris*), dated to the beginning of the 8th millennium cal BP, were also found in the nineteenth century (Detry and Cardoso, 2010). According to Roche, several pits without funerary remains (some at the bottom of the stratigraphy) and hearths were detected (Roche, 1980), but the details of these features are unknown. Also according to his stratigraphic observations (the presence of inclined layers, some large pits), the shell midden would have been flattened several times, in order to allow new occupations (Roche, 1966; 1980; 1989). Research was also undertaken in the surroundings of the site, but the remains that were found could not demonstrate the presence of residential features (Costa, 1865; Roche, 1966). More recently, Nuno Bicho's team has suggested that the site had a 'cairn' of 10–30 cm high on the top, formed by pebbles and fire-

cracked rocks, similarly to another feature observed at Cabeço de Amoreira (Bicho et al., 2013a).

According to the most recent research concerning the chronology (Peyroteo Stjerna, 2016; Peyroteo-Stjerna, 2021), the funerary activity at the site started at the end of the 9th millennium cal BP, at the beginning of the Late Mesolithic, and mainly took place between c. 8000–7600 cal BP. Some later burials were dated to the end of the 8th millennium/beginning of the 7th millennium cal BP, when Neolithisation was already in progress in Portugal. Considering this, the use of the site, notably for funerary purposes, seems to have continued for a long time. However, it is not clear if there were breaks in the sequence of occupation (Bicho et al., 2013a).

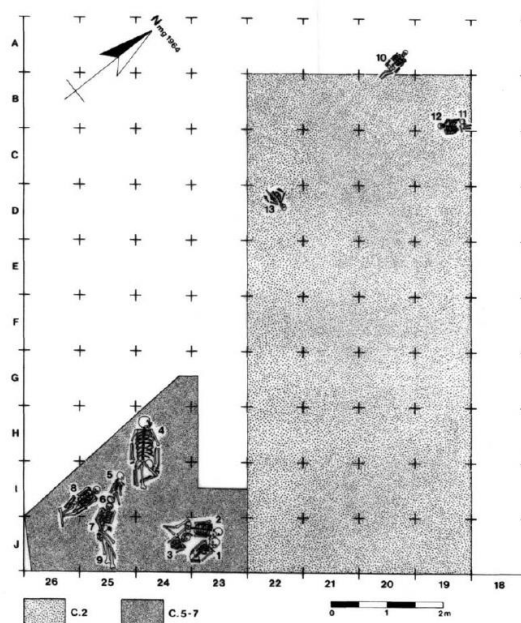


Figure 33: Cabeço da Arruda, Tejo valley – site plan from the excavations in the 1960s (reproduced from Cardoso and Rolão, 2000, fig. 57).

Overall, and despite the long history of research and large dimensions of Cabeço da Arruda shell midden in the context of the Muge complex, there is not much available data concerning site structure and function. Funerary activities seem to have started at the beginning of the occupation of the site and were concentrated in the first phases of the Late Mesolithic (including the dog burial). However, some occurrences indicate that the funerary function continued in later times, during the Mesolithic–Neolithic transition period. Burials were apparently organised in clusters, but the nature and placement of the other features, such as pits and hearths, are unknown. The presence of a diverse lithic industry including geometric microliths, as well as other artefacts and ecofacts, suggest that various other activities were undertaken, notably hunting and gathering, tool production or food processing. While the dimensions of the site and the presence of diverse elements may indicate that Cabeço da Arruda was a residential base camp, the opinions are not unanimous. For example, based on faunal data, Rowley-Conwy proposed that the site was a special purpose camp for winter hunting and specialised in neonatal red deer and aurochs, being

connected with base camps, such as Moita do Sebastião and Cabeço da Amoreira (Rowley-Conwy, 2015).

4.2.1.2.4. Cabeço da Amoreira

The shell midden of Cabeço da Amoreira (Salvaterra de Magos, Santarém) is located on an alluvial terrace, on the left bank of the Muge River, at about 20 m above the present sea level (*Appendices – Table A4*). It forms an elliptical shaped mound, which stood about 90 m and 50 m in length and had a stratigraphic depth of 2.5 m in the past (Roche, 1966) (Figure 34). Large areas of the site were excavated in the nineteenth century (Roche, 1966; Cardoso and Rolão, 2000), in the 1930s by Mendes Corrêa (Corrêa, 1933) and in the 1960s by Ferreira and Roche (Roche, 1980). More recently, field work was undertaken between 1997 and 2001 by Rolão's team (Rolão et al., 2006). Since 2008, the site has been excavated and subject to several analyses under the direction of Bicho and collaborators (Bicho et al., 2013a; 2017; Cascalheira et al., 2015; Gonçalves et al., 2018). These most recent excavations have been undertaken over a relatively large area (over 140 m²) in the south-western part of the site, and also around the shell midden.



Figure 34: Cabeço da Amoreira, Tejo valley – general view of the site and a stratigraphic section (2011) (photos by author).

According to the most recent investigations (Bicho et al., 2013a; 2017; Aldeias and Bicho, 2016), Cabeço da Amoreira would have been used for residential and funerary purposes. However, the existence of several phases of occupation and interruptions has been suggested, based on microstratigraphic studies. The first phase of occupation (Late Mesolithic, c. 8000–7600 cal BP) was identified on the top of the basal sand layers, where abundant features were found, notably pits, possible postholes and hearths, as well as human burials (cutting into the basal sands). It is thought that, during this phase, the site was a residential long-term camp (Bicho et al., 2013a, p. 136). The following phase (Late Mesolithic, c. 7900–7400 BP) would have occurred after a short hiatus, being characterised by the deposition of shell-rich layers of *Scrobicularia plana* and *Cerastoderma edule*, varying laterally in thickness and state of preservation, and the occurrence of some burials. The last phase of occupation (after 7400

cal BP) was identified in the upper layers and would have occurred after another hiatus, being characterised by a covering of pebbles and fire-cracked rocks, the presence of some pottery remains (including those attributed to the Early Neolithic) and some burials. This stone covering has been considered to be a cairn resulting from anthropogenic action to protect the necropolis (Bicho et al., 2013a, p. 136). The researchers suggested that Neolithic occupation would have occurred at the site or at least close to it, as indicated by several pieces of evidence found in the surrounding area (Bicho et al., 2013a, p. 134). Although the site has been providing evidence of occupation lasting over two thousand years, the radiocarbon data indicate that shell deposition occurred during the time-span of c. 8000–7350 cal BP (Bicho et al., 2017), taking about 400–600 years.

Overall, abundant mammal fauna and lithic remains (with a high quantity of geometric microliths), as well as fish and bird remains, bone tools and shell adornments have been found (Lentacker, 1986; Dias et al., 2012; 2019; Gonçalves et al., 2018; Paixão et al., 2019). The study of malacological remains from the site has revealed a dominance of one single species (*Scrobicularia plana*), reaching more than 90% of the NMI, which is thought to result from the exploitation of a relatively strict number of species in the estuary (Dupont and Bicho, 2015).

Several human burials (at least 35 individuals) have been identified so far at the bottom of the stratigraphy, within the shell-rich deposits and in the upper layers, suggesting the occurrence of several phases of funerary activity (Bicho et al., 2017, p. 34). Most skeletons were recovered during the excavations in the 1930s and 1960s in the central part of the shell midden (Figure 35). A significant quantity of burials was found at the bottom of the stratigraphy, although there is not much contextual data (Figueiredo, 2013). Single inhumations predominate, although some double burials were also recorded. Apparently, there was some spatial organisation of the burials in groups, but the available information on this subject is too limited for further consideration (Cardoso and Rolão, 2000).

With respect to non-burial features, the available data also do not have much detail. The presence of several pits along the stratigraphy was pointed out by Corrêa (Corrêa, 1933) and Roche (Roche, 1966; 1989). Corrêa mentioned the identification of pits in the basal sands that were filled with a high quantity of shells (some of them still closed), fish remains and charcoal (Corrêa, 1933, p. 156). However, as discussed in the case of Moita do Sebastião, the storage function of these features is dubious. Roche reported the existence of relatively large pits at the bottom of the stratigraphy, but also noted the identification of features in the middle and upper layers (Roche, 1966; 1989, p. 611). Negative features were also found in the most recent works, such as the case of ‘pit 1’, found in the southern part of the site (excavated before by Corrêa), which was dug into the sterile bottom sands (around 60 cm in depth). The geoarchaeological analysis of the fill suggests that the feature was not intentionally filled, possibly due to a break in occupation (Aldeias and Bicho, 2016). Several other pits and postholes were found in the same area, but few details are known. Some pits with different morphologies were also identified in the most recently excavated zone, in the south-western part of the site (Dias, 2018; Gonçalves et al., 2018).

The existence of several hearths at the site is known through the descriptions from Serpa Pinto in the 1930s (Cardoso and Rolão, 2000, p. 104), Jean Roche in the 1960s (Roche, 1966)

and the most recent excavators (Bicho et al., 2013a; Dias, 2018; Monteiro, 2018). According to Roche, some hearth-pits filled with a dark sediment (with charcoal and calcinated elements) were found at the bottom of the stratigraphy, cutting into the basal sands. In the area excavated by Corrêa, over the abovementioned ‘pit 1’, a hearth (‘hearth 1’) was also found, but it presented a ‘cuvette’ type morphology, with only 10 cm depth, and several fire-cracked rocks (Bicho et al., 2013a; Monteiro, 2018). The presence of several other hearths (with associated fire-cracked rocks, lithic tools and faunal remains) in the same zone were reported (Dias, 2018). In addition, in the south-western part of the site, one combustion feature was identified in a shell midden layer, composed of grey/red sediments, charcoal, burnt shells and faunal remains (Monteiro, 2018, p. 81). Considering these data, combustion features seem to have presented some morphological variability and were constructed in different areas and phases of occupation at the site.

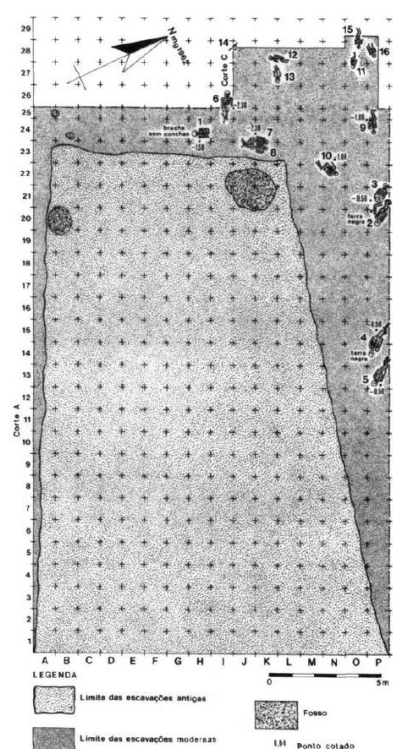


Figure 35: Cabeço da Amoreira, Tejo valley – plan of the area excavated in the 1930s and 1960s, with indication of the skeletons and pits that were found (reproduced from Cardoso and Rolão, 2000, fig. 45).

During recent excavations, a concentration of red deer bones (total of 88 bones of *Cervus elaphus*) and lithic remains was detected over an area of c. 1.40 m² (Gonçalves et al., 2018). The concentration, called Feature A, was found in a shell-rich layer and close to the western limit of the mound. Some bones were still anatomically articulated and the lithic remains, mainly composed of quartzite flakes and cores, allowed for some refits. Evidence of bone breakage was also detected. The concentration indicated to the authors the existence of a local, expedient production of stone tools that could have been used for processing meat that was brought to the location. According to this view, the specific context likely

corresponded to a short occupation episode that was covered relatively fast and was unaffected by major post-depositional processes (Gonçalves et al., 2018, p. 1007). The researchers also suggested two possibilities of interpreting the function of the deposit – an economic purpose as a refuse deposit (resulting from carcass processing and bone marrow extraction) or, considering its unique preservation, a social function as an intentional, symbolic deposit as a red deer burial (Gonçalves et al., 2018, p. 1009). However, it could be argued that the typology of the lithic materials associated with the deposit and the evidence of bone breakage are more suggestive of an economic function, rather than a funerary one, although the processing and consumption of red deer itself could also have a symbolic purpose.

Despite the long history of research at Cabeço da Amoreira, which included the immediate surroundings of the site, evidence of dwellings have not been reported (Roche, 1966; Bicho et al., 2017). Apart from the possible ‘cairn’ and the abovementioned red deer bone deposit, the archaeological materials found in the most recent excavations have revealed a uniform and random distribution across most of the stratigraphy of the site, without showing a clear spatial organisation. This situation has been interpreted as a result of the complex set of human activities and post-depositional processes that occurred at the site (Dias et al., 2012; Gonçalves et al., 2018).

During the excavations of the 1960s, Roche observed that the surface of Cabeço da Amoreira shell midden could have been flattened and homogenised several times during the formation of the site, in order to allow for new occupations (Roche, 1966; 1980; 1989). The same was also observed at Cabeço da Arruda by Roche. This possibility was more recently supported by the geoarchaeological study of Cabeço da Amoreira (Aldeias and Bicho, 2016; Duarte et al., 2017a), which detected the presence of reworked anthropogenic deposits (secondary depositions resulting from dumping and spreading out of previously deposited materials) underlying deposits with horizontally oriented components and abundant crushed shells (interpreted as evidence of trampling and possible occupational surfaces). According to the authors, this indicates the existence of intentional flattening for the establishing of new occupations (Aldeias and Bicho, 2016, p. 13). Primary depositions (shell tossing events) and natural sedimentation were also detected, revealing a high stratigraphic complexity and diversity in the formation processes of the shell midden. Secondary organic-rich deposits (charcoal, bone fragments) were also identified, suggesting a preferential discard of combustion and organic debris in specific areas of the site/mound (Aldeias and Bicho, 2016, p. 15). Overall, despite the homogeneous aspects of the shell midden, the detection of different types of anthropogenic deposits (e.g., primary and secondary deposits, possible occupation surfaces) indicates that the mound did not result from a unilinear or random accumulation of debris.

While the geoarchaeological and chronometric data suggest that Cabeço da Amoreira was not continuously occupied, it is clear from the archaeological record that the site was frequented after the Mesolithic occupation, during the Neolithic. The funerary function of the site persisted, although most burials were identified at the bottom of the stratigraphy and attributed to the Late Mesolithic. Features of various types were detected in the basal sands, but contrary to Moita do Sebastião, structures were also identified in the shell midden and

top layers, which indicates that several activities, with different meanings, were carried out in different contexts at the site. However, the extension of the residential function of the site remains unclear. Recently, it was suggested that Cabeço da Amoreira was not residential in nature most of the time (Gonçalves et al., 2018). Compared to the French shell middens, Catherine Dupont and Nuno Bicho classified Cabeço da Amoreira as a 'littoral multifunction' site, instead of a 'littoral residential base' or a 'littoral location'/temporary site (Dupont and Bicho, 2015). In fact, the absence of identified dwelling features continues to pose difficulties in evaluating the residential character of the site with more precision.

4.2.1.2.5. Other sites

Few data are available about the other shell middens of the Tejo valley (Cabeço dos Morros, Magos de Baixo, Cabeço da Barragem, Arneiro do Roquete/Cova da Onça, Magos de Cima, Fonte do Padre Pedro, Flor da Beira, Fonte da Moça I, Fonte da Moça II, Monte dos Ossos), in particular about those located by the Magos and Fonte da Moça rivers. These sites were subject of little research, since some were mostly destroyed or excavated in the past without appropriate recording. For some of them, even the exact location is unknown. The study undertaken by Rolão in his doctoral thesis considered that some shell middens (Vale Fonte da Moça I and II, Cabeço dos Morros and Cova da Onça) were temporary/specialised sites, based on certain characteristics, such as the relatively low number of recovered lithic remains (Rolão, 1999b).

Despite that situation, the presence of human remains at many of these sites is recorded, notably Fonte da Moça 1, Fonte da Moça 2, Fonte do Padre Pedro, Flor da Beira, Cova da Onça and Cabeço dos Morros. However, for the majority of these sites, the number of recovered skeletons was less than five individuals (Peyroteo Stjerna, 2016, p. 65). Exceptionally, Cova da Onça provided a relatively high number of skeletons (32 or 36 individuals), suggesting that the site was used as a necropolis. One skeleton was dated to the Late Mesolithic, indicating a funerary use of the site in this period. Unfortunately, the archaeological contexts of these remains are lost (Peyroteo Stjerna, 2016, p. 74), constraining further considerations.

4.2.1.2.6. Analysis of general trends

The analysis of the general parameters of the shell middens in the Tejo valley (*Appendices – Table A5*) highlights the fact that all sites (n=13) were associated with a brackish water environment (estuary), being located on terraces with low altitudes (a mean altitude of 14.9 m). Most sites (62%) were located less than 2 km from the main river (the Tejo River) at the time of the occupation. The mean area of the distribution of shells at these middens is 4514 m², although estimations are only known for four sites. The three largest sites (Moita do Sebastião, Cabeço da Arruda and Cabeço da Amoreira), which can be classified as actual 'mounds', were formed by shell deposits with a mean thickness of 4 m, while the typology of the other sites is less clear.

The majority of the sites provided evidence of diverse fauna (54%), indicating the exploitation of varied food sources at the time of occupation. A large number of malacological species was identified in a significant number of sites (39%). However, the

absence of detailed malacological studies poses difficulties in gaining a better understanding of the exploitation of the estuary and mollusc species. In the case of Cabeço da Amoreira, the studies undertaken so far have indicated a dominance of one single mollusc species (*Scrobicularia plana*) in terms of NMI, which seems to be a consequence of the exploitation of a strict number of species (Dupont and Bicho, 2015).

The presence of diverse artefacts was only found at three major sites. Concerning the other shell middens, only lithic remains are known, but this could have resulted, at least partially, from the lack of large excavations. Lithic remains can be classified as diverse at most sites (62%), which indicates the practise of local knapping in general, although detailed information is still lacking for a considerable number of sites.

Concerning funerary activity, the majority of shell middens in the Tejo valley had human remains (69%), although the presence of formal burials was only documented in 46% of the sites. In four sites (31%), burials were abundant (more than eight). However, the presence of non-burial features was only recorded in 38% of the sites. Only two sites clearly provided an abundant number of features (more than eight records). Possible dwelling features were only recorded at one site (Moita do Sebastião), although several questions can be posed about them. Overall, the activities can be characterised as diverse at some sites (39%, corresponding to five from 13 sites). However, three cases reveal evidence of limited activities, and a characterisation is not possible in five cases. The three major sites can be characterised as having long occupations (more than 1000 years), but the period of shell midden accumulation is still a difficult subject to address. So far, a robust set of radiocarbon data was only obtained for Cabeço da Amoreira, which indicates that the formation of the shell midden took about 400–600 years (Aldeias and Bicho, 2016; Bicho et al., 2017).

4.2.1.2.7. Discussion

Despite the long history of research of the shell middens of the Tejo valley, the available information concerning site structure and function of these sites is essentially limited to the largest shell middens – Moita do Sebastião, Cabeço da Amoreira and Cabeço da Arruda. These sites can be classified as mounds, but little information is available concerning the characteristics of the other sites in the complex. Even for the three major sites, data are quite dispersed, due to the fact that different field seasons have been undertaken since the nineteenth century and most of them were focused on the anthropological component.

It should be highlighted that most shell middens of the Tejo valley provided human remains, which indicates that the funerary function was particularly significant at these sites. At the same time, the largest sites with a long stratigraphy seem to have had particularly important funerary activity during the Late Mesolithic, and especially at the beginning of the occupations.

From Moita do Sebastião's record, it has become clear that the display of funerary and non-burial features was spatially organised in clusters, despite the uncertain function of many of these structures. In addition, burials were spatially circumscribed to certain areas of the site. The organisation of burials in clusters and their placement in specific areas of the site seem also to have occurred at Cabeço da Arruda, and possibly at Cabeço da Amoreira, although there is little available documentation.

A significant number of pits was constructed at these sites, being diverse in size and depth. The presence of closed shells in the infills of some pits was noted by the early researchers of Moita do Sebastião and Cabeço da Amoreira, but it is difficult to understand the purpose of such accumulations, which could be merely economic (for immediate consumption or waste) or ritual. Combustion features also seem to have had some diversity, although hearth-pits were not detected in the most recent excavations. Considering this, it is possible that deep hearths were more frequent in the first phases of occupation of the sites and related to funerary activity.

One of the most relevant outputs of the recent investigations was the geoarchaeological approach to the site of Cabeço da Amoreira (Aldeias and Bicho, 2016; Duarte et al., 2017a). The research concluded that, despite the huge stratification and prolonged use of the site, it was not subject to a continuous, uninterrupted occupation. This perspective deconstructs the preconception that large and apparently homogenous shell accumulations are always a result of intensive and/or continuous occupations. Another important point from these recent investigations is the conclusion that several types of deposits formed the midden (primary and secondary deposits), indicating that the actions behind the deposition and accumulation of the shell middens were substantially different from each other. In addition, the recent identification of certain features at Cabeço da Amoreira, such as the concentration of articulated red deer bones and lithic material with refits (Gonçalves et al., 2018), indicates that, despite the post-depositional elements that usually affect these deposits, it is still possible to detect preserved areas of activity through the distribution of material remains, even inside shell accumulations.

4.2.1.3. Sado valley

4.2.1.3.1. Introduction

The shell middens of the Sado valley are positioned approximately 100 km south of the Tejo complex, in the Alentejo region. The 12 known sites are located at 40–50 km upstream of the present-day Sado estuary and spread along 15 km through the banks of the Sado River (Arapouco, Cabeço do Rebolador, Barreirão, Cabeço das Amoreiras, Barrada das Vieiras, Cabeço do Pez and Vale de Romeiras) and its tributaries (Várzea da Mó, Barrada do Grilo, Poças de São Bento, Fonte da Mina and Barranco da Moura) (Figure 36). The shell middens on the banks of the Sado River are mostly positioned on the edge of small plateaus of 40–60 m high, facing the valley (Arnaud, 1989; Diniz and Arias, 2012), although some sites are located at lower altitudes. Geologically, these sites are typically located above Pleistocene/Holocene sands covering the tertiary bedrock of mainly sandstone and conglomerates (Pimentel et al., 2015; Arias et al., 2017).

After the discovery of some of these sites in the 1930s (Barradas, 1936), excavations were carried out in the 1950s and 1960s at eight sites in the Sado valley (Arapouco, Cabeço do Rebolador, Amoreiras, Cabeço do Pez, Vale de Romeiras, Várzea da Mó, Barrada do Grilo and Poças de São Bento), under Manuel Heleno's direction (director of the National Museum of Archaeology at that time). Despite the large quantity of archaeological materials and human skeletons that were found, the results of these excavations were not properly published at that time (Heleno, 1956). In 1967–68, two other shell middens (Barranco da

Moura and Fonte da Mina) were discovered by Manuel Farinha dos Santos (Santos, 1967; 1968). However, interdisciplinary research on these sites was only undertaken several decades after for the first time, under the direction of José Arnaud (1987a; 1989; 2000), and later with the collaboration of Lars Larsson (1996; 2010). More recently, field work and analyses were carried out at some sites between 2010 and 2016 by the team of the Sado-Meso project, directed by Pablo Arias and Mariana Diniz (Diniz and Arias, 2012; Arias et al., 2015a). Overall, a large quantity of artefacts (mainly lithic tools, but also some bone tools, a few pottery sherds and other remains), faunal remains (from molluscs, mammals, fish, crustaceans, and others), human skeletons and other material were found. Several specific analyses have been undertaken so far concerning the material culture (Araújo, 1995–1997; 2015; Marchand, 2001; Diniz, 2010; Diniz and Nukushina, 2014; Diniz and Cubas, 2015; Nukushina, 2015; Silva, 2020), anthropology (Cunha and Umbelino, 2001), funerary/ritual behaviour (Peyroteo Stjerna, 2016), palaeodiet (Umbelino et al., 2007; Fontanals-Coll et al., 2014; Guiry et al., 2015), geoarchaeology (Duarte et al., 2017a; 2017b; Duarte, 2019), geophysics (Arias et al., 2017) and the palaeoenvironment (Costa et al., 2019; López-Dóriga et al., 2019), among other topics.

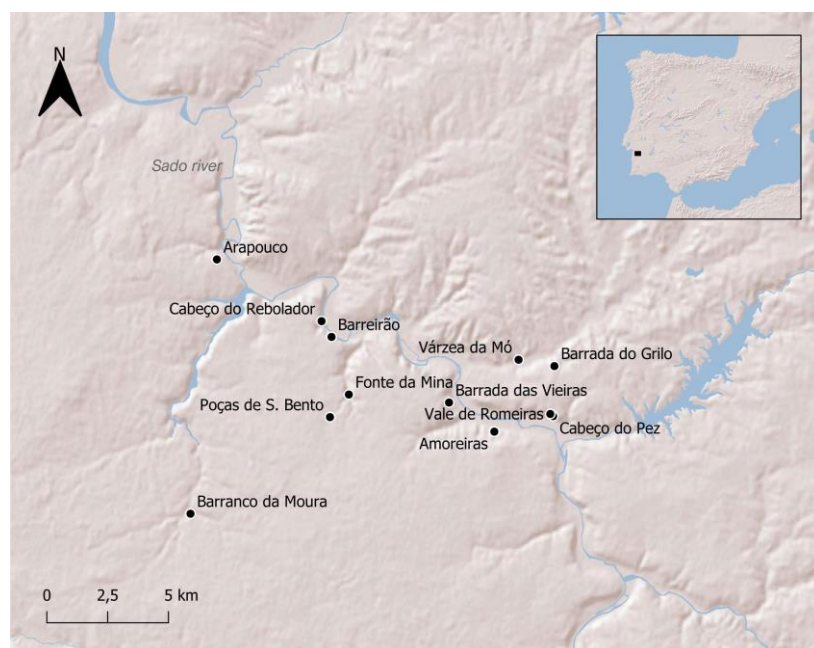


Figure 36: Location of the shell middens of the Sado valley, Portugal (according to *Portal do Arqueólogo* database and Diniz and Arias, 2011) (image by author).

It has been observed that the stratigraphy of the sites in the Sado valley usually contain a single shell-rich layer (mainly with shells of *Scrobicularia plana* and, with lower frequency, *Cerastoderma edule*). The shell accumulations are horizontally sparse and often discontinuous, lying on the basal sands and being covered by topsoil. The shell midden layers are usually no more than 0.80 m thick (Arnaud, 1989; Diniz and Arias, 2012) and include remains of charcoal, mammals, fish, crustaceans, lithic and bone tools, etc.

Contrary to the sites in the Tejo valley, the Sado shell middens are not shaped like a mound. The exact limits of these sites have been difficult to establish due to the lack of

visibility on the local topography (Arnaud, 2000; Arias et al., 2017). Traditionally, it has been considered that the stratigraphy of the Sado shell middens would have developed more by horizontal juxtaposition rather than vertical accumulation (Arnaud, 1987a; Diniz and Arias, 2012). However, recent microstratigraphic studies undertaken in the Tejo and Sado shell middens suggest that, at least at Cabeço da Amoreira in Muge and Poças de São Bento in the Sado valley, the accumulation of shell-rich sediments took place through similar processes of both superposition and juxtaposition (Duarte et al., 2017a; Duarte, 2019).



Figure 37: Sado valley and view of the Amoreiras hill (photo by author).

The numerous lithic remains found at the Sado shell middens indicate the practice of local lithic production mainly characterised by a microlithic industry (with a high quantity of small bladelets and geometric microliths) and the use of local rocks (Arnaud, 1987a; 1989; Araújo, 1995–1997; Marchand, 2001; Diniz and Nukushina, 2014; Araújo, 2015; Nukushina, 2015; Pimentel et al., 2015). Faunal remains were also abundantly found at these sites. A large quantity of mammal remains was detected at Cabeço do Pez, Amoreiras and Vale de Romeiras. Fish remains were less common, but had a significant presence at Arapouco, and with a lower proportion, at Poças de São Bento and Cabeço do Rebolador (Arnaud, 1989; 2000; Gabriel, 2015).

Several features were identified at these sites, notably burials (several human graves and a dog burial), pits, hearths and possible postholes (Arnaud, 1989; 2000; Arias et al., 2015a; 2017). Human remains were found in six of the 12 Sado shell middens, from which four sites provided more than 16 individuals (Arapouco, Cabeço do Pez, Vale de Romeiras and Poças de São Bento). However, in comparison with the Tejo shell middens, the numbers are much lower. Most burials in the Sado valley were found in the basal sands below the shell midden layers (Arnaud, 2000; Peyroteo Stjerna, 2016).

The function of the Sado shell middens has been approached and discussed from different perspectives. According to the logistical movement model proposed by Arnaud (1989; 2000; 2002), the shell middens in the Sado valley would have been overall contemporary and part of the same settlement system. In this regard, most of the group would have occupied two large base camps – Cabeço do Pez, during the autumn/winter station, and Poças de São Bento, during the spring/summer season. Each base camp would have been associated with smaller temporary camps, where specialised activities would have been developed (such as

Cabeço do Rebolador and Arapouco). Logistical movements to these smaller specialised/temporary camps would have occurred. However, Arnaud noted that this system only would have worked during a later phase of the Late Mesolithic (Arnaud, 2000, p. 41). The classification of Cabeço do Pez and Poças de São Bento as base camps was fundamentally based on the large dimensions of the sites, the high quantities of lithic and faunal remains in comparison to the other sites and the identification of several features. A different perspective was later proposed by Marchand (2001; 2005), who considered, based on the lithic typology and the available absolute dates at the time of his studies, that there were substantial chronological differences between these sites. In his model, Arapouco and Vale de Romeiras were considered to probably belong to an earlier phase (the end of the 9th millennium–beginning of the 8th millennium cal BP), while the sites of Várzea da Mó, Cabeço do Rebolador and Poças de São Bento were seen as more recent shell middens (the second half of the 8th millennium cal BP). However, the currently available radiocarbon data indicate that the funerary use of most shell middens was more or less synchronous (Peyroteo-Stjerna, 2021).

Trace element and isotopic studies have indicated that there was a significant inter-site variation in the Sado valley (Umbelino et al., 2007; Fontanals-Coll et al., 2014; Guiry et al., 2015; Peyroteo Stjerna, 2016), as suggested by some authors (Diniz and Arias, 2012). The western group of sites (Arapouco, Poças de São Bento) has provided data indicative of a mixed diet (with over 40% being protein from marine-estuarine sources), while the eastern group (Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, Várzea da Mó) was characterised by individuals with a more or full terrestrially-oriented diet. For Eric Guiry and collaborators, the isotopic data support a dual settlement model in which each section of the site complex was exploited more intensively by a separate and localised community, with particular subsistence practises (Guiry et al., 2015, p. 468). The presence of at least two distinct populations was also advocated by Stjerna concerning the use of burial grounds in each section (Peyroteo Stjerna, 2016, p. 436), which seem to have occurred at the same time. This idea of substantial differentiation between the sites in diet and resource exploitation has also been supported by the variations observed in the faunal remains from these sites, notably the relative abundance of fish remains at Arapouco and Poças de S. Bento and the frequency of mammal bones at Cabeço das Amoreiras, Vale de Romeiras and Cabeço do Pez (Arnaud, 1989; Gabriel, 2015; Rowley-Conwy, 2015). Moreover, the recent geomorphological research concluded that the influence of the estuarine conditions at Sado valley reached the westernmost area occupied by the shell middens in the Late Mesolithic, at least until the São Bento area (Costa et al., 2019), but the other shell middens located to the east were possibly much farther from the estuarine resources than what has been thought. Questions about the effective importance of estuarine food sources for the location and formation of these sites have been raised, leading researchers to consider other possible explanations, such as the availability of lithic raw materials or freshwater sources (Larsson, 2010; Arias et al., 2015a; Pimentel et al., 2015), or the social and ritual meaning of these sites (Peyroteo Stjerna, 2016).

The site structure of the Sado shell middens has often been analysed with a focus on funerary activity. It has been noted that human burials were organised in groups and in specific areas of the sites, except in the case of Vale de Romeiras, whose necropolis seem to

have occupied the entire area of the site (Arnaud, 2000; Peyroteo Stjerna, 2016). In this sense, the presence of non-burial features has not been appreciated in the literature, due to the lack of detailed documentation, but also their low degree of archaeological visibility and complexity. The most recent excavations by the Sado-Meso project allowed researchers to identify several features at Poças de São Bento in different areas of the site, notably pits and hearths, as well as a human and dog burial (Arias et al., 2015a; 2017). The available data indicate that there was some diversity in the structures at these sites and some degree of spatial arrangement. Besides this, micromorphological analyses undertaken at Poças de São Bento (described below in more detail) provided evidence of a significant intra-site variation of the deposits and associated activities (Duarte et al., 2017b; Duarte, 2019). Overall, it seems likely that the spatial organisation of the Sado shell middens was not limited to funerary activity and related features, but also included other components of the occupations.

4.2.1.3.2. Poças de São Bento

Poças de São Bento (Alcácer do Sal, Setúbal) is located approximately 3 km south of the Sado River, on a plateau on the left bank of a small brook, approximately 80 m high (*Appendices – Table A6*). The site lies on a gentle slope descending to a rivulet that runs towards the Sado River. It has a relatively inland location when compared to the other sites located in the margins of the Sado River (Figure 38). Despite that, Poças de São Bento is one of the two largest sites of the Sado shell midden complex, having an estimated area of 3500 m² (Arnaud, 1989; Arias et al., 2017). Close to the site, there are small permanent ponds, important fresh water sources which would be available during the Middle Holocene (Larsson, 2015; Pimentel et al., 2015; Arias et al., 2017).



Figure 38: Poças de São Bento, Sado valley (photo by author).

According to available documentation from the Personal Archive of Manuel Heleno (Arquivo Pessoal de Manuel Heleno, Museu Nacional de Arqueologia), the site was first excavated in the 1960s by Heleno's team. Around 60 m² at the eastern part of the site would have been excavated at that time (Arnaud, 1989). Later research occurred in the 1980s, as well as in the eastern part of the site (around 26 m²), with a test pit carried out in 1986 and excavations in 1987 and 1988 by the team of José Arnaud and Lars Larsson. Several analyses of the recovered material remains were also undertaken (Arnaud, 1989; 2000; Araújo, 1995–

1997; Larsson, 1996; 2010; 2015). More recently, research was carried out under the direction of Pablo Arias and Mariana Diniz (Sado-Meso project), which included the excavation of a total of 11 areas at the western and eastern parts of the site, between 2010 and 2016 (Arias et al., 2015a; 2017; Diniz et al., 2016), and several interdisciplinary analyses (e.g., Araújo et al., 2015; Duarte et al., 2017b; López-Dóriga et al., 2019) (see Chapter 5). Overall, a high quantity of animal remains (mainly mollusc shells, but also crustaceans, fish and mammal remains), fire-cracked rocks, charcoal, tools (mostly lithic, but also bone tools) and plant macroremains were found. Several burials, at least 16 individuals, were identified, mainly located in the basal sands below the shell layers and concentrated in small groups (Cunha and Umbelino, 2001; Arnaud, 2002; Larsson, 2015; Peyroteo Stjerna, 2016). According to the descriptions, some of the skeletons were apparently put in shallow pits (Larsson, 2015). Although most of the burials would be Late Mesolithic, at least one individual was dated to the Middle Neolithic (the end of the 7th millennium – beginning of the 6th millennium cal BP), which indicates that some late funerary activity occurred at the site. A dog burial (*Canis familiaris*), dated to the Late Mesolithic, was also identified in the Sado-Meso project excavations, but in the western part of the site, which corresponds to the opposite side of the human burial zone (Arias et al., 2015a). A number of hearths, pits and possible postholes was also identified.

The most recent field work has confirmed that, despite some lateral variations, the stratigraphic sequence was relatively consistent in the different excavated areas (Arias et al., 2017; Duarte et al., 2017b). Shell midden deposits were located above Pleistocene/Holocene aeolian sands and appeared as one single shell-rich layer with a high homogeneity (sands with highly fragmented mollusc shells, mainly composed of *Scrobicularia plana* and, with less frequency, *Cerastoderma edule*) and a maximum thickness of about 0.80 m (Figure 39). These deposits were generally dated to the late 9th millennium–8th millennium cal BP. The accumulations were sparse and difficult to delineate. Overlying the shell midden deposits and below the top sediments were blackish sands with a low density of shells and sparse archaeological material (which included some rare Neolithic pottery sherds). These deposits showed a lot of bioturbation and were dated to the Neolithic.

According to a recent micromorphological study carried out at Poças de São Bento, there was a certain dynamism in the formation of the deposits and a clear intra-site differential use of the space (Duarte et al., 2017b; Duarte, 2019). As found at Cabeço da Amoreira, in Muge, primary accumulations, secondary deposits and occupation surfaces were identified. According to this study, most shell-rich deposits from Poças de São Bento corresponded to redeposited sediments (secondary deposits), suggesting that the site was predominantly formed by the spreading of redeposited sediments, instead of primary deposits resulting from direct tossing. The author also argued that the redeposition of previously discarded sediments could be explained as an attempt to flatten out the area or prepare occupation surfaces (Duarte, 2019, p. 283). The study also suggested that the western part of the site was intensively occupied, considering that the shell midden layers reveal intensive trampling, overlying a dumping of reworked activity debris. Also in this area, a pit filled with a shell midden deposit and a dog burial were found (Diniz and Arias, 2011; Diniz et al., 2012). In the eastern part of the site, an area near the funerary zone of the site seems to have been

preferentially used for food refuse, considering it shows little trampling and indicators of rapid burial (superimposed single tossing events intercalated with at least one sediment dumping event) (Duarte, 2019, p. 267). In addition, the micromorphological approach highlighted that in certain areas of the site (notably in the eastern part), there was intentional vertical superposition of shell-rich sediments, and not only lateral juxtaposition of deposits. Overall, the study allowed researchers to understand that the apparent single and homogeneous shell midden layer at the site was a result of several activities from depositions of different natures and from different occupations. Abandonment episodes were not detected in the stratigraphy.



Figure 39: Stratigraphic section of Poças de São Bento, Sado valley (excavations of 2012 by the Sado-Meso project, area S1) (photo by author).

Through the history of research, Poças de São Bento has often been classified as a semi-sedentary base camp occupied in spring/summer, considering its larger size, the quantity and diversity of the lithic and faunal remains and the features found so far, as well as the ecological characteristics of the area, notably the availability of freshwater (Arnaud, 1989; 2000; Larsson, 1996; 2015). A slightly different perspective was presented by Rowley-Conwy, who sustained that Poças de São Bento was a special purpose camp used in the summer season for rabbit hunting, due to the abundance of bones of that species (Rowley-Conwy, 2015). However, the results from trace element and stable isotope analysis indicate that the individuals from this site had a mixed diet of marine-estuarine and terrestrial food sources (Umbelino et al., 2007; Guiry et al., 2015), although less marine-estuarine-oriented than Arapouco, differing from the individuals from the sites of the eastern side of the shell midden complex, where the data suggest a predominance of terrestrial diets. Despite the relative distance to the Sado River, it seems that aquatic food sources were relatively important at Poças de São Bento. A wide range of food sources was exploited and diverse activities took place at the site, including fishing in the estuary, and probably in the sea (Arias et al., 2015a; Gabriel, 2015).

4.2.1.3.3. Cabeço do Pez

Cabeço do Pez (Alcácer do Sal, Setúbal), also known as Quinta de Baixo and Quinta de D. Rodrigo, belongs to the eastern part of the Sado shell midden complex. The site is located

on the right margin of the Sado River, on a hill at approximately 57 m of altitude with good visibility over the river (Figure 40). It is one of the largest sites in the Sado valley, extending over an area of about 4000–8000 m² (Arnaud, 1989; 2002; Arias et al., 2015a) (*Appendices – Table A7*).

The site was identified in the 1930s and extensively excavated in the 1950s and 1960s by Heleno's team from the National Archaeological Museum (Santos et al., 1974; Arnaud, 2000). A large number of human skeletons from 32–36 individuals was found at that time (Cunha and Umbelino, 2001; Peyroteo Stjerna, 2016). References and records of several structured hearths with a circular form are also known at the site (see Chapter 5). Unfortunately, little information is available today from these excavations, which covered the central area of the site. In the 1980s, excavations of a small area of 2 m² were carried out by Arnaud's team (Arnaud, 1984; 2000). Finally, in 2010, small excavations (4 m²) were undertaken by the team from the Sado-Meso project, on the edges of the midden, which revealed a complex stratigraphy which had been affected by strong erosional processes (Arias et al., 2015a).



Figure 40: View of the Sado valley from Cabeço do Pez (photo by author).

Data about the stratigraphy of the site are rare. According to Arnaud (2000), the basal layer (clayey-silty sediments) was cemented by calcium carbonate generated by the dissolution of shells from the upper layers. Sandy deposits overlaid the basal layers and alternated with silty and clayey-silty layers. This situation was interpreted as indicative of different periods of occupation and abandonment. The shell midden layers presented variations in shell density. These layers contained a sandy matrix, charcoal remains and a large quantity of fire-cracked rocks, suggesting, according to the researcher, the practice of shell processing and mollusc consumption.

Overall, a large quantity of lithic and faunal remains, some bone and antler tools and few shell adornments were found (Santos et al., 1974; Arnaud, 1989; 2000). A significant quantity of mammal remains was reported, being dominated by red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*). According to Rowley-Conwy (2015), the mammal remains, notably the relative scarcity of unfused rabbit bones, are indicative of an occupation of the site during the winter season (Rowley-Conwy, 2015). The presence of Neolithic pottery sherds and a grinding stone tool on the top levels of the site was also noted, suggesting a continuity of occupation or a later reoccupation of the site after the Late Mesolithic (Santos et al., 1974; Arnaud, 2000).

According to the latest research on the human skeletons (Peyroteo Stjerna, 2016; Peyroteo-Stjerna, 2021), the main burial activity at this site occurred in the Late Mesolithic, in the first half of the 8th millennium cal BP and over a relatively short time (less than 150 years). Apparently, the activity was mainly concentrated in two areas of the site (with at least 24 burials). Burials also seem to have occurred in the Neolithic, but in a sporadic way, which is concomitant with the archaeological material found at the site. At least one burial, outside the main funerary areas, was dated to the end of the 7th millennium cal BP (Middle Neolithic).

Overall, Cabeço do Pez has been characterised as a winter base camp, considering the large dimensions of the site, the high quantity of materials and the seasonal data obtained through the faunal remains (Arnaud, 1989; 2000; Rowley-Conwy, 2015). Although the detailed sequence of occupation of the site is unknown, the available data indicate the existence of, at least, two phases of occupation, both with funerary activity – one in the Late Mesolithic and another in the Middle Neolithic.

4.2.1.3.4. Vale de Romeiras

Located in close proximity to Cabeço do Pez, Vale de Romeiras (Alcácer do Sal, Setúbal) also belongs to the eastern group of the Sado shell middens. The site is positioned on the right bank of the Sado River, on a hill with approximately 55 m of altitude and good visibility of the valley (*Appendices – Table A8*). It has an estimated area of 54 m², being one of the smallest sites of the Sado complex (Figure 41).



Figure 41: View of Vale de Romeiras from Cabeço do Pez, Sado valley (photo by author).

The shell midden was probably identified in the 1950s by Heleno's team and, apparently, completely excavated in 1959 and 1960 by them. According to the available records from these excavations (Personal Archive of Manuel Heleno and National Museum of Archaeology), the stratigraphy was characterised by layers of brown soil covering the shell midden deposits, which were over the yellowish basal sands. In some areas, layers of black soil also covered the basal sands (see Chapter 5). In spite of the small dimensions of the site, about 26 human skeletons were discovered during these excavations, including some non-adults (Cunha and Umbelino, 2001). The skeletons were inhumated as individual primary deposits and mostly found in the basal sands, while only few were placed in the shell layer (Peyroteo Stjerna, 2016). Although the placement of cadavers in constrained grave pits would

also have occurred at other sites, the pits at Vale de Romeiras seem to have been particularly small, with the bodies being put in contracted positions. In addition, the burial area of Vale de Romeiras apparently corresponded to the entire area of the site (Arnaud, 1989) – as a consequence, the highest burial density of the Sado valley is recorded at this site (Peyroteo Stjerna, 2016). The spatial arrangement of the burials in semicircle, without superposition and facing the river, has also been highlighted, leading some authors to consider that the graves were probably contemporaneous (Arnaud, 1989; 2000; Cunha and Umbelino, 2001). However, although limited, recent chronological data indicate that these burials did not correspond to one synchronic group (Peyroteo Stjerna, 2016). The beginning of the funerary activity at the site would have occurred in the second half of the 9th millennium cal BP, during an early phase of the Late Mesolithic, but burials were also dated to the end of the first half of the 8th millennium cal BP. One skeleton was dated to the modern period, although it is thought that the funerary activity predominantly occurred during the Late Mesolithic. Despite this, according to Stjerna, it is possible that there were synchronic burial subgroups within the site, but additional radiocarbon data are required to support this hypothesis (Peyroteo Stjerna, 2016, p. 391).

The idea that Vale de Romeiras could have been used as a necropolis for the neighbouring site Cabeço do Pez had been suggested before, considering the small dimensions of the site and the proximity to Cabeço do Pez (Arnaud, 1989). It should be noted, however, that Vale de Romeiras provided, like other sites of the Sado valley, a significant amount of materials other than human skeletons, notably lithic tools and mammal remains (Arnaud, 1989). Concerning the lithic remains, the available data indicate the presence of all the categories of a lithic technological sequence, and thus the occurrence of local production at the site (Reis, n.d.). Therefore, it can be assumed that the site had other functions in addition to a funerary one. More recently, Rowley-Conwy suggested that the abundance of rabbit bones compared to the proportion of remains of large mammals indicates that Vale de Romeiras was a winter rabbit procurement camp, which was contemporaneous with Cabeço do Pez (Rowley-Conwy, 2004, p. 266). Trace element and isotopic analyses indicated that the individuals at this site had a terrestrial diet (Umbelino et al., 2007; Fontanals-Coll et al., 2014; Guiry et al., 2015; Peyroteo Stjerna, 2016), which seems to be consistent with the archaeozoological evidence.

4.2.1.3.5. Other sites

Concerning the other sites of the Sado shell midden complex (Arapouco, Cabeço do Rebolador, Barreirão, Cabeço das Amoreiras, Barrada das Vieiras, Várzea da Mó, Barrada do Grilo, Fonte da Mina and Barranco da Moura), few data on site structure have been obtained so far. Nevertheless, the shell middens of Arapouco, Cabeço do Rebolador and Amoreiras have provided some interesting data for the discussion of site function and the Late Mesolithic settlement system in the Sado valley.

Arapouco

Arapouco (Alcácer do Sal, Setúbal) is the western-most site of the Sado shell midden complex (Figure 42). It is located on the left bank of the Sado valley, at approximately 47 m high, having good visibility of the river (*Appendices – Table A9*). The site has an estimated area

of 1174 m². It was excavated in the 1960s by the team of Heleno, but very little information is known from these excavations (see Chapter 5). A large quantity of archaeological material was found, notably lithic remains (Diniz and Nukushina, 2014). Several human burials were identified, which comprised at least 32 individuals (Cunha and Umbelino, 2001). Despite a lack of documentation, the archaeoethanatomical data indicate the practice of mainly individual primary burials, with the bodies being placed in pits, similarly to what would have happened in other sites in the Sado valley (Peyroteo Stjerna, 2016). One of these skeletons was dated to the beginning of the Late Mesolithic period (the end of the 9th millennium–beginning of the 8th millennium cal BP), indicating an early occupation of the site. Some test pits were carried out at the site in 2016 by the Sado-Meso project, but the results were quite limited (Diniz et al., 2017; Silva, 2020).



Figure 42: Arapouco, Sado valley (photo by author).

Several researchers have argued that Arapouco was a temporary and specialised site for fishing during the summer, due to its downstream location in the Sado complex (that would allow it to have a stronger estuarine influence), its particular abundance of ichthyofaunal remains, primarily of meagre (*Argyrosomus regius*) and gilthead bream (*Sparus aurata*), as well as crab remains (*Carcinus maenas*), and few mammal remains compared to other sites (Arnaud, 1989; 2000; Gabriel, 2015; Rowley-Conwy, 2015). Isotopic data and trace element analysis (Umbelino et al., 2007; Guiry et al., 2015; Peyroteo Stjerna, 2016) have indicated a mixed diet pattern with marine-estuarine and terrestrial food sources for the individuals found at Arapouco, with a higher frequency of aquatic food when compared to the sites located in the eastern portion of the shell midden cluster. Despite the specialised character of the site evidenced by several elements, an analysis of artefacts revealed that lithic production took place locally at Arapouco as observed in other sites of the Sado valley. The recovered chipped stone materials is diverse and does not indicate a specialisation in specific tool types; geometric microliths have a lesser importance, while varied types of tools on flakes are more frequent compared to other sites (Diniz and Nukushina, 2014; Pimentel et al., 2015; Silva, 2020). Few lithics with use-wear have been identified so far, indicating short activities of cutting or scraping of hard or soft materials (Silva, 2020). Considering this, and assuming that Arapouco was a specialised site, the archaeological information seems to contradict the idea that lithic tools at specialised camps are necessarily less varied or typologically more

specialised. It can also be argued that, although Arapouco has some specificities, the diversity of activities that characterises this site can also be observed at other shell middens with funerary activity in the Sado valley.

Cabeço do Rebolador

Cabeço do Rebolador (Alcácer do Sal, Setúbal) is located in proximity to Arapouco. Little information is known about the site, since it was only excavated in the 1950s (Marchand, 2001). Despite this, Cabeço do Rebolador was also considered by Arnaud (1989; 2000) to be a possible specialised and temporary site (probably occupied in the winter/early spring), due to the relative abundance of crabs among the recovered faunal remains. However, it can be observed that the crab remains from Cabeço do Rebolador that were quantified were much less significant when compared to the those found at Arapouco (Arnaud, 1989; 2000; Rowley-Conwy, 2015). Lithic remains provided evidence of local production without specialisation (Marchand, 2001), as found at Arapouco and other sites (Araújo, 1995–1997; Marchand, 2001; Diniz and Nukushina, 2014). However, contrary to several other sites from the Sado valley, the presence of human remains is unknown at Cabeço do Rebolador.

Amoreiras

Amoreiras, also known as Cabeço das Amoreiras (Alcácer do Sal, Setúbal), belongs to the eastern group of the Sado shell middens. It is located on the left bank of the Sado River, at 52 m high, having an outstanding view of the valley (Figure 43). The site has an estimated area of 1270 m² and was first excavated during the 1950s and 1960s under the direction of Heleno (Arnaud, 1989; 2000) (*Appendices – Table A10*). Thousands of pieces of archaeological material were recovered, and six human skeletons were found (Arnaud, 1989; 2000; Cunha and Umbelino, 2001). Later excavations were developed by the team of Arnaud (1984–1986), in small areas, whose results led the researcher to suggest that the shell midden would have mainly developed in area, through the juxtaposition of small amounts of shells (Arnaud, 1986b; 2000). Excavations in small areas were also carried out between 2014 and 2016 by the team from the Sado-Meso project near the slope of the hill (Diniz et al., 2014; 2015; 2016). However, apart from the observation of irregularities in the distribution of the shell midden, the obtained data was quite limited concerning site structure. Several analyses of materials from this site have been undertaken so far, notably on human skeletons (Cunha and Umbelino, 2001; Peyroteo Stjerna, 2016), fauna (Albizuri Canadell, 2010; Dean, 2010), pottery (Diniz, 2010; Arias et al., 2017), and lithic remains (Nukushina, 2012; Pimentel et al., 2015; Silva, 2020). One of the skeletons was dated to the beginning of the Late Mesolithic period (the end of the 9th millennium–beginning of the 8th millennium cal BP), while some radiocarbon and artefact data indicate the existence of Neolithic occupations, whose intensity and meaning has been discussed (Zilhão, 1998; Arnaud, 2000; Diniz, 2010; Nukushina, 2012).

In terms of site function, the model proposed by Arnaud (1989) for the Sado valley considered Amoreiras to be a temporary site associated with specialised activities, based on the relatively higher presence of remains of large-sized terrestrial animals and scarcity of fish remains, which contrasted with Arapouco. Trace element and isotopic analysis of human skeletons from this site also indicate a predominance of terrestrial diets (Umbelino et al.,

2007; Fontanals-Coll et al., 2014; Guiry et al., 2015; Peyroteo Stjerna, 2016). A recent functional analysis confirmed that at least some lithic tools would have been used for hunting and meat processing activities (Silva, 2020), although the number of lithics from the Sado shell middens that were subject to a functional analysis are still too limited to verify possible differences between sites. From a technological and typological perspective, the analysis of lithic remains revealed the practice of local production, as occurred at other sites in the Sado valley, although with a relatively high proportion of geometric microliths among the retouched tools (Nukushina, 2012; Silva, 2020), a characteristic could imply the possibility of a particular relevance of hunting activities at the site.



Figure 43: Amoreiras, Sado valley (photo by author).

4.2.1.3.6. Analysis of general trends

All the shell middens of the Sado valley ($n=12$) were associated with a brackish water environment (estuary) and located on river terraces with low and medium altitudes (with a mean of 53 m). The analysis of general parameters of the sites (*Appendices – Table A11*) indicates that most sites (67%) were positioned less than 2 km from the main river (Sado River) at the time of occupation. The mean area of shell distribution is 1925 m². The shell accumulations are formed by relatively thin layers, reaching in total a mean thickness of 0.69 m. Although measurements are not available for several sites, in general, the Sado shell middens are smaller and thinner than the sites in the Tejo valley.

Only the two largest sites of the complex (Poças de São Bento and Cabeço do Pez) provided evidence of exploitation of diverse fauna. In most sites, a limited quantity of faunal species was found (42%) or the obtained data were not enough for a characterisation (42%). A large number of malacological species was only identified at two sites (Arapouco and Amoreiras) and 58% of the sites provided a limited number of mollusc species. As observed for the Tejo valley, the absence of detailed malacological studies can justify these numbers and poses difficulties for a better understanding of the exploitation of the estuary. The presence of diverse artefacts was found at 50% of the sites, while in 42% of the cases, only lithic remains were found or recovered. Despite that, assemblages of diverse lithic remains were identified in most cases (at least 58%), indicating the practise of local knapping at many of these sites.

Concerning funerary activity, the presence of burials was observed at 50% of the sites. Four sites contained an abundant number of burials (more than eight burials). The case of Vale de Romeiras, where a high quantity of burials was found in a relatively small area, suggests that the dimensions of the site or the area of shell distribution was not always related to the frequency of burials. The presence of non-burial features was recorded at 42% of the sites, which mostly also contained burial features. However, only the two largest sites (Poças de São Bento and Cabeço do Pez) provided an abundant number of non-burial features (mainly hearths and negative features, the latter including cases with a poor definition). Dwelling features were not recorded at all. Overall, the activities related to these sites can be considered as diverse in at least 50% of the sites. Although with a main occupation attributed to the Late Mesolithic, the most excavated sites of the complex (Poças de São Bento, Cabeço do Pez, Amoreiras and Vale de Romeiras) revealed evidence of long occupations (more than 1000 years), but the few radiocarbon dates do not allow a precise period for the shell midden accumulation.

4.2.1.3.7. Discussion

As observed for the Tejo shell middens, there are limited data concerning the site structure and function of the Sado shell middens, despite the long history of research at these sites. Burials seem to have been organised and concentrated in the space, independently of the dimensions of the sites. However, other activities, including shell accumulation, are less visible in the archaeological record and their spatial dimensions remains difficult to understand. Despite the limitations, the growth of the excavated areas and the use of micromorphology in recent field work has contributed to a better understanding of the formation and organisation of the sites. In the case of Poças de São Bento, the most recently obtained data suggest the existence of substantial intra-site spatial differentiation of activities (Duarte et al., 2017b; Duarte, 2019).

Concerning the function of these sites, the available data, notably from faunal and palaeodietary studies, indicate that there was a significant inter-site variation of the groups and some economic activities carried out at these sites, such as fishing. Although all these sites are shell middens, the evidence indicate that the relevance of aquatic food sources differed between them, being higher in the sites along the western (and downstream) part of the complex, where the estuarine influence was stronger. However, the classification of the sites located to the west as specialised sites is debatable, considering the diverse archaeological evidence that they have provided. It is also clear that there was a relevant funerary function during the Late Mesolithic and possibly in later periods for some sites. Nevertheless, an important number of shell middens in the Sado valley did not provide human remains, which may be related to the type of field work that was undertaken or indicate that not all the shell middens were funerary in nature. In the case of Vale de Romeiras, one of the smallest shell middens in the valley in which several activities would have been carried out (such as burial, lithic tool production and hunting), suggests that the small dimensions of the site were not necessarily a limiting factor for the practise of diverse activities.

4.2.1.4. South-western coast of Alentejo and Algarve

4.2.1.4.1. Introduction

On the south-western coast of Alentejo and Algarve, in southern Portugal, shell middens are also known from the end of the nineteenth century (Cartailhac, 1886). The sites attributed to the Late Mesolithic developed around the Mira and Ribeira de Seixe valleys (Fiais, Montes de Baixo and Paço Velho), and on the adjacent coast (Samouqueira, Vidigal, Castelejo, Armação Nova/Rocha das Gaivotas) (Figure 44, Figure 45). A significant part of the excavations at these sites was undertaken in the 1970s and 1980s. The research on these sites has focused on settlement, subsistence, artefact production and issues surrounding the Mesolithic–Neolithic transition (Straus et al., 1990; Vierra, 1992; Soares, 1996a; Silva and Soares, 1997; Zilhão, 1998; Arnaud, 2002; Lubell et al., 2007; Reis, 2014; Valente et al., 2014; Soares and Tavares da Silva, 2018; Jackes et al., 2019).

Contrary to the estuarine shell middens in the Tejo and Sado valleys, the sites of this region located on the coast are relatively small and characterised by the presence of mollusc species that are typical of rocky coastal environments. In general, few features have been found. The site of Fiais (Odemira) contrasts with this panorama, being a large shell midden located at the end of the palaeoestuary of the Mira River, at 10–12 km from the modern coast, where a large quantity of faunal remains, lithic materials and several features were identified (Arnaud, 2002; Lubell et al., 2007).

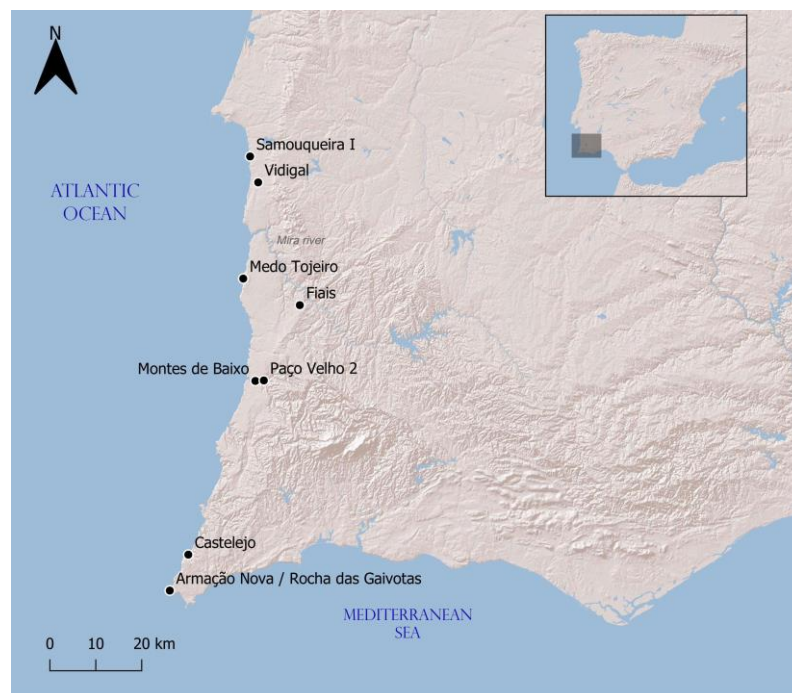


Figure 44: Location of the shell middens of the south-western coast of Alentejo and Algarve, Portugal, with Late Mesolithic occupations (according to *Portal do Arqueólogo* database) (image by author).

According to the settlement model suggested by Arnaud (2002), the base camps located at the interface between the littoral region and the interior (such as Fiais) and presumably occupied year-round or part of the year would have been predominantly dedicated to hunting. This activity would have been complemented by plant gathering, and also fishing and mollusc

gathering carried out from the temporary camps in the littoral region (such as Vidigal). The model advocated by Joaquina Soares and Carlos Tavares da Silva has some similarities – Fiais, and also Samouqueira I, Vidigal and Vale Marim I (a non-shell midden littoral site) were considered to be base camps located in ecotone areas with access to diverse resources, where year-round occupations and several functions would have been undertaken (Soares, 1996a; Soares and Tavares da Silva, 2018). Contrary to this, Montes de Baixo, Castelejo and Armação Nova were categorised as temporary/specialised sites with smaller dimensions and few and less diverse artefacts, from which a strict number of sources would have been exploited and transported to the base camps. These researchers also argued that, while specialised sites tended to be located only on the coast, base camps were developed either on the coast or in the estuary (Soares, 1996a). The model designed by Rowley-Conwy (2015) also has some similarities, but it only considered the occurrence of summer occupations, with Fiais being categorised as a base camp and Vidigal, Samouqueira, Medo Tojeiro and Montes de Baixo as special purpose camps.



Figure 45: South-western coast of Alentejo at Malhão, Vila Nova de Milfontes, Portugal (photo by author).

Despite the investigation carried out so far, the chronology of many of these shell middens is uncertain due to several factors, notably the low quantity of recovered bone materials, many of these contexts being affected by marine erosion and the rarity of large-scale excavations. For sites such as Paço Velho, Vidigal and Medo Tojeiro, it is not clear whether they were occupied in the Late Mesolithic, in the Early Neolithic, or in both periods (Arnaud, 2002; Reis, 2014). This situation has caused serious difficulties in better understanding the organisation and function of these sites.

4.2.1.4.2. Fiais

Fiais (Odemira, Beja) is a shell midden located at 100 m of altitude on a high river terrace, approximately 10–12 km inland from the modern coast and about 2 km from the Mira River, being close to a tributary (*Appendices – Table A12*). Its position in a transition zone between the estuary and the coast, and between the flat littoral region and the mountainous area inland, has been highlighted, since it provided access to diverse resources (Arnaud, 2002; Reis, 2014).

Fiais is the largest shell midden known in the region, with an estimated area of 4000 m² (Arnaud, 2002) (Figure 46).

The site was excavated in 1986 by José Arnaud and David Lubell, and then in 1987–1989 by Arnaud, using artificial levels and sieving procedures (Arnaud, 1987b; 1988a; Lubell et al., 2007). According to the investigation, the thickness of the shell layers had some variability across the site, but reached a maximum of 0.70 m. The formation of the shell midden was interpreted as a result of juxtaposition of small shell accumulations (Arnaud, 1987b). The available chronological data from the site indicate that it was occupied in the Late Mesolithic, although radiocarbon dates range between the end of the 9th and the end of the 8th millennium cal BP (Lubell et al., 2007).



Figure 46: Fiais, Odemira (photo by Helena Reis).

A high quantity of mammal bones and lithic remains was found, as well as shells of marine and estuarine species and fish remains. Mammal faunal remains were particularly frequent, being dominated by red deer, wild boar and roe deer. Malacological remains were mainly composed of *Scrobicularia plana* and *Ostra edulis* (Arnaud, 1988a). Lithic remains revealed the presence of a microlithic industry with a high proportion of bladelets made on chert (Vierra, 1992). Contrary to the Sado shell middens, a large amount of non-local lithic material was detected in the tool assemblage (Lubell et al., 2007).

Some features were identified at the site (González-Morales and Arnaud, 1990; Arnaud, 2002; Lubell et al., 2007). A dense concentration composed of thousands of bones, mostly of red deer, roe deer, wild pig and aurochs was detected in an area of about 9 m² (Figure 47). Some of these bones were still articulated or allowed refitting. The feature was interpreted by excavators as an intentional deposit that occurred in a butchery and meat consumption area. In addition, at least three hearths (defined by stones) and some stone concentrations were identified at the site. Despite this, no dwelling evidence was reported. With respect to funerary activity, there is little information. Some scattered human bones were found in 1986–1987. In 1988, remains probably belonging to one individual were found concentrated in one area of the site, but there is no detailed information (Arnaud, 1988a).

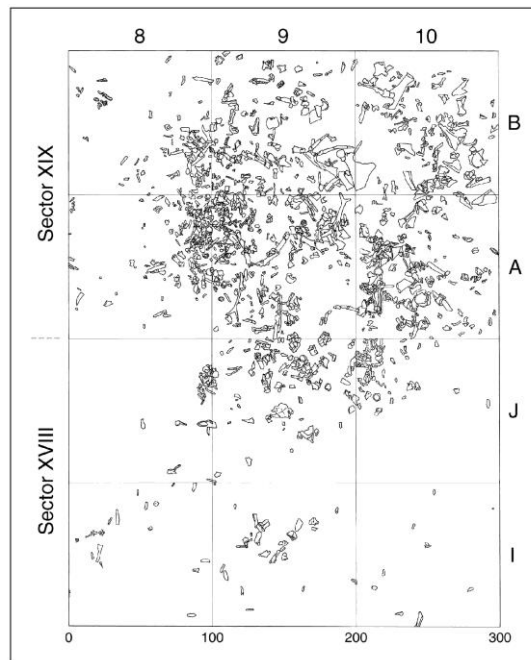


Figure 47: Fiais, Odemira – concentration of animal bones found in the excavations (reproduced from Lubell et al., 2007, fig. 5).

Concerning the spatial distribution of lithic artefacts, most of the remains were considered to not be in a primary context due to the impacts of agricultural activities and possible bioturbation (Lubell et al., 2007). Despite this, the researchers suggested the existence of a substantial intra-site spatial differentiation. According to Lubell and others (2007), in the excavations of 1986, a possible hearth was found adjacent to a concentration of bone (indicated by the high frequency of burnt material), a main area of tool production coincident with the bone concentration and a possible area for hyaline quartz working located nearby. Considering the overall results of the excavations, Arnaud (1988a; 2002) confirmed later that two areas could be distinguished at the site – the northern part was characterised by the presence of hearths and stone pavements, while the south-eastern area contained the abovementioned concentration of bones.

Fiais has been described as a residential base camp destined for the exploitation of a wide range of resources, based on the low presence of mandibles and the relatively high proportion of meat-bearing bones, as well as the identification of human remains that indicate the existence of funerary activity (Lubell et al., 2007; Rowley-Conwy, 2015). For several authors, the site was occupied during most of the year and worked in conjunction with specialised temporary camps located nearby, such as Vidigal (Soares, 1996a; Arnaud, 2002). However, according to Lubell and collaborators (2007), it is difficult to effectively determine whether the site was seasonally or permanently occupied, considering that the zooarchaeological data are only indicative of an occupation in the warmer season, a position also shared by Rowley-Conwy (2015, p. 264).

4.2.1.4.3. Other sites

Numerous other shell middens are known in the Mira valley and the south-western coast of Alentejo and Algarve, either in estuarine or coastal contexts. However, the chronological

attributions have not been clear in several cases, since the shell midden deposits often yielded few materials other than shells (Zilhão, 1998; Arnaud, 2002; Soares and Tavares da Silva, 2018).

Vidigal

One of the best-known coastal sites of the region is Vidigal (Sines, Setúbal), which is located at the top of a promontory, 1 km from the sea and approximately 10 km from the Mira estuary. The site covers an area of approximately 5000 m² (Straus et al., 1990). However, only a small area was excavated in 1988–1989 by Lawrence Straus, Bradley Vierra and José Arnaud (Straus et al., 1990; Arnaud, 2002). These excavations allowed the recovery of an assemblage of lithic remains similar to those found at Fiais, and a set of faunal remains from a small number of animal classes, which indicates a more limited exploitation of food sources. A predominance of fish and marine shellfish remains (mainly composed of limpets, whelks and mussels) was found, leading the researchers to suggest that fishing and mollusc gathering activities were dominant at the site and complemented by some hunting of aurochs, red deer and wild boar (Arnaud, 2002). Regarding the structures, only one possible combustion feature formed by a stone concentration was identified (Straus et al., 1990).

The perspectives concerning the functions of this shell midden have differed. Some authors considered that the site was a temporary/specialised camp that operated in association with Fiais (Arnaud, 2002; Rowley-Conwy, 2015), while others advocated that it was a base camp (Valente et al., 2014; Soares and Tavares da Silva, 2018). However, it is unclear through the available chronological data if the site was occupied in the Late Mesolithic, in the Early Neolithic (Straus et al., 1990; Carvalho, 2008a; Reis, 2014), or in both periods.

Medo Tojeiro

Chronological uncertainties also affect other sites, such as Medo Tojeiro (Odemira, Beja), a small shell midden located on a cliff close to the Lapa das Pombas beach, 8 km from the Mira River's estuary. The shell midden is essentially formed by shells of limpets and mussels. The presence of other faunal remains was not detected. The chronology of the site is not clear, being attributed to the Late Mesolithic and/or Early Neolithic, due to the incongruence and weakness of the radiocarbon dates and material contexts, namely of the pottery remains (Zilhão, 1998; Lubell et al., 2007; Carvalho, 2008a; 2008a; Reis, 2014). Medo Tojeiro has been considered to be a temporary/specialised site, with a probable seasonal occupation (Lubell et al., 2007; Valente et al., 2014; Rowley-Conwy, 2015; Jackes et al., 2019).

Samouqueira

The cultural ascription (Mesolithic and/or Neolithic) of Samouqueira I (Sines, Setúbal), another coastal site, has also been discussed (Zilhão, 1998; Carvalho, 2008a). The site is located on a cliff about 2 km from Porto Covo. The most recently obtained radiocarbon dates from the skeletons found at the site indicated the existence of a Late Mesolithic burial context (Jackes et al., 2019). The excavations at the site provided a number of malacological remains (dominated by rocky species, such as *Mytilus* sp.), some lithic tools, fish and mammal

remains and some human bones from two individuals (Soares, 1996a; Arnaud, 2002; Jackes et al., 2019). The recently published analysis of the isotopic data from these individuals indicated the presence of a high marine component in their diets (Jackes et al., 2019). Soares argued that Samouqueira I would have been a base camp, due to the extensive area of the site, the presence of artefacts and features, and the practice of a broad spectrum economy as evidenced by the faunal remains (Soares, 1996a). However, according to the most recent perspective of Jackes and collaborators (2019), the site would have been subject to an intermittent, probably short-term and seasonal occupation over a long period, considering its unprotected location on the coast and the results of the analysis of fish remains, which mostly indicated a major season of capture in the spring-summer (Gabriel, 2015).

Montes de Baixo and Paço Velho 2

Located 2 km from the coast and south of the Mira estuary, the site of Montes de Baixo (Odemira, Beja), on the right bank of the Seixe River, has been more clearly attributed to the Late Mesolithic (*Appendices – Table A13*), although a Chalcolithic occupation was also identified (Silva and Soares, 1997). It is a relatively small site (approximately 1500 m²), being characterised by a stratigraphy composed of shell midden layers (dominated by *Mytilus sp.*, *Ostrea sp.* and *Scrobicularia*) separated by sandy layers and a low frequency of artefacts (Soares, 1996a; Silva and Soares, 1997) (Figure 48, Figure 49). The absence of faunal remains from species other than molluscs, among other elements, lead the researchers to consider Montes de Baixo to be a specialised site (Soares, 1996a; Valente et al., 2014).

Paço Velho 2, a site located nearby (less than 2 km east from Montes de Baixo), is also formed by shells of coastal and estuarine origin and provided some lithic tools. However, it is dated to the second half of the 8th millennium cal BP, having a chronological attribution to the Late Mesolithic and/or Early Neolithic (Reis, 2014). There is little available data as excavations were not undertaken at the site. It can be highlighted, however, that Montes de Baixo and Paço Velho 2 were both located close to the coast and river, a situation that enabled the exploitation of both environments.



Figure 48: Montes de Baixo, Odemira (photo by Helena Reis).

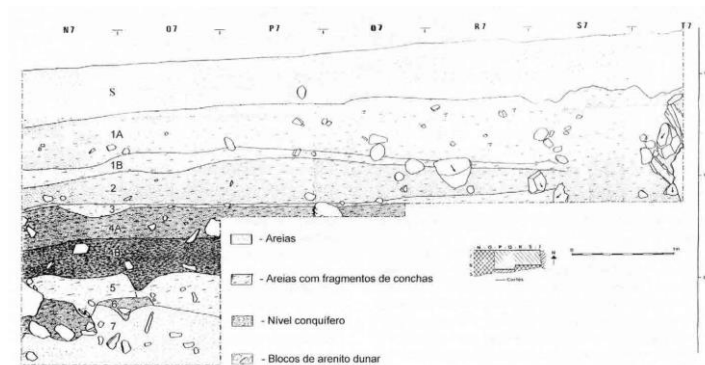


Figure 49: Montes de Baixo, Odemira – representation of a stratigraphic section from the excavations in 1986. The shell layers are filled with dark colours (reproduced from Silva and Soares, 1997, fig. 9).

Rocha das Gaivotas/Armação Nova and Castelejo

In the western Algarve, shell middens with Late Mesolithic occupations were identified at Rocha das Gaivotas/Armação Nova and Castelejo (Vila do Bispo, Faro). Rocha das Gaivotas and Armação Nova (*Appendices – Table A14*) are located on a cliff 1 km north of Cabo de São Vicente, at around 60 m of altitude, being part of the same complex, although excavated by different teams. Armação Nova was excavated in 1991 by Soares and Silva, who identified Early and Late Mesolithic occupations. These works yielded some ‘cuvette’ type fireplaces and lithic remains (Soares and Silva, 2004). According to the excavators, the main function of the site would have been the exploitation of the locally available flint, considering the high frequency of core preparation and maintenance material among the lithic remains and the little presence of other categories, such as cores and microlithic tools (Soares and Silva, 2004, p. 413). Concerning the locus of Rocha das Gaivotas, which extended for at least 300 m², the excavations undertaken in 2003–2004 identified a succession of occupations from the Early Mesolithic to the Early Neolithic (Carvalho, 2008a; Valente et al., 2014). The Late Mesolithic occupation, dated to the beginning of the 8th millennium cal BP, was detected in one of the identified layers, which comprised three well-structured hearths of different typologies: one ‘cuvette’ and two other features with flat base stones. An assemblage of lithic remains was also identified, which was dominated by flakes and did not contain any cores. The malacological species were dominated by rocky shore species, notably *Pollicipes pollicipes*, *Patella sp.* and *Mytilus sp.*

Castelejo is located further north, 10 km from Cabo de São Vicente, 100 m from a beach of the same name. It has an estimated area of 3000 m² and a complex stratigraphy of several shell deposits intercalated by sand levels. Occupations from the Early Mesolithic to the Early Neolithic were found at this site. The Late Mesolithic layers only provided shell remains, mostly from limpets (*Patella sp.*) and mussels (*Mytilus sp.*) (Soares, 1996a; Silva and Soares, 1997).

Overall, both sites have been considered to be specialised sites (Soares, 1996a) that would have been mainly dedicated to shell gathering. In the case of Rocha das Gaivotas/Armação Nova, flint collecting would have also acquired a significant importance (Soares and Silva, 2004; Carvalho, 2008a; Valente et al., 2014).

4.2.1.4.4. Analysis of general trends

The shell middens of the south-western coast of Alentejo and Algarve with occupations attributed to the Late Mesolithic (n=8) were associated with a saltwater environment (open coast), but some cases (four sites) were also related to a brackish water environment (estuary). The majority of the sites (63%) was located less than 2 km from the main aquatic environment. The mean altitude of these sites is 55 m, indicating a location at middle altitudes. The mean area of shell distribution is 2638 m². The shell accumulation occurred as layers, totalling a mean thickness of 0,61 m. A similar value was obtained for the shell middens in the Sado valley.

Through the analysis of the general parameters (*Appendices – Table A15*), the majority of these sites provide evidence of exploitation of a limited number of animal classes (88%), although a relatively large number of mollusc species were identified in most cases (63%). The recovered artefacts were often limited to lithics (88%). In some cases (at least four sites), the presence of all stages of the lithic *chaîne opératoire* was found, indicating local knapping, while in others, only a limited number of categories was detected.

Concerning funerary activity, human remains were only identified at two sites and burials were only formally detected at one site, in a low quantity. The presence of non-burial features was quite more frequent, being recorded at 50% of the sites, although in low numbers and mostly limited to combustion features. Dwelling features were not recorded in the region. Overall, the activities related to these sites can be classified as diverse in half of the sites, while the other half provided evidence of limited activities. Chronological data are particularly infrequent and problematic for these sites. Only one site provided evidence of occupation of more than 1000 years. For this reason, the periods of occupation at the sites and formation of the shell layers are still difficult to quantify.

4.2.1.4.5. Discussion

The south-western coast of Alentejo and Algarve is characterised by the presence of several shell middens, mostly in coastal locations. Due to the impact at many of these sites by strong marine erosional processes, the information concerning the exact chronology and nature of the occupation is relatively more limited. In addition, most sites are small and/or limited areas were excavated.

The researchers have attributed a temporary/specialised character to many coastal sites of the region, despite the probability that the available information is highly truncated. It has been thought that the main purpose of its occupation was the exploitation of shellfish and, in some cases, of other specific local resources, such as flint. It has been also sustained that the occupation of these sites tended to be seasonal, even for sites such as Fiais that could have been a base camp. The indicators of funerary activity in these sites are clearly less numerous compared to the shell middens of the Tejo and Sado valleys, a situation that suggests a substantial functional difference between the two areas. However, similarities can also be found, notably between the estuarine site of Fiais and the middens in the Tejo and Sado valleys. Concerning the features, it is interesting to note that concentrations of animal bones dominated by red deer remains with bones still articulated were found either at Fiais and Cabeço da Amoreira (Muge), a situation that highlights the importance of hunting and, possibly, of this animal in particular for these groups.

4.2.2. Shell middens in France

4.2.2.1. Overview

Six Late Mesolithic shell middens are known in France, being concentrated in the north-west area, in Brittany and Pays-de-la-Loire regions (Dupont, 2003b; Marchand, 2003; Dupont et al., 2007b) (Figure 50). However, only four sites are currently preserved: Beg-an-Dorchenn (Finistère), Beg-er-Vil (Morbihan), Tévéc (Morbihan) and Hoëdic or Port-Neuf (Morbihan). Shell middens have been known in this area since the end of the nineteenth century, when the first site (Beg-en-Dorchenn) was identified (Du Châtellier, 1881). In the 1920s and 1930s, the sites of Tévéc and Hoëdic were excavated by Marthe and Saint-Just Péquart (Péquart et al., 1937; Péquart and Péquart, 1954), becoming internationally well-known in Europe by the discovery of exceptionally elaborate burials (Schulting, 1996). After that, excavations were developed in the 1980s at Beg-an-Dorchenn and Beg-er-Vil under the direction of Olivier Kayser (Kayser, 1985a; 1986a; 1988c). In the beginning of the twenty-first century, excavations were also developed at the site of Saint-Gildas 1B (Loire-Atlantique) (Dupont and Marchand, 2003; Dupont et al., 2007a). More recently, new excavations and interdisciplinary analyses were conducted at the site of Beg-er-Vil between 2012 and 2018, under the direction of Grégor Marchand and Catherine Dupont (Marchand and Dupont, 2014b; Marchand et al., 2018).

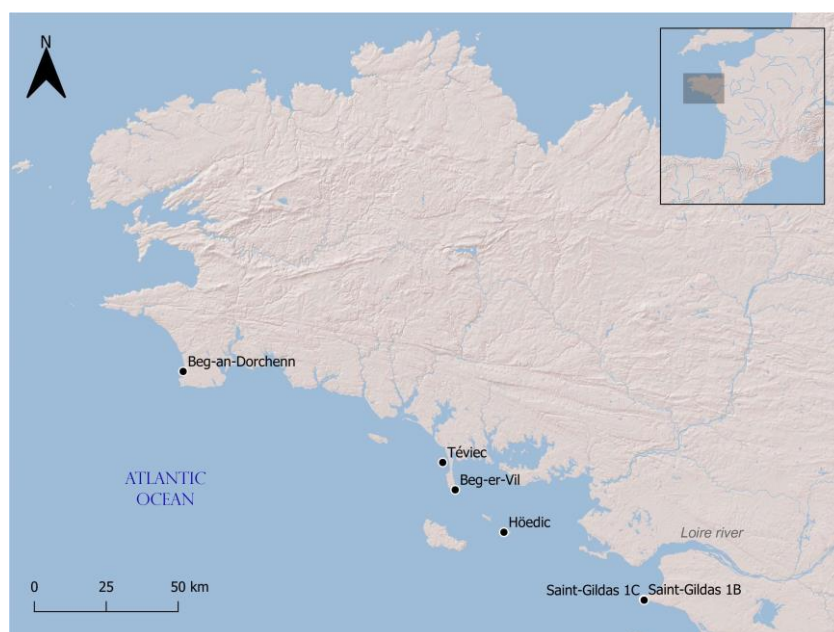


Figure 50: Location of the Late Mesolithic shell middens in the north-west France (according to *GéoBretagne* database and Dupont et al., 2007a) (image by author).

The Late Mesolithic shell middens in the north-west France are coastal sites located on cliffs, currently covered by sand dunes and subject to constant erosion. At the time of occupation, these sites would be positioned less than 1 km from the coast (Dupont et al., 2007b). The absence of preserved shell middens from periods previous to the Late Mesolithic in France has been explained by the submergence of the existing sites due to sea-level rise and being covered by sedimentary deposits (Dupont et al., 2007b; Gutiérrez-Zugasti et al.,

2011). In addition, the concentration of Late Mesolithic shell middens in north-west France in particular can be explained by the fact that the sandy shores between the Armorican Massif and the Pyrenees are much more exposed to erosion than the rocky coastlines of north-west France (Marchand, 2020).

Early descriptions indicate that most Late Mesolithic shell middens were relatively large, and at least 100 m². According to currently available data, the sites are formed by few shell layers between 0.20 m and 1 m thick, usually containing marine shell fragments, ash, charcoal, sand and silt forming a dark sediment. Currently, these sites do not present a prominent form that can be seen in the terrain (Marchand, 2003; 2014; Dupont et al., 2007b), but it is possible that sites such as Beg-an-Dorchenn had a mounded form in the past (Du Châtellier, 1881; Bénard Le Pontois, 1929). Due to the effects of marine erosion, it is difficult to know more about the original form and dimensions of the shell middens.

The archaeological record of the majority of these sites (except for Saint-Gildas) has been characterised by the presence of diverse faunal evidence (shellfish, fish, marine mammals, sea birds, terrestrial mammals, and others) and material culture remains, indicating an exploitation of different environments. The main exploited mollusc species were available in the immediate environments of the sites, notably limpets (*Patella sp.*), flat oysters (*O. edulis*), mussels (*Mytilus edulis*), thick topped shells (*O. lineatus*), periwinkles (*L. Littorea*), cockles (*C. edule*), peppery furrow shells (*Scrobicularia plana*) and carpet shells (*Ruditapes decussatus*). In addition, several features were identified, such as hearths of different types and complexity, pits and stone pavements. Dwelling features have not often been detected, but the recent excavations at Beg-er-Vil provided some relevant evidence (Marchand and Dupont, 2018; Marchand et al., 2018). Funerary activity seems to have been restricted to specific sites. Burials have only been identified at Téviec and Hoëdic so far, although in large quantity and revealed a high complexity in funerary rituals (Péquart et al., 1937; Péquart and Péquart, 1954; Schulting, 1996). Stable isotope analysis results on bone collagen from individuals from Téviec and Hoëdic indicated that marine resources had a substantial importance in the diets of these coastal populations, with a reliance of 50–80% on marine protein (Schulting and Richards, 2001; Schulting, 2015).

In most Late Mesolithic shell middens known in France, multiple activities of a different nature would have been undertaken. For this reason, the sedentary or semi-sedentary occupation of these sites has been largely assumed (Marchand, 2014). Contrary to the Portuguese case, several littoral sites other than shell middens are known in open air locations in north-west France, notably on the islands in the region of Brittany (such as the open air site of Bordelann, Morbihan) and on the continental coast (sites on cliffs such as Pors-Bali, Finistère, or located more inland, such as Ty-Nancien, Finistère), which have provided a more diverse and complete image of coastal settlement (Marchand, 2014; 2020). In this region, Late Mesolithic shell middens and other littoral sites seem to have been part of the same littoral settlement system characterised by groups with a developed maritime mobility between the mainland and islands and a complete economy based on the exploitation of locally available resources. However, further investigation is required to know more about non-shell midden littoral sites, notably excavations, considering that they are mostly known through surface surveys, occasional finds, or small test pits. In addition, inland sites occupied

in the Late Mesolithic have also been documented, allowing researchers to argue about the existence of two opposing settlement systems in this period – littoral and inland (Marchand, 2020). According to the view of Marchand (Marchand, 2003; 2020), the archaeological evidence, notably the presence of coastal flint pebbles at inland sites and the absence of continental rocks at littoral sites, suggests the existence of exchanges between the two regions, occupied by different groups, instead of period migrations of the same group. This idea is also supported by other indicators, notably the high ratio of marine protein in the diets and the complete economy of the coastal groups evidenced by faunal and seasonality studies, suggesting that the coastal populations achieved a high level of stability in this region.

4.2.2.2. Beg-er-Vil

The shell midden of Beg-er-Vil (Quiberon, Morbihan) is located on the southernmost part of the Quiberon peninsula, on an ancient cliff, on the western side of a low rocky point (Beg-er-Vil point) (Figure 51). The site is positioned at 5 m of altitude, being exposed to marine erosion (*Appendices – Table A17*). It is thought that, during the Mesolithic, the site was located 150–500 m from the coast (Dupont et al., 2007b). The shell midden has an estimated area of about 130 m², but due to marine erosion, dune cover and impact from urbanism, it is difficult to understand its original configuration and extent. Currently, the site is visible as a single, organic level of black sediment with shells, lithic remains, bones, charcoal and other elements, with an average thickness of 0.20–0.40 m. It is found on a Pleistocene beach (with numerous pebbles) and granitic bedrock, and below thick dune deposits (Marchand et al., 2018).

The site of Beg-er-Vil was discovered in 1970 by Gildas Bernier. Formal excavations were done for the first time between 1985 and 1988 under the direction of Kayser, through an area of 22 m² (Kayser, 1985c; 1987b; 1988b). These works were focused on the thickest zone of the shell deposit (Marchand and Dupont, 2015). Several analyses on material remains recovered during this field work were published (Kayser, 1988c; Poissonnier and Kayser, 1988; Kayser, 1992; Marchand, 2000; Tresset, 2000; Dupont, 2003a; Schulting et al., 2004; Dupont and Gruet, 2005; Tresset, 2005; Dupont et al., 2007b).

Between 2012 and 2018, the site was subject to new archaeological excavations under a research project directed by Marchand and Dupont (Marchand, 2012; Marchand and Dupont, 2013; 2014a; 2015; 2016a; 2017; 2018; 2019; Dupont and Marchand, 2021). The excavated area extended to east, reaching not only a relatively marginal zone of the shell midden, but also the surroundings. In total, an area of 170 m² was excavated with an extensive recovery system (Marchand et al., 2019). The general stratigraphy of the site in the shell zone comprised, from top to bottom: the dune; a sandy layer with archaeological remains, but no shells; a series of rich dark organic sandy-silty black-coloured layers with a large quantity of shells, lithics and bones; a level of numerous reddened granitic blocks containing the main features; a sandy layer with numerous shells and tools; a clayey-silty layer with numerous pebbles and no archaeological objects, placed on the Pleistocene beach (Marchand and Dupont, 2018; Marchand et al., 2018).

The excavations undertaken so far yielded a large quantity of artefacts, notably lithic remains and ecofacts (mammal and bird bones, charcoal, crab and fish remains and fruit,

among other things). The lithic components, mostly made of flint, are diverse and indicate the practice of local debitage, with an important presence of geometric microliths, notably symmetrical trapezes. A recent functional analysis identified use-wear on some lithic material, suggesting their use in a wide variety of activities on diverse materials, notably plant working, soft animal material processing and projectile use (Calvo-Gómez, 2023). Also, bone/antler tools and some shell tools were found. Faunal remains from several animals were identified, showing a high diversity of exploited resources (terrestrial mammals, marine mammals, marine and terrestrial birds, crustaceans, molluscs, fish remains), from terrestrial and marine environments that were close to the site (Schulting et al., 2004; Tresset, 2005; Dupont and Bicho, 2015). The identified mollusc species – at least 33 – indicate an exploitation of diverse aquatic environments, although with a preference for rocky and sandy shores (Dupont and Bicho, 2015, p. 94). The main malacological species are mussels (*Mytilus edulis*), limpets (*Patella* sp.), periwinkles (*Littorina littorea*), cockles (*Cerastoderma edule*), topshells (*Porcus lineatus*), European clams (*Ruditapes decussatus*), dog whelks (*Nucella lapillus*), peppery furrow shells (*Scobicularia plana*) and flat oysters (*Ostrea edulis*) (Marchand et al., 2018). All species typical of the intertidal zone were exploited, indicating that the groups were adapted to the foreshore all year long (Marchand and Dupont, 2019).



Figure 51: Beg-er-Vil, Brittany region – view of the site and excavated area in 2018 (photo by author).

The structures found at this site present some diversity, comprising hearths, pits, stone concentrations and dwelling features. Several types of hearths were identified (circular areas defined by reddened stones, hearth-pits and others), revealing the importance of combustion activities at the site, possibly for different purposes (Marchand, 2020). Although isolated human remains were found, no graves were identified.

Concerning the spatial organisation of the site (see Chapter 5), the most recent excavations allowed researchers to distinguish the shell midden area, where several hearths were found, from a sandy peripheral area, which, according to the researchers, probably corresponded to distinct functional areas (Marchand et al., 2019; Dupont and Marchand, 2021). It is thought that the shell midden area was used as a place for disposal and diverse activities, whereas the sandy zone was dedicated to several activities, but also to residential functions. In this area, two circular features of approximately 3.5 m in diameter were found, defined by several postholes and a hearth-pit inside. These features were interpreted as

dwelling, although other functional possibilities (a fish or meat drying structure, a sweat lodge) were also suggested. In the same area, several hearth-pits and surface hearths were also found.

With respect to the chronological data, the most recently obtained radiocarbon dates indicate an occupation of the site during the last two centuries of the 9th millennium cal BP (approximately 8200–8000 cal BP). Considering the homogenous stylistic character of the lithic industry, with an almost complete predominance of symmetrical trapezes, and the radiocarbon data, it has been suggested that the occupation of the site was relatively short, possibly less than 100 years (Marchand et al., 2018; Marchand and Dupont, 2019).

Beg-er-Vil has been interpreted as a long-term residential site, mostly due to its extent and large quantity of materials and features that were detected. The diversity of identified animals is another argument in favour of this perspective, since it shows an exploitation of a wide range of resources that were available in different seasons of the year and biotopes (Dupont and Bicho, 2015; Marchand and Dupont, 2019). According to the researchers, all identified mollusc species collected alive are accessible on dry land at low tide, suggesting that the Mesolithic groups at the site had a detailed knowledge of the intertidal environments and tidal cycles (Dupont and Marchand, 2021). Furthermore, the ongoing microstratigraphic study has indicated a prolonged occupation of the site without visible periods of abandonment, in which the shell midden would have corresponded to a waste zone with intense trampling activity (Marchand and Dupont, 2019). Contrary to the well-known sites of Tévéc and Höedic, graves have not been found at Beg-er-Vil so far, despite the relative extent of the excavated area and the frequency of non-burial features, including the probable dwellings, for which parallels at other shell middens in Brittany are unknown. Overall, the residential function of this site is much better supported by the archaeological record in comparison with Tévéc and Höedic, for which less information is available about the domestic aspects (Péquart et al., 1937; Péquart and Péquart, 1954).

4.2.2.3. Beg-an-Dorchenn

Also known as Pointe de la Torche and Pointe du Coussin, the site of Beg-an-Dorchenn (Plomeur, Finistère) is located on a natural peninsula barring the south-east end of the Bay of Audierne (*Appendices – Table A18*). In the north-eastern part of the Pointe de la Torche promontory, the shell midden is positioned at the beginning of the isthmus, on the rocky seashore. A megalithic monument is also known on the top of the outcrop. In addition, several Bronze and Iron Age remains were identified on the promontory and a German bunker was constructed at the level of the megalithic monument, affecting the shell midden (Figure 52). It is thought that the distance from the site to the coast in the past was between 10 and 500 m (Dupont et al., 2007b).

The site was identified and excavated for the first time at the end of nineteenth century by Paul du Châtellier (Du Châtellier, 1881; 1882–1883; 1889), who discovered a probable proto-historic human burial. The field work at the site continued, namely by Charles Bénard Le Pontois between 1920 and 1926 (Bénard Le Pontois et al., 1919; Bénard Le Pontois, 1929) and by Pierre-Roland Giot between 1946 and 1950 (Giot, 1947; Giot and Guilcher, 1947), whose works were carried out in various zones of the site and provided several lines of

evidence for Mesolithic, Neolithic (megalithic), Bronze Age and Iron Age occupations. However, the largest and best-known excavations were centred on the Late Mesolithic shell midden and undertaken by Kayser between 1984 and 1988 (Kayser, 1984; 1985b; 1985a; 1986b; 1987a; 1988a). The researcher excavated an area of 53 m² in the current footpath zone and found evidence of a funerary Iron Age occupation, specifically four tombs, and numerous Mesolithic remains. A more recent excavation was undertaken in 2001 by Dupont and Marchand, on a small area of 2 m² (Dupont et al., 2010).



Figure 52: Beg-an-Dorchenn, Brittany region – view of the site from the German bunker (photo by author).

The shell midden of Beg-an-Dorchenn is formed by a shell layer with a lenticular form. According to Du Châtellier (Du Châtellier, 1881; 1882–1883; 1907; Bénard Le Pontois, 1929; Giot and Guilcher, 1947), the shell midden would have been around 80–100 m² at the end of the nineteenth century. Dupont and collaborators observed that the flint remains found on the surface suggested the existence of a Mesolithic site covering an area of at least one hectare, of which the shell midden would have occupied only a part (2010, p. 231). The shell deposit is today a thin layer, with 0.30–0.40 m in thickness according to the most recent observations (Kayser, 1984; Dupont et al., 2010). However, it would have been 1 m or even 1.60 m according to past descriptions (Du Châtellier, 1881; 1882–1883; 1907; Bénard Le Pontois, 1929). In fact, the consequences of the erosion on this site (caused by the sea and human impact) were already clear in the twentieth century (Du Châtellier, 1907, p. 10). Kayser estimated the destruction of 100 m² of the site after Du Châtellier's excavations (Kayser, 1984).

The stratigraphy of the Mesolithic occupation was affected by the subsequent Neolithic, Iron Age and modern occupations, and also by the construction of a German bunker. The excavations undertaken by Kayser between 1984–1988 led the researcher to recognise the following levels, from top to the bottom (Kayser, 1988a): a level of sand and gravel attributed to a medieval occupation, a level of sand (dune) from a protohistoric occupation, where several tombs were found cutting the bottom levels, a level of sand (dune) with Neolithic materials on the top, a shell midden layer attributed to the Mesolithic, and a silty/clayey layer with a Palaeolithic industry. The shell midden layer was further divided into four sublayers: a sandy layer with a rich industry, an organic layer with a high quantity of shells, a sandy layer and a silty/clayey layer. In 2001, a stratigraphic section in the cliff was obtained, which mostly

corresponded to the previous description of the stratigraphy: below several levels of sands of the dune formation, a dark, organic layer of sediment with shells, bones and lithics was identified, over a silty and clayey layer with some intrusive shells (Dupont et al., 2010).

The chronological data are still rare and somewhat problematic to define the duration of the Mesolithic occupation with precision. The most recent radiocarbon data place the formation of the shell midden in the Late Mesolithic in the first half of the 8th millennium cal BP (Dupont et al., 2010).

The excavations provided several materials, notably a high number of lithic remains with a diverse industry mainly made of flint, indicating the practice of local debitage (Rault, 1992; Dupont et al., 2010). Two main operational sequences were identified – the production of bladelets and split pebbles/splintered pieces (Rault, 1992). According to the analysis undertaken by Olivier Rault (see Chapter 5), there was a knapping area in the south-east zone of the site, in association with an isolated block, which was indicated by the presence of a high quantity of splintered pieces (Rault, 1992, p. 151). Concerning the faunal remains, a high quantity of animals was identified, which included molluscs (more than 30 species), birds, fish, crab and terrestrial and marine mammals. Mollusc shells were dominated by edible species, namely *Patella sp.*, and after *Cerastoderma edule* and *Ruditapes decussatus*. The identified species are thus indicative of the exploitation of different marine environments, notably rocky, sandy and muddy shorelines (Dupont et al., 2010, p. 243). Some hazelnut remains were also detected. The exploitation of a diverse range of food sources is thus suggested by the archaeological record.

In addition, several features were identified, which included some hearths, possible dwelling floors, stone concentrations and pits (see Chapter 5). A stone structure was documented, being formed by large reddened and fire-cracked pebbles/blocks with a flat and oval surface of at least 3.5 m length and 3 m width. A flat surface hearth with a circular form and 1 m in diameter was found in the middle of the feature. Overall, the set of features was interpreted as a dwelling floor by Kayser (Kayser, 1985b), a hypothesis that was also considered by Marchand (Marchand, 2020).

The shell midden of Beg-an-Dorchenn has been characterised as a residential site with a broad spectrum economy (Dupont et al., 2010; Dupont and Bicho, 2015), mainly due to the dimensions of the site, the high diversity of faunal remains suggesting that the groups had access to diverse resources near the coast for at least half of the year, the existence of a diverse lithic industry indicating a local and unspecialised lithic production for multiple purposes and the presence of some features related to domestic activities and, possibly, residential purposes. Despite the diversity of activities that was recorded at the site, it seems likely that funerary activity was absent during the Mesolithic.

4.2.2.4. Téviec

The shell midden of Téviec is located on a granitic island with the same name, 1.8 km from the Quiberon peninsula, in the municipality of Saint-Pierre-de-Quiberon, Morbihan (*Appendices – Table A19*). The site was found in the north-west part of the island, in front of a cliff. Despite its current insular condition, it is thought that the island was connected to the

mainland during the Late Mesolithic (Rozoy, 1978). According to estimations, the site was located approximately 20–1000 m from the coast at that time (Dupont et al., 2007b).

The site was discovered by Félix Gaillard in 1883, who proceeded to conduct a small survey. After some occasional material finds, Marthe and Saint-Just Péquart confirmed the existence of the shell midden and developed extensive excavations between 1928 and 1930 (Péquart and Péquart, 1929; Péquart et al., 1937) (Figure 53). Although it was considered that the archaeological record was relatively correct for this period (Schulting, 1996), these excavations and respective publications focused on the graves, whereas the non-funerary aspects of the site were barely described. In addition, sieving does not appear to have been used. Despite these limitations, several analyses of the documents and materials from these works have been undertaken (Rozoy, 1978; Schulting, 1996; 1999; Schulting and Richards, 2001; Dupont, 2003a; Tresset, 2005; Large, 2013; Fontan, 2015; 2016; Boulestin, 2016).



Figure 53: Téviec, Brittany region – general view of the excavations in 1929, with some graves and a large hearth-pit (reproduced from Péquart et al., 1937, fig. Pl.1-5).

Péquart and collaborators described that the site had a surface of 200 m², based on the distribution of the shells (Péquart et al., 1937, p. 5). However, it was noticed that the original surface was larger and partially destroyed by marine erosion. The shell deposit was characterised as a layer with 0.60–1 m of thickness composed of a uniform, dark and compact sediment, with charcoal remains (Péquart et al., 1937, p. 18). Contrary to Hoëdic, an upper level with Neolithic remains was not detected according to the excavators.

Despite the problems of contamination and the reservoir effect, most radiocarbon dates obtained from the site in the end of the twentieth century indicate a Late Mesolithic occupation in the second half of the 8th millennium cal BP (Schulting, 1999; Schulting and Richards, 2001). The oldest date was obtained from burial 13 (OxA-6665: 6740±60 BP) and the most recent one from burial 2 (OxA-6662: 5680±50 BP), showing a huge spread. Recently, a new radiocarbon date was obtained from roe deer remains from grave D, with a result of 7190±30 BP (Beta-436330) (Marchand and Schulting, 2019). Apparently, this suggests an earlier occupation at the end of the 9th millennium cal BP, that would have preceded the period indicated by the former radiocarbon dates. However, since only bone remains from graves have been dated so far, it is difficult to detail the chronology of the site's formation.

Unfortunately, the material from the excavations at Tévéc was sent to different institutions and parts of the assemblage became lost (Rozoy, 1978, p. 785; Tresset, 2000, p. 24). The material described in the literature includes chipped stone tools on flint, ground stone tools on quartz pebbles and schist, bone and antler tools, faunal remains, personal ornaments (mostly on shell), ochre, charcoal, and other things. However, Péquart et al. noted that the quantity of recovered stone and bone tools was not impressive (Péquart et al., 1937, p. 72). A hundred chipped lithic artefacts, which included geometric microliths, was identified in association with graves. However, most material were retouched tools. The presence of cores and flakes was noted (Péquart et al., 1937, p. 18) but, apparently, debris material was not recovered (Rozoy, 1978, p. 785). It is probable that the recovery of artefacts was selective, which poses limits to the interpretation of the nature of the lithic industry. A total absence of ceramic and polished stone tools was highlighted by Péquart et al. (1937, p. 4). The main malacological remains included *Patella* sp., *Osilinus lineatus* and *Ostrea edulis* (Dupont, 2003a). Mammal remains were abundant, notably red deer (*Cervus elaphus*), roe deer (*Cervus capreolus*) and wild boar (*Sus scrofa*), but few fish remains were found (Péquart et al., 1937). In addition, remains from 21 species of birds were identified, some presenting traces of cutting and burning (Tresset, 2005, p. 86). Overall, diverse faunal remains were found at the site.

The diversity of exploited food sources was also indicated by stable carbon isotope results obtained from the individuals buried at Tévéc. These analyses suggested the existence of a balanced economy incorporating marine and terrestrial protein sources in nearly equal proportions into the diets. A greater use of terrestrial resources in comparison with Hœdic was evidenced, a difference that was attributed by the researchers to the less isolated position of Tévéc that gave easier access to a larger terrestrial hinterland (Schulting and Richards, 2001).

Several structures were identified during the excavations, which included a high number of hearths of different types (hearth-pits, some defined by large blocks, natural depressions, flat hearths made of stones and ritual hearths with a coffer form and placed over graves), 10 human graves (pits and natural depressions) and one isolated stone structure (Péquart et al., 1937). Hearths were classified into three types – domestic, feasting and ritual. Feasting and ritual hearths were associated with burials. Burials of 33 individuals (adults and children) were found, with the graves being concentrated in a specific area of the site, without overlapping. These graves with one or more individuals were cut into sterile beach deposits and/or the shell midden, corresponding to complex structures, mostly with associated features, notably hearths, stone structures or both. The stone structures (cairns) associated with some of these graves were described as massive concentrations of blocks forming a repository (cenotaph), usually filled with shell deposits and mandibles of red deer or wild boar. Two skeletons had structures made of antler covering the bodies, while others had antler deposits near them. Several other grave goods were found. Despite the richness of the burial features and associated materials, non-burial pits and dwelling-related structures were not identified in the site.

The site of Tévéc became known for its exceptional evidence of funerary use, being classified by Péquart et al. (1937) as a 'habitat-necropolis'. The funerary and ritual activities

are well-documented, considering the complexity of the funerary structures and the abundant grave goods. However, despite the presence of ‘domestic’ hearths, the accumulation of the shell midden and the diversity of animals among the recovered faunal remains, the residential function of the site is badly evidenced by the available archaeological record, although being generally accepted (Schulting and Richards, 2001; Marchand, 2003; 2015; Dupont and Bicho, 2015). The idea of contemporaneity between the different functions of the site (residential and funerary) has been questioned (Marchand, 2017), despite the limitations of the chronological data that do not allow researchers to better understand the dynamics of the site’s formation.

4.2.2.5. Hoëdic

The shell midden of Hoëdic (Quiberon, Morbihan), also known as Port Neuf, is located on the island of Hoëdic, 18 km from the Arzon Peninsula, south of Morbihan (*Appendices – Table A20*). The site is located on a cliff at an altitude of 6 m, in the north-western part of the island, north of ‘Port Neuf’ (Figure 54). Nowadays, the island is covered with sand dunes. It is thought that, during the Mesolithic, Hoëdic was already an island (Marchand, 2003; 2015) and the shell midden was positioned 20–1000 m from the sea (Dupont et al., 2007b).

The site was identified in 1923 and excavated between 1931 and 1934 by Marthe and Saint-Just Péquart (1954). There is relatively little information available about these works when compared to Tévéc. Yet, some material from these excavations is known and several analyses were undertaken (Rozoy, 1978; Schulting, 1996; 1999; Schulting and Richards, 2001; Dupont, 2003a; Large, 2013; Boulestin, 2016). More recently, new field work (geophysical surveys and short excavations) were started by the team of Pablo Arias and Grégor Marchand between 2018 and 2021 (Marchand and Arias, 2018; 2021).



Figure 54: Hoëdic, Brittany region – view of the site (photo by author).

According to Marthe and Saint-Just Péquart (1954), the site had an area of 200 m² (based on the distribution of the shells) and the thickness of the shell deposit was approximately 0.25–0.50 m at the time of their field work in the 1930s. Two main horizons of occupation were described. Under a level of sand (at the top of the dune), a level of brownish aeolian sand was identified with Neolithic or more recent remains. This layer covered a sterile level of pebbles and dark sand that was deposited over the shell midden layer. Any Neolithic

artefacts (ceramic or polished stone tools) were found in the shell midden layer, which was directly on top of the bedrock (Péquart and Péquart, 1954, p. 11). According to the descriptions, the stratigraphy at Höedic was thinner than at Tévéc.

The radiocarbon dates from Höedic that were obtained at the end of the twentieth century present a larger spread than those of Tévéc, being probably affected by contamination and the reservoir effect. Also considering the typological data, it has been generally stated that the site was occupied in the second half of the 8th millennium cal BP (Schulting and Richards, 2001; Marchand and Schulting, 2019).

The exact numbers are unknown, but, according to Péquart and Péquart (1954), abundant lithic remains were not found in the 1930s at Höedic. Jean-Georges Rozoy noted a total of 324 tools (Rozoy, 1978, p. 781). The main recovered material was retouched blades, geometric microliths (trapezes and triangles), scrapers and drills made on flint (Péquart and Péquart, 1954, p. 24). Apart from a microburin, lithic debris was not recovered (Rozoy, 1978, p. 779). However, based on the identification of a lithic deposit near a hearth, Péquart and Péquart suggested that lithic production was undertaken at the site (Péquart and Péquart, 1954, p. 17). In fact, the analysis of some of the lithic material recovered during the most recent field work identified the presence of abundant debris, flakes and other material types that were almost absent from the older descriptions, confirming the existence of lithic production activity at the site (Marchand and Arias, 2021), and the impact of the different methodologies of excavation on the available data. In the 1930s, several bone and antler tools were also recovered, although it was stated that funerary materials were not so rich as those from Tévéc (Péquart and Péquart, 1954). Personal ornaments were found in a large quantity, notably perforated shell adornments using *Littorina obtusata* and *Trivia monacha* (Dupont, 2003a; 2007).

Diverse faunal remains from six animal classes were identified, indicating an exploitation of a wide range of resources at the site, although it was considered that the quantity of remains was lower than those found at Tévéc (Péquart and Péquart, 1954; Rozoy, 1978; Tresset, 2005). The known malacological information indicates that the majority of molluscs was gathered from rocky shores, with *Ostrea edulis*, *Mytilus edulis*, *Patella* sp. and *Osilinus lineatus* being among the dominant species (Dupont, 2003a; 2007). Some shells with traces of abrasion were identified.

Despite the variety of remains that were found, the results of isotopic analyses undertaken on bones of the individuals from this site suggested that these groups had a particularly high marine protein intake (around 70–80%), even compared to individuals from Tévéc (Schulting and Richards, 2001).

Detailed descriptions of the structures found in the 1930s at Höedic were not published. It was stated that, in general, the features were less-solid and complex compared with Tévéc (Péquart and Péquart, 1954, p. 62). Some hearths of different types (surface hearths and hearth-pits) were identified. A total of 10 graves of different types (grave pits, natural depressions, simple depositions) were found, from which nine contained human remains. Most features were concentrated in the eastern part of the excavated area. The absence of stone structures ('mausoleums') as identified at Tévéc was highlighted by the excavators (Péquart and Péquart, 1954, p. 62). Despite the relative paucity of structures at Höedic, antler

covering structures on graves were more frequent than at Tévéc (Péquart and Péquart, 1954, p. 72; Large, 2013). A circular and large stone pavement, without associated materials, was identified east of the necropolis and interpreted as a structure for flattening the terrain's surface, with a possible social or ritual function (Péquart and Péquart, 1954, p. 64). Special attention was paid to a set of about 50 narrow and thin blades found near a hearth, which was interpreted as a probable deposition of lithic material for stock and use for microlithic tool production (Péquart and Péquart, 1934; 1954, p. 17).

The funerary function of this site is clear considering the several graves and ritual evidence that were found, despite the apparent lower complexity of the features when compared with Tévéc. Also, as observed for Tévéc, there is little evidence of a residential use of the site, apart from the reported hearths and some other features described with few details. Despite that, the residential function of the site has been considered (Marchand, 2003; 2015; Dupont and Bicho, 2015), although its relation to the funerary activity is still difficult to understand.

4.2.2.6. Saint-Gildas

A set of three Mesolithic sites separated by 100 m is known in the Saint-Gildas headland, located between the Loire estuary and Bourgneuf Bay, in the municipality of Préfailles, Loire-Atlantique region. Two sites are shell middens – Saint Gildas 1b and 1c – which border the two main faults on the south-western part of the headland. The sites are located between the foreshore and the plateau, having an easy access to the foot of the cliffs (Dupont and Marchand, 2008). At their identification, the sites were very close to the sea (10 m away), but it is estimated that during the Mesolithic they were located approximately 1 km from the sea, in the ancient estuary of the Loire. A third station (Saint-Gildas 1a) without shells was discovered nearby (Tessier, 1965; 1984), but only contained lithic and ceramic materials.

Saint-Gildas 1b

Saint-Gildas 1b (*Appendices – Table A21*) was reported as a small shell midden with a microlithic lithic industry by M. Tessier (1965; 1984). In 2003 and 2004, after the site was almost destroyed, four small surveys were carried out by Dupont and Marchand (behind the shell zone), in a total area of 10 m² (Dupont and Marchand, 2003; 2008; Dupont et al., 2007a). The site was characterised as a shell layer that was strongly affected by erosion (Dupont and Marchand, 2008, p. 143). According to earlier information, shells were observed within an area of 2.50 m in length, 0.80 m in width and 0.25 m in thickness (Bellancourt, 1980). More recently, lithic remains were detected over an area of 500 m² and the total surface of the archaeological site was estimated to be less than 1000 m² (Dupont and Marchand, 2008, p. 144). A survey carried out in 2003 (1 m²) led to obtaining a stratigraphic section that contained a layer of 15 cm of aeolian sands, deposited on a sandy/silty layer of dark brown colour with some lithic material (approximately 10 cm in thickness), followed by a silty dark and organic sediment and a lens of shells in a dark and clayed sediment, which was over the bedrock (Dupont et al., 2007a, p. 166).

A diverse lithic industry was identified, comprising chipped and ground stone tools that suggest the practise of local lithic knapping (Figure 55). The recovered materials were mostly small flakes and regular blades and bladelets on locally available flint. Remains from the first

steps of the operational sequences, namely the removal of cortical pieces, and tools such as geometric microliths were also found (Dupont et al., 2007a). However, with respect to the faunal remains, only malacological materials were found. Those were dominated by *Scrobicularia plana*, which represented more than 95% of the total MNI from the survey in 2003 (Dupont et al., 2007a; Dupont and Marchand, 2008). The presence of other species, such as limpets (*Patella* sp.), suggests that distinct zones of the foreshore (mudflats, rocks) were exploited. No structures were found at this site.

The absence of reported faunal remains other than shells, the low diversity of mollusc species (the predominance of one species), the absence of structures and the low volume of the shell deposit have been the main arguments used by the researchers to suggest a temporary and logistical occupation for this site, possibly in context of specific expeditions (Dupont and Marchand, 2008, p. 149). Two radiocarbon dates were obtained from shell samples (Gif-3531: 7850 ± 140 BP and Beta-194786: 8000 ± 40 BP), indicating an occupation during the second half of the 9th millennium cal BP, although the reservoir effect was not corrected (Dupont and Marchand, 2008, p. 145).

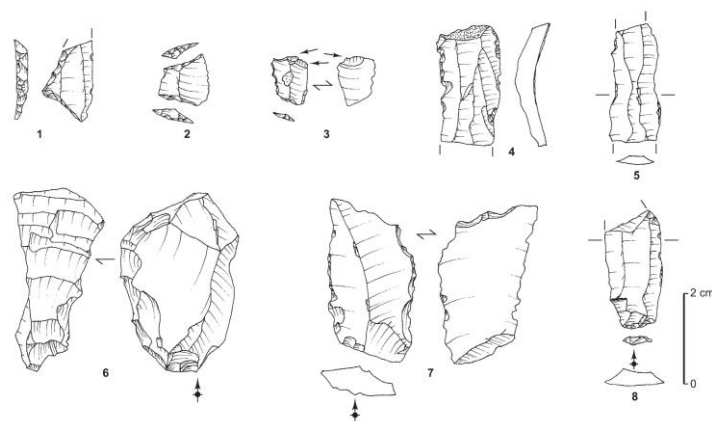


Figure 55: Saint-Gildas 1b, Loire-Atlantique region – lithic remains found in the excavations in 2003 (reproduced from Dupont et al., 2007a, fig. 4).

Saint-Gildas 1c

Saint-Gildas 1c, also located on the cliff, was discovered after a strong storm in 1978 (Tessier, 1984). Unfortunately, excavations were not undertaken, the shell deposit disappeared and little information was left (Dupont et al., 2007a; Dupont and Marchand, 2008). It was described by Michel Tessier (1984, p. 78) as a small shell midden, covering a surface of approximately 20 m. The site was then classified by Dupont and Marchand as a shell pocket and studied with more detail (Dupont et al., 2007a; Dupont and Marchand, 2008). One radiocarbon date was obtained on a shell sample (Gif-4847: 7120 ± 90 BP), suggesting an occupation in the first half of the 8th millennium BP (7800–7500 BP). This site also provided relatively abundant and diverse lithic remains with similar characteristics to those found Saint-Gildas 1b. Also, faunal remains other than shells were not found. The main identified molluscs species were *Scrobicularia plana*, being followed by *Patella* sp. No structures from this site were reported. Similarly to Saint-Gildas 1b, a temporary and

logistical occupation has been also suggested for this site, considering the low diversity of activities that was documented (Dupont et al., 2007a; Dupont and Marchand, 2008).

To summarise, the shell middens of Saint-Gildas, with an estuarine character, are unique in the context of north-west France, contrary to other regions in Atlantic Europe, such as Portugal, where estuarine sites are frequent. However, little information is known about these sites. Saint-Gildas 1b and 1c are overall characterised as small shell deposits, although this image is, at least partially, a result of the effects of strong erosion at these sites. The absence of faunal material other than shells was possibly a characteristic of the deposits since their origin (Dupont et al., 2007a, p. 190), being also exceptional in the context of the Mesolithic shell middens in north-west France. The activities undertaken at Saint-Gildas seem to have been centred on mollusc gathering and the production of flint tools, notably hunting weapons (Dupont and Marchand, 2008). While estuarine molluscs were predominant, it is important to note that its strategic location allowed access to resources from the estuary and also the seashore. Information on site structure is not available, due to the limited areas of the sites that were preserved, the small-scale excavations, and the absence of known features. In addition, chronological data are rare, limiting a better knowledge about the formation of these two sites, which seems to have occurred in distinct periods. Overall, the archaeological evidence indicates that there were temporary, logistical, and relatively specialised occupations at these strategically located sites.

4.2.2.7. Analysis of general trends

Through the analysis of general parameters (*Appendices – Table A22*), it is possible to confirm that the six Late Mesolithic shell middens known in France are all located at a low altitude (a mean altitude of 9.1 m). The sites were mainly associated with a saltwater environment (rocky coast), excepting the Saint-Gildas sites, which were mostly in a brackish water environment (estuary) despite its current coastal location. The shell middens were positioned less than 2 km from the main water source at the time of the occupation. Although only four sites provided estimations, the obtained value of the mean area of shell distribution is 158 m², indicating relatively small dimensions of the sites. The shell accumulations can be described as layers with a mean thickness of 0.51 m. However, it has been recognised that coastal erosion substantially affected these sites. For example, according to early descriptions, Beg-an-Dorchenn was probably a mound-type shell midden in the past.

The four largest sites (Beg-er-Vil, Beg-an-Dorchenn, Téviec and Höedic) provided abundant evidence of diverse fauna and malacological species, which indicates the exploitation of varied food sources. Contrary to this, at the Saint-Gildas sites, faunal remains other than shells were not found. The exploitation of molluscs at Saint-Gildas seems to have been also restricted to a limited number of species. The presence of diverse artefacts was found at the four major sites, while the Saint-Gildas sites only provided lithic remains. However, the recovered lithics can be classified as diverse at all sites and indicate the practise of local knapping in general.

Burials were only documented at Téviec and Höedic, although in large quantity, whereas non-burial features were detected at the four coastal sites. Non-burial features were

characterised as abundant at three sites. However, evidence of dwelling features was only found at one site (Beg-er-Vil). Overall, the available evidence from the four major sites allows researchers to classify the activities related to these sites as diverse. The archaeological record from the Saint-Gildas sites is exceptional in this context, indicating the practice of relatively limited activities. Despite recent advances, data about the period of accumulation and occupation of the shell middens are still generally rare, limiting the analysis. The chronology is only relatively well-defined for Beg-er-Vil, whose formation was estimated to have occurred within less than 200 years.

4.2.2.8. Discussion

The currently available information on the site structure of the French shell middens is heterogenous. For example, while a large quantity of data on funerary activities was provided by Tévéc and Höedic, there is less information about other domains (e.g., stratigraphy or material culture). Moreover, these two outstanding sites were mainly excavated at the beginning of the twentieth century, without applying detailed methods of recovery and recording as they would have been today. The results of recent field work in 2018–2021 at Höedic are still limited and preliminary. Contrary to this, Beg-er-Vil was still being excavated until recently, and a large body of different types of data was obtained, despite the absence of funerary features (Marchand et al., 2018). However, a large quantity of information from this site is still in progress. Except for the Saint-Gildas sites, several features were identified in the French shell middens, notably hearths of different types, stone concentrations (pavements, alignments), graves, pits, postholes/dwellings, in some cases with some complexity that suggests a significant investment of time and effort. These features also indicate the existence of some spatial arrangement, considering the absence of overlapping features and the concentration of some feature types in certain areas of the site, notably in the case of the funerary sites. The recent discovery of dwelling features at Beg-er-Vil, outside but close to the shell accumulations, provided rare evidence of residential structures in Mesolithic shell midden sites and highlighted the importance of better investigating the areas adjacent to the middens.

With respect to site function, these shell middens have been usually divided between residential base camps (Beg-er-Vil, Beg-an-Dorchenn, Tévéc and Höedic) and temporary/specialised sites (Saint-Gildas) (Dupont and Marchand, 2008). In addition, the four shell middens usually considered to be base camps have been separated into two groups – shell middens with necropolises (Tévéc and Höedic) and those without necropolises (Beg-er-Vil and Beg-an-Dorchenn) (Marchand, 2020). It has been considered that the groups occupying these sites were at least semi-sedentary and that the residential shell middens would have developed a major role in the settlement systems (Marchand, 2003; 2020). However, it is not clear whether these sites were occupied during a prolonged period in a continuous way, or through a succession of short stays. Stronger efforts in radiocarbon dating are still necessary to better define the chronology and the nature of the occupation of these sites. Similarly, further investigation that includes extensive excavations of non-shell midden littoral sites is required to obtain a more detailed picture of the settlement system.

4.2.3. Analysis of general trends of the Portuguese and French shell middens

The number of known Late Mesolithic shell middens in France is low compared to Portugal. Other differences between the two areas can be indicated, notably in the main associated or exploited aquatic environment from these sites (with a dominance of brackish water in Portugal and saltwater/open coast in France). Despite this, and considering the chronological and cultural proximity of the Late Mesolithic groups, some comparative analyses have been undertaken on subjects such as the exploitation of aquatic environments and food sources, seasonality and material culture (Dupont and Bicho, 2015; Marchand, 2015).

The results of a joint analysis of the parameters from the French and Portuguese sites (n=44) (*Appendices – Table A23*) demonstrate that the activities undertaken at these sites or associated with them can be classified as diverse for a significant number of shell middens (43% of the sites) and as limited for a smaller number of sites (30%). Despite the higher frequency of sites with diverse activities, direct evidence of residential activity (as indicated by the presence of dwellings) has rarely been identified.

A high discrepancy between the number of shell middens associated with a brackish environment (n=29) and a saltwater (open coast) environment (n=8) or both environments (n=6) is also visible (Figure 56). Regarding the relation between the main aquatic environment and the activities at these sites, it can be found that, due to their numerical dominance, the sites with a brackish water environment were more frequently associated with the practice of diverse activities (58%) (Figure 57). However, it can be observed that 75% of sites with a saltwater environment provided evidence of diverse activities, which is a higher value when compared with the percentage of sites with a brackish water environment which can be classified as having developed diverse activities (38%). Considering this, the type of associated aquatic environment (estuary or open coast) seems to have not had a major influence on the diversity of activities undertaken at these sites or associated with them (Figure 58). Contrary to this, the typology of the shell midden seems to have had a stronger influence. It can be observed that, although being less numerous, mound-type shell middens (n=3 or 5) always provided evidence of diverse activities (Figure 59). Also, the mean thickness of the shell deposits is much higher at sites with diverse activities (1.42 m versus 0.41 m for limited activities).

The presence of diverse animal classes, mollusc species and artefacts often occurred in sites classified as having diverse activities. The opposite situation can be found in sites with limited activities. Concerning the features, the presence of human burials and non-burial features is almost always associated with the practice of diverse activities (87% and 90%, respectively). In addition, when a high number of features is recorded, this association is definite. Most sites with burials also contained non-burial features (73%). Contrary to this, the majority of sites without identified burials (72%) did not reveal the presence of non-burial features. Therefore, it can be highlighted that shell middens with evidence of funerary activity tended to provide evidence of other types of activities, notably resource processing (such as combustion, which in this analysis was only counted as a processing activity for simplification) or tool production. However, the exact meaning of some features, such as the

different types of combustion features found at Tévéc and Höedic (ritual, ‘domestic’ or both), remains an open question that challenges the functional characterisation of these sites.

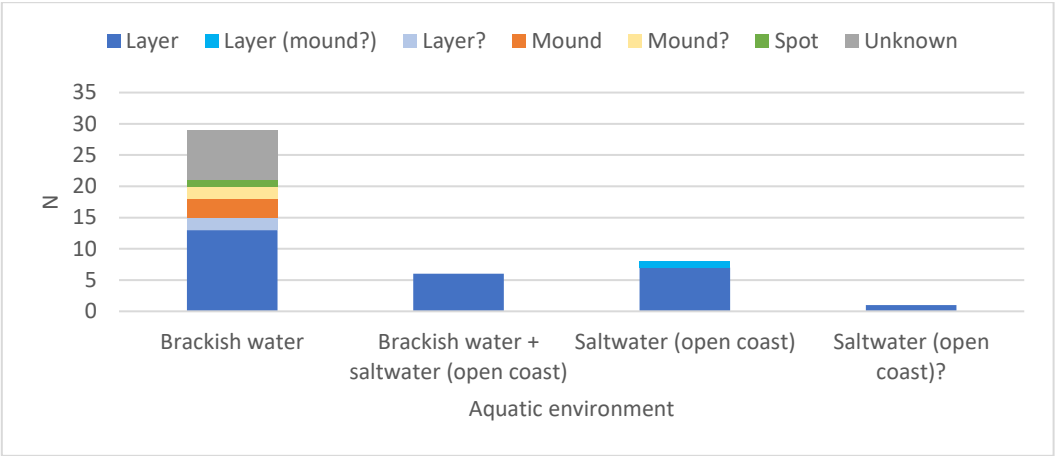


Figure 56: Distribution of shell midden types by main aquatic environment (associated with the site or exploited) in Portugal/France (n=44).

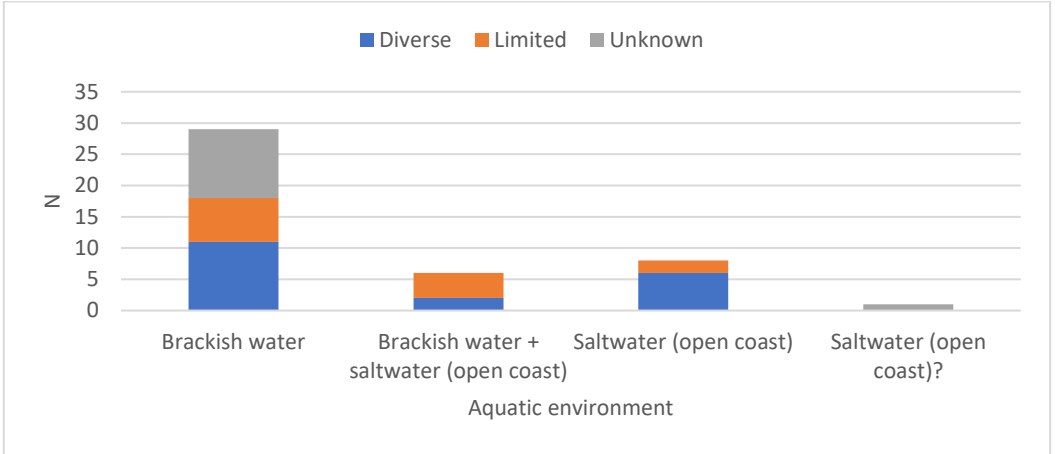


Figure 57: Distribution of shell midden site activity characteristics by main aquatic environment (associated with the site or exploited) in Portugal/France (n=44).

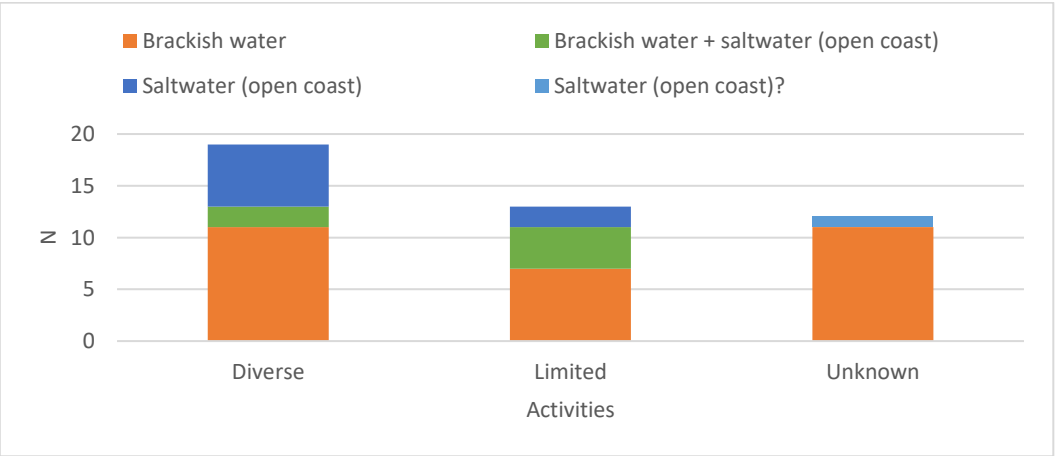


Figure 58: Distribution of main aquatic environment types (associated with the sites or exploited) by shell midden group classified by site activity characteristics in Portugal/France (n=44).

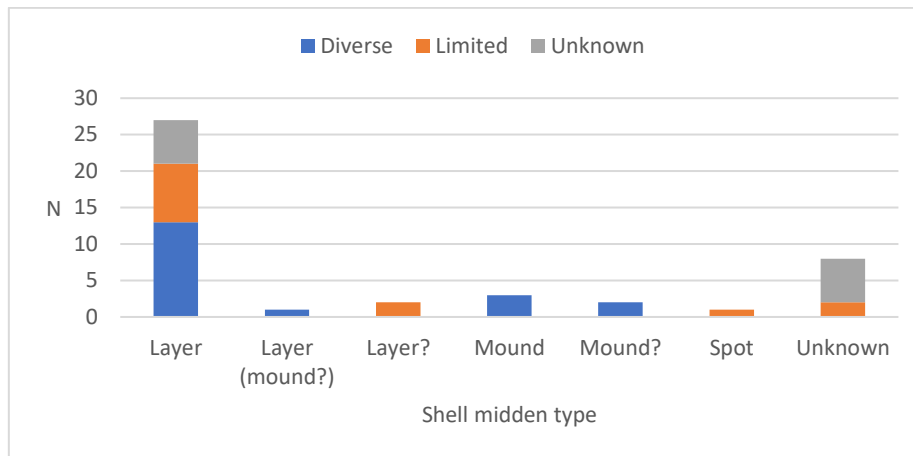


Figure 59: Distribution of site activity characteristics by shell midden type in Portugal/France (n=44).

4.2.4. Some insights from other regions

Due to the high quantity of known sites, it is not possible to review the information on shell midden site structure and function from all the Late Mesolithic sites in Atlantic Europe in this study. However, some regions are highlighted in this section considering their particular importance in the shell midden record – the Cantabrian region, in Spain, and northern Denmark.

4.2.4.1. Shell middens in the Cantabrian region, northern Spain

A large quantity of Mesolithic shell middens is known on the central coast of northern Spain. The sites are particularly dense in the western part of the Cantabrian region (coast of Asturias), where about 130 Mesolithic shell middens were identified, belonging to the so-called ‘Asturian culture’ (Fano, 2019). These shell middens are located near the shoreline, in the mouths of caves and rock shelters, from where it was possible to access both the coast and the coastal plain. Despite their abundant distribution, the interpretation of these sites has been difficult, in part due to the shell middens being affected by erosional processes and the scarcity of recent large-scale excavations (Fano, 2019). In fact, it has been pointed out that many of these sites correspond to cemented remnants of shell middens adhered to walls and ceiling of rock shelters and cave entrances, which seem to have mostly resulted from naturally reworked accumulations of archaeological material. Few sites present single homogenous layers, superimposed shell-rich layers or layers with internal fine stratifications (Duarte, 2019). In addition, in many cases, radiocarbon data are not available or the stratigraphic information is imprecise, posing difficulties for the chronological characterisation of the sites.

The shell middens in this region are typically composed of marine invertebrate shells of limpets (*Patella intermedia* and *P. vulgata*), topshells (*O. lineatus*) and mussels (*Mytilus galloprovincialis*), evidencing the predominant exploitation of the nearby open, rocky coastal environments, although estuarine species were also gathered. Among the mammal remains, the presence of red deer is dominant, but remains of other animals have been also identified, such as roe deer (*C. capreolus*) and wild boar (*Sus scrofa*). The presence of marine fish (such as sardines, anchovies, horse mackerel and others), brackish water fish (such as *Sparidae*, *Soleidae*

and *Serranidae* families) and crustaceans is common, as well as some bird remains (Gutiérrez-Zugasti et al., 2011; Fano, 2019). Charred plant remains are also documented, indicating the consumption of wild fruits, notably of hazelnuts (López-Doriga, 2016). However, lithic and bone tools are rare at these sites. Lithic remains are mostly characterised as heavy-duty tools made on local raw materials, notably the famous ‘Asturian picks’, which would have been mostly used to collect limpets (González-Morales, 1982; Fano, 2019).

Habitation areas and features were not identified at the majority of the sites. For a long time, these shell middens were seen as disposal areas. The habitation areas were supposed to be placed in open-air locations, in the vicinity of the caves or shelters where the refuse would have been deposited (Gutiérrez-Zugasti et al., 2011; Arias et al., 2015b). Recently, the application of geophysical survey techniques allowed for the identification of an open-air occupation at El Alloru, in the proximity of a rock shelter with a shell midden dated to the early 9th millennium cal BP (Early Mesolithic), sustaining this perspective (Arias et al., 2015b). The test pits undertaken at the site allowed the detection of two small pits that were considered to be postholes. Geoarchaeological analyses undertaken at some of the Asturian shell middens also concluded that the accumulation of carbonate-cemented shell middens was primarily a result of natural agents (notably spring activity) that caused redeposition of materials previously deposited elsewhere. According to this perspective, these cemented deposits would have corresponded to peripheral areas during the Mesolithic, when the spring systems were active, whereas the main occupations would have occurred in their proximity (Duarte, 2019).

Despite this, some (rare) shell midden sites in the region seem to have been effectively occupied. Miguel Fano argued that not all the shell deposits seem to have resulted from simple waste accumulations and, at least in some cases and/or times, caves would have been used as dwelling areas (Fano, 2019). For example, an occupation surface was identified at Mazaculos II (La Franca, Asturias), a Mesolithic stratified shell midden (not cemented) inside a cave where a level with lithics, bones, charcoal, burnt stones (probably from dismantled hearths) and other material was found orderly placed at the base and still within the shell midden (González-Morales, 1982). At El Mazo and El Toral III (Llanes, Asturias), some structures were found, suggesting that several activities took place inside. El Mazo is a rare stratified shell midden in a rock shelter with an Early–Late Mesolithic chronology (between 9000–7500 cal BP), where a stone-structured hearth was identified, as well as reddened clay and charcoal lenses which probably corresponded to other combustion features (Gutiérrez-Zugasti et al., 2016; Duarte, 2019; García-Escárcaga et al., 2019). El Toral III is another rock shelter where a succession of clay and shell midden layers from the Early and Late Mesolithic and some postholes were detected (Rigaud and Gutiérrez-Zugasti, 2016). Funerary remains were found at some sites in the region, but contrary to other cases in Atlantic Europe, usually these sites only contained a single individual. Grave goods are rarely documented, but the presence of personal adornments has been recorded, such as beads made of shell and red deer canines (Gutiérrez-Zugasti et al., 2011; Fano, 2019).

The largest shell middens have been considered as a result of relatively stable or at least repeated occupations, while small sites with evidence of short occupations have been seen as seasonal sites (Gutiérrez-Zugasti et al., 2011; Fano, 2019). The archaeological data from

these sites indicate an exploitation of locally available resources, thus also suggesting that these groups had limited mobility. According to the palaeodietary data, these groups had a relatively balanced diet, with a consumption of marine and terrestrial proteins in similar proportions (Gutiérrez-Zugasti et al., 2011; Fano, 2019). Inland sites are also known in the mountains, being considered that littoral and inland settlements, although only 10–15 km apart, corresponded to distinct foraging populations in the region with contrasting diet patterns (a mixed terrestrial-marine diet in the littoral and full terrestrial diet inland) (Rigaud and Gutiérrez-Zugasti, 2016).

Overall, despite the substantial homogeneity that characterises the Cantabrian shell middens (revealed, for example, by the patterns of site location and being affected by post-depositional effects), the archaeological evidence also reveals some diversity. Some shell middens seem to have strictly worked as waste accumulations of nearby open-air settlements, while others seem to have had additional functions and were effectively occupied. In both cases, the deposition of shells in specific and delimited areas can be regarded as a particular characteristic that these groups had in common.

4.2.4.2. The Ertebølle shell middens in Denmark

In Denmark, about 400 shell middens are attributed to the Late Mesolithic (Ertebølle, around 7400–6000 cal BP), being the largest concentration known in the Scandinavian region and in northern Europe (Andersen and Johansen, 1986; Larsson, 1990; Andersen, 2007; Bailey and Milner, 2008; Gutiérrez-Zugasti et al., 2011). According to the works of Søren Andersen (2000; 2007), Mesolithic shell middens are concentrated in the north/north-east part of Denmark and have a large variation in size (from a few to thousands of square meters in area and between 0.10 m and 2 m of thickness). Usually, the middens have a characteristic, oblong outline, lying directly on and along the ancient coastline. The sites are formed by layers of different species of shellfish and cultural debris and tend to be situated in the coastal biotopes of the region with sheltered waters, notably estuaries, bays, fjords and lagoons, and often close to natural shell banks. In particularly productive areas, these sites are often recorded in groups. The predominant malacological species are oysters (*Ostrea edulis*), which are characteristic of this region, followed by cockles (*Cerastoderma edule*), mussels (*Mytilus edulis*) and periwinkles (*Littorina littorea*). Stone tools, bone/antler tools, animal bones (in particular fish bones), charcoal and some pottery remains are among the other main materials that can be found. At Hjarnø Sund (Hjarnø, Jutland), an underwater shell midden located at the Horsens Fjord, wooden artefacts were also recovered (Skriver et al., 2018). Contrary to other regions in Europe, shells seem to have been rarely used for the production of artefacts such as beads (Gutiérrez-Zugasti et al., 2011).

It has been argued by Andersen (2000; 2007) that many of these shell middens had an internal organisation maintained over long periods of time, which is evidenced by the identification of different deposits and activity areas. According to the researcher, the sites are usually composed of small heaps or layers of shellfish, that indicate that each mollusc species tended to be processed separately. In addition, in front of several middens, a ‘drop-zone’ consisting of layers of debris thrown and/or washed out into the sea can be found, while the areas behind the shell middens usually contain evidence of occupation. However,

despite the high number of known sites and the extensive excavations undertaken so far that allowed the detection of signs of occupation inside and outside the middens, few well-defined dwellings have been identified (Larsson, 1990; Andersen, 2000; Rowley-Conwy, 2013). According to Rowley-Conwy (2013), the most reliable evidence (foundation cuts and postholes) was found at Visborg (Mariager) and Lollokhuse (Sjælland) shell middens, but the dwellings were located below the shell accumulations at both sites. In many cases, substantial occupations seem to have taken place before the accumulation of the shell middens, being suggested that dwellings were possibly constructed without leaving any traces. Rowley-Conwy (2013) pointed out that the absence of dwelling evidence at shell midden sites may largely be caused by their destruction, since ‘smearing and blending’ processes (movement and re-deposition of shell heaps during the accumulation of the middens) and recycling of structural elements (for the construction of new dwellings) can be frequent at shell middens.

Several other features have been identified at these shell middens, mainly in the shell layers – hearths, but also pits, postholes and a few graves (Larsson, 1990; Andersen, 2000; 2007) (Figure 60). The most common hearth types are circular stone-built features and lenses of burnt shell matrix. According to Andersen, the frequency of lenses of burnt shell matrix in the shell horizons reflects a strong internal structuring of the middens over long periods, indicating the existence of spatial organisation and feature maintenance (Andersen, 2000, p. 377). For example, at Ertebølle (Limfjord), several hearths were found within the same area of the midden and mostly superimposed (Andersen and Johansen, 1986, p. 48). Following the models advocated by Binford, the researcher considered that fireplaces were focal points at these shell midden sites, since cultural waste is usually concentrated in these areas (notably lithic and bone remains, suggesting that flint knapping and food processing took place around these features) (Andersen, 2000, p. 377). Other types of features have been documented in a sporadic way, notably pits and graves of humans and dogs.

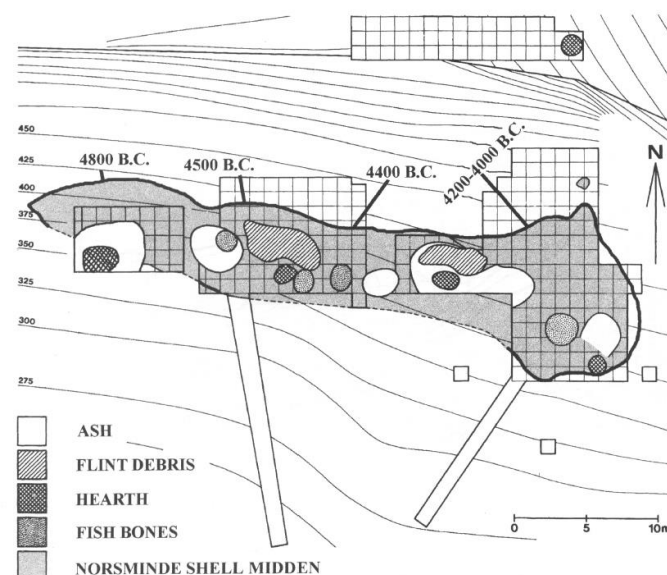


Figure 60: Plan of the stratified shell midden of Norsminde (Jutland, Denmark), with several hearths and concentrations of lithics and fish bones inside the midden (reproduced from Andersen, 2000, fig. 14).

With respect to site functionality, and based on seasonality studies, it has been considered that the larger sites with features and several artefacts were used over a long span of time (c. 1000–2500 years), corresponding to year-round occupations (Andersen, 2000; 2007). These larger sites are often stratified shell middens with Mesolithic and Neolithic occupations, evidencing that there was some continuity and stability to Mesolithic–Neolithic transition, although indicators of permanent and continuous occupation have been lacking from the archaeological record. Contrary to this, smaller sites with more limited material assemblages and fewer features are thought to reflect specialised and seasonal activities. In addition, it has been observed that, in limited areas, such as estuaries, usually only one of the middens is large and centrally positioned in the biotope, being surrounded by several smaller, contemporary sites, a situation that suggests the existence of site hierarchy. Chronology has also been interpreted as an element of differentiation of site function – most Late Mesolithic shell middens seem to correspond to residential sites, while Neolithic middens seem to have tended to be used as waste disposal areas of a nearby settlement (Andersen, 2000; 2007).

Coastal settlement sites without shell layers are also known in the same regions where shell middens are identified. In fact, non-shell midden sites are the predominant type of coastal sites in the region (Andersen, 2000; 2007). Shell midden sites appear to be identical to non-mollusc sites in terms of site location and cultural remains, except for the presence of shells. Therefore, it has been argued that the location of Ertebølle settlement sites would have been mainly conditioned by the access to good fishing resources, and not to shellfish, although the latter would have also been exploited if natural banks were available in the environment (Andersen, 2000, p. 365). Additionally, in many middens, fish bone layers were found, reflecting the practice of intense fishing and, possibly, the systematic use of specific areas of the middens for fish processing (Andersen, 2000, p. 378; Ritchie, 2010). Inland sites are also known in the region, especially near rivers and lakes. The available isotope evidence suggests that a significant part of the protein in the diets of the Mesolithic individuals of this region was obtained through marine food sources, even at inland sites (Fischer et al., 2007). It has been thus understood that coast–inland movement was a regular phenomenon in the Mesolithic, probably being undertaken by boat (Larsson, 1990).

To synthesise, the Ertebølle shell middens in Denmark have provided a large amount of data on site formation, organisation and function. The perspective that these sites were spatially organised at both intra- and inter-site levels has been underlined. However, while it seems clear that many Danish shell middens did not result from a random disposal of shells, it is still up for discussion if these sites had a particular social or ritual importance. Graves are few in Danish shell middens, although being largely identified in other site-types (Larsson, 1990), and in shell middens of other regions in Europe. Also, despite the large number of identified shell middens, the relevance of marine molluscs for these populations has been subject to discussion, considering the evidence of important fishing activity and the rare use of shells as raw material for artefacts. However, the existence of different types of shell middens, some with large dimensions, long occupations and positioned in central locations in the settlement systems, suggests that the social importance of these sites could have varied according to context.

4.3. Case studies from the Jomon of the Japanese archipelago

4.3.1. Shell middens in western Japan

4.3.1.1. Overview

Only about 17% of the currently known Jomon shell midden sites in the Japanese archipelago (422 out of 2443 sites) are located in western Japan (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division], 2017). The lower presence of shell middens in western Japan, in relation to eastern Japan, corresponds with a lower density and smaller size of Jomon sites in general, which are thought to reflect a lower population density, residential stability and economic intensification in the region (Akazawa, 1986; Habu et al., 2011; Matsumoto et al., 2017). The lower number and density of Jomon sites in general in western Japan in relation to eastern Japan has been explained by several environmental factors, notably, differences in the forest zones, available food resources, geomorphology and site location.

According to Izumi (1985 as cited in Matsumoto, 2011), in eastern Japan, the period of food gathering for Jomon people would be relatively restricted due to the dominance of deciduous tree forests (including chestnut trees) with a restricted number of species. This would have resulted in the development of more intensive labour organisation. However, the forests in western Japan, dominated by evergreen broad-leaved trees, would be characterised by a higher biodiversity, enabling a longer harvest time and requiring less labour intensification.

Concerning available food resources, several other issues have been discussed. According to Takeru Akazawa (1986), the forest and estuarine/Pacific shelf littoral ecosystems in eastern Japan could supply a much more stable seasonal procurement for Jomon hunter-gatherers (year-round maritime and forest productivity) than the forest-freshwater ecosystems of western Japan, where the groups would be less specialised and more dependent on plant resources. However, it is important to note that since the 1980s, advances were made in Jomon research (Mizunoue, 2008; Yagiura, 2012) and sites with different types of location – not limited to forest-freshwater systems – have been detected in western Japan (Koizumi, 2016). More recently, Akira Matsui, following Sugao Yamanouchi, highlighted the importance of access to anadromous salmon. According to the author, in western Japan, Jomon groups did not enjoy access to these resources, which would represent a storable, high quality food that was largely exploited in eastern Japan (Matsui, 1999, p. 333). Nevertheless, this opinion is not agreed upon among researchers (e.g., Takahashi et al., 1998).

Finally, it is important to note that western Japan is characterised by a lower number of plateaus and a higher frequency of lowland locations, which would have resulted in the archaeological invisibility of many sites. Several Jomon sites in western Japan are thus deeply buried under alluvial plains (Seguchi, 2009, p. 77), posing difficulties for identification and research.

Overall, and although the western Japan is characterised by a much lower quantity of Jomon shell middens, some concentrations can be highlighted, such as the clusters of the Ariake Sea (Saga, Nagasaki and Kumamoto prefectures) and the Seto Inland Sea (Okayama prefecture) (Takahashi et al., 1998; Toizumi, 2014) (Figure 61). In the Kinki region, some large shell middens developed in Osaka Bay, especially during the Late–Final Jomon

(Toizumi, 2014). Although rare, in the Biwa Lake region, freshwater shell middens developed between the Initial and Middle Jomon periods, as exemplified by the sites of Awazu (Shiga prefecture) (Iba, 2005). On the island of Kyushu, in the Ariake Sea region, shell middens formed with more intensity between the end of the Initial Jomon and the Late Jomon periods, being mostly associated with the exploitation of muddy tidal flats and estuaries (Toizumi, 2014). The discovery of the Higashimyo shell midden, in Saga prefecture, became internationally well-known, due to the waterlogged conditions of the site and the exceptional preservation of organic material (Matsui, 2013; Nakamura et al., 2013). In addition, large shell middens developed in the region in the Late Jomon period. In the northern part of Kyushu, around Ko-Onga and Dokai Bay, some shell middens were also formed on the rocky shores, with particular emphasis in the Late Jomon period, although shell middens that resulted from the exploitation of open-sea coasts are rare in Japan (Mizunoue, 2008; Toizumi, 2014; Nakao, 2016).

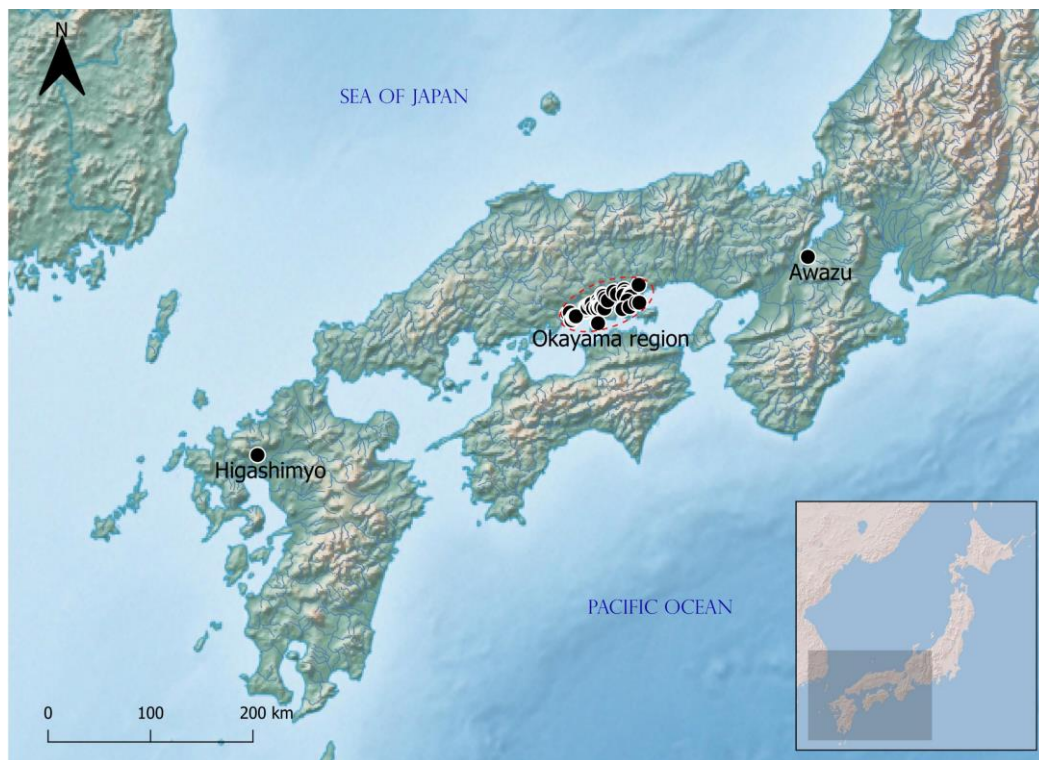


Figure 61: Western Japan and location of the Jomon shell middens mentioned in this text – complex of Okayama region, Higashimyo and Awazu (image by author).

The Seto Inland Sea region is a shell midden-rich area, especially the central zone of the northern part of the sea, which currently corresponds to the Okayama and eastern part of Hiroshima prefectures (Yagiura, 2012; Toizumi, 2014). Most shell middens were formed in the ancient Kojima Bay, in the Okayama region (Takahashi et al., 1998; Mizunoue, 2008; Tajima, 2008). The formation of the Seto Inland Sea started in the 9th millennium BP, with the Holocene Transgression and the advance of salt waters (Tajima et al., 2008). The development of a suitable environment for shells and the increased reliance on aquatic resources by human groups in the region are attested by the formation of shell middens since the Initial Jomon and the increase in dimensions of shells through time at these

archaeological sites (Tajima et al., 2006, p. 4). The majority of the sites was formed in embayments and estuaries, in association with the exploitation of muddy tidelands, being predominantly composed of shells of *Tegillarca granosa* (blood cockle) and *Crassostrea gigas* (Japanese oyster). The sites are mainly located on sandbanks, sandy beaches and near low terraces at the foot of mountains (Koizumi, 2016). According to a proposal by Mitsuo Koizumi (2016, p. 86), these shell middens can be classified as general settlement sites. Specialised processing sites have not been identified in this area, although this type of shell midden is known in other parts of western Japan, such as Kinki and Kyushu (Koizumi, 2016, p. 107).

Contrary to eastern Japan, few integral excavations of shell middens have been undertaken in western Japan, in part due to the lower quantity of preserved features at the sites (Tajima et al., 2006, p. 7). Moreover, many sites were excavated a long time ago, with the main purpose of recovering human remains or obtaining pottery typologies (Yagiura, 2012). Recent and specific research on shell middens is still rare, particularly in Chugoku and Shikoku regions (Koizumi, 2016, p. 85). Despite these constraints, the discovery of submerged shell middens of Awazu (Shiga prefecture) and Higashimyo (Saga prefecture) strongly contributed to changing this picture and enriched the Jomon shell midden record of western Japan (Iba, 2005; Matsui, 2013; Nakamura et al., 2013; Nishida et al., 2016b).

The location of shell midden sites in western Japan also has some particularities. In the Kanto region, most settlement shell middens are located on plateaus, the base of plateaus or terraces and several mollusc processing specialised sites have been found on lowland sites (Abe, 2007). However, in western Japan, the majority of shell middens are lowland, waterfront settlement sites (Koizumi, 2016), becoming impossible to evaluate site function using the same criteria of the Kanto region. Also, according to Koizumi (2016, p. 81), the different characteristics of site location could explain the rarity of circular or horseshoe-shaped shell middens in western Japan. The researcher also highlighted the formation of shell middens with specific layouts in western Japan, notably cases of large settlement sites containing a shell midden in the central area, such as the Hirajo shell midden, Ehime prefecture.

4.3.1.2. Okayama region

The prefecture of Okayama, in the Chugoku region, western Japan, is characterised by a mountain landscape in the north, a coastal plain in the south and the Kibi plateau in the middle. The coastal alluvial plain was shaped by several rivers, such as Yoshii, Asahi and Takahashi, and developed on the Seto Inland Sea, which is punctuated by numerous islands (Figure 62).

The littoral area of Okayama has been known as a relatively dense region for shell middens since early archaeological research in Japan (Ikehasu, 1971). Several Jomon pottery styles from the Seto Inland Sea region have the names of shell midden sites from Okayama. According to the most recent inventory (Yamaguchi et al., 2015), 52 Jomon shell middens are known in Okayama prefecture (Figure 63), being the densest concentration in the Chugoku and Shikoku regions. Nevertheless, many of these sites were excavated a long time ago and lack detailed information, notably environmental data. The first archaeological field

work was aimed at the discovery of human skeletons (e.g., Kiyono et al., 1920), and later, the attention shifted towards the study of pottery and settlement issues (Kawase, 2006; Tajima, 2015a), as also occurred in other regions in Japan.



Figure 62: View of the Seto Inland Sea from Inujima island (southeast area of Okayama prefecture) (photo by author).

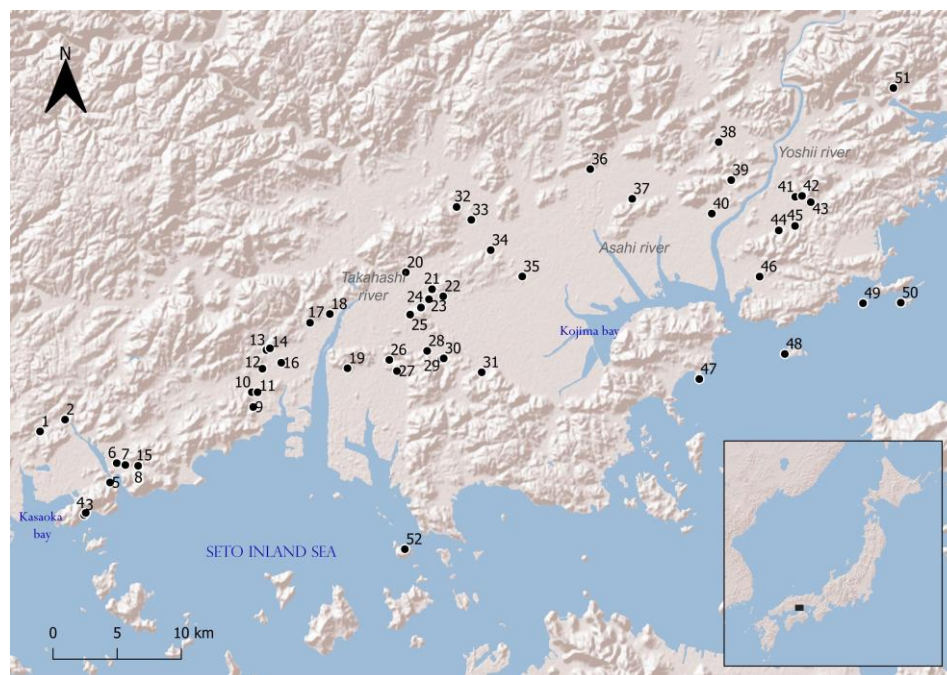


Figure 63: Distribution of the Jomon shell middens in Okayama prefecture (according to Yamaguchi et al., 2015): Arida (1); Jomi (2); 3: Daidō 1 (3); Daidō 2 (4); Higashimura (5); Kasaoka Kōgyō Kōkō Guraundo (6); Tsukumo (7); Hara (8); Nakatsu (9); Nishimoto Hama (10); Higashimoto Hama (11); Awara (12); Kishimoto (13); Tsukinoki (14); Hama (15); Shimaji (16); Suzumimatsu (17); Satogi (18); Tsurajimanishi No Ura (19); Nishioka (20); Kurosaki (21); Nakaobie (22); Itsukaichi (23); Hashima (24); Funagura (25); Urada (26); Fukuda (27); Funamoto (28); Isonomori (29); Funatsubara (30); Hikozaiki (31); Yabeokuda (32); Nishio (33); Ouchida (34); Senoo (35); Asanebana (36); Hyakkengawa Sawada (37); Numa (38); Takehara (39); Kanayama Nishi (40); Miyashita (41); Yamate (42); Shintoku Kaizuka B (43); Ōhashi (44); Enbari Higashi (45); Kurowa (46); Habarizaki (47); Inujima (48); Kuroshima (49); Kishima (50); Naganawate (51); Yanagi No Tani (52) (image by author).

According to recent geomorphological studies (Yamamoto et al., 2018), the Okayama coastal plain area suffered substantial changes in the Jomon period as a consequence of marine transgression and regression processes. It is thought that a major marine transgression episode started in the Initial Jomon and reached a peak in the Early Jomon period, allowing the formation of shallow coastal water environments through the region. At that time, the sea would have reached the area of Tsushima Okadai, at Okayama city (a site currently located on the campus of Okayama University and far from the sea). Then, a temporary decrease in temperatures and sea level regression occurred in the Middle Jomon, which would have allowed the expansion of tidelands and brackish water environments. In the Late Jomon, a new episode of sea transgression took place in the area. Finally, sea regression occurred again in the Final Jomon and Yayoi periods, allowing the accumulation of sediments and the beginning of the formation of the current alluvial plain.

The rich and calm shallow bay and estuarine environments of the Jomon period supported the development of fishing, hunting and gathering activities, and, consequently, the formation of shell middens in the Okayama region (Kawase, 2006; Toizumi, 2014; Tajima, 2015a; Koizumi, 2016). The sites are predominantly located on coastal terraces and shoals and distributed along three main areas: the ancient Kojima Bay, the ancient Kasaoka Bay and islands. The highest densities are known in the area of the ancient Kojima Bay, which was an inland sea spreading 50 km (west–east) in the Jomon period, and the Kasaoka Bay to the west (Kawase, 2006; Tajima, 2015a). According to Masanori Tajima (2015a), most sites of the ancient Kojima Bay developed between the middle phase of the Early Jomon and the Final Jomon on coastal terraces, shoals, low hills and alluvial plains. These sites are characterised by the dominance of marine species blood cockle (*Tegillarca granosa*) and oyster (*Crassostrea gigas*), the presence of ceramic sherds and fishing tools and the occurrence of several structures (Tajima, 2015a, p. 48). Although less frequent, shell middens dominated by the brackish water species *Corbicula japonica* are also known in the region (Table 5).

Generally, the most frequent mollusc species in the shell middens of Okayama prefecture are oysters (*Crassostrea gigas*) and cockles (*Tegillarca granosa*), which are typical of muddy tidelands, the brackish species *Corbicula japonica* and, in a much lesser quantity, the clam *Meretrix lusoria*, typical of sandy tidelands (Tajima, 2015a). Remains of terrestrial mammals have been found, notably of wild boar (*Sus scrofa*) and deer (*Cervus nippon*). Fish, reptile and marine mammal remains have also been detected with some frequency. The typical material culture remains are pottery sherds and chipped lithic tools (mostly on sanukite, a variety of andesite), as well as ground and polished stone tools, shell, antler and bone tools (including fishing tools) and personal ornaments (Yamaguchi et al., 2015).

According to the model proposed by Koizumi (2016) for the Chugoku and Shikoku regions, the Late Jomon shell middens from Okayama can be classified as general and residential-type shell middens of small dimensions. Shell middens specialised in processing activities have still not been identified in the region. This view can be extended to the preceding subperiods, with the exception of the Hikozaki shell midden, which is considered to be one of the largest shell middens in the Early Jomon period in western Japan (Tajima et al., 2006). However, and despite the lack of information for many cases, the existence of

some functional differences between the sites can be suggested, notably through the presence/absence of a funerary record and other features.

Table 5: Classification of the Jomon shell middens of the Kojima Bay according to the main malacological species, as proposed by Tajima (2015a).

Group (area)	Characteristics	Description
1 (eastern area)	Main location	Low hills near estuaries; inner zones of drowned valleys
	Main malacological species	<i>Corbicula japonica</i>
	Main chronology	Early–Middle Jomon
	Other characteristics	Few features
	Examples	Ōhashi (Setouchi city)
2 (central area)	Main location	Low hills near estuaries, coastal terraces and alluvial plains
	Main malacological species	<i>Corbicula japonica</i>
	Main chronology	Later phase of the Middle Jomon–Late Jomon
	Other characteristics	Significant number of features
	Examples	Asanebana, Hyakkengawa Sawada (Okayama city)
3 (central and western area)	Main location	Coastal terraces, shoals, low hills, alluvial plains
	Main malacological species	<i>Tegillarca granosa</i> , <i>Crassostrea gigas</i>
	Chronology	Early–Final Jomon
	Other characteristics	Large sites between the late Early and Middle Jomon High quantity of materials and features
	Examples	Hikozaki (Okayama city), Funamoto, Fukuda, Satogi (Kurashiki city)
4 (southeast area)	Main location	Islands
	Main malacological species	<i>Corbicula japonica</i>
	Chronology	Initial Jomon
	Other characteristics	Few features
	Examples	Inujima (Okayama city)

Funerary activities are well attested at several shell middens in Okayama. According to the latest inventory of shell middens (Yamaguchi et al., 2015), human remains have been recovered from 18 shell middens (approximately 35% of the total) located in Kasaoka Bay and the western part of Kojima Bay. Primary pit burials are dominant, as found in other regions in the Jomon period (Yamada, 2009). The most impressive case is the Tsukumo shell midden (Kurashiki city), a large necropolis developed in the Late and Final Jomon period which comprised about 170 human skeletons, which were found at the bottom of the shell layers. The burials were organised in groups and many of them had associated ornaments (Kiyono et al., 1920). Several other sites also yielded a significant number of human burials,

mostly from the Early, Middle and Late Jomon periods, notably Hikozaiki (Okayama city) with at least 34 individuals, Satogi (Kurashiki city) with 20 individuals, Funamoto (Kurashiki city) with 16 individuals or Suzumimatsu (Kurashiki city) with 15 individuals. However, despite the frequency of funerary remains, relatively little information is known about them, notably the details of the archaeological contexts. The best-known cases indicate that the skeletons were mostly inhumated in flexed positions into individual pits in the shell midden layers, and tended to not affect previous burials. Associated ornaments such as shell bracelets, earrings and waist accessories made from antler have been frequently found. In some cases, it was possible to verify that the burials were situated in specific areas of the site, such as at Hikozaiki (Tajima et al., 2008) and Nakatsu shell midden (Kurashiki city) (Suzuki, 1986).

Non-burial features, such as dwellings, storage pits or hearths, were only identified at nine sites (without considering the shell middens with adjacent settlement sites). Most of these sites are located on bay shores and inner zones and were occupied in the Middle and Late Jomon period. Dwellings are rare in these contexts, although being relatively frequent in non-shell midden sites, especially in the Late and Final Jomon periods. The placement of storage pits, considering their dominant typology in western Japan (wet-type storage pits), would be conditioned by the availability of swampy zones in low-lying areas (Sakaguchi, 2009), a situation that may explain the rarity of these features in shell middens. The presence of hearths of different typologies was reported in some sites, such as Hikozaiki shell midden (Tajima et al., 2008). However, their relative rarity may reflect the construction of surface hearths without resistant structures, as suggested by the few references to burnt soils and shells that would have been found in the excavations at Satogi shell midden (Makabe, 1971).

In some cases, the relationship of the shell midden to other areas of the sites is unclear. For example, at the site of Naganawate (Bizen city), pit-dwellings from the end of the Middle Jomon, hearths, pits and artefact concentrations were identified, but the location of the previously identified shell midden was not found (Okayama-ken Kodai Kibi Bunkazai Senta, 2005). At the site of Hyakkengawa Sawada (Okayama city), a small shell deposit from the Late Jomon was identified near storage pits and other negative structures, fireplaces and pottery concentrations. However, dwellings were not recorded, although it was considered that they probably existed (Kensetsusho Okayama Kasen Koji Jimusho and Okayama-ken Kodai Kibi Bunkazai Senta, 1993). On the opposite side of the Asahi River, the Asanebana shell midden (Okayama city) would have been related to the site of Tsushima Okadai, a settlement site located nearby from the Late Jomon period (Yamamoto, 2004). The residential area of Tsushima Okadai was found in the north-eastern zone of the site, close to the shell midden, comprising two pit-dwellings, hearths, storage pits, other negative structures and a debitage area. The higher frequency of non-burial structures in shell middens with Late Jomon occupations reflect the settlement and subsistence changes that occurred at a regional level in this period, notably the increase of site density, the expansion of the settlement to lowland and inland areas and the complexification of the intra-site organisation of residential sites in general (Yamamoto, 2004; Tajima, 2015a).

Although shell middens from the Initial Jomon to the Final Jomon are documented in Okayama prefecture, the Middle and Late Jomon are the best represented sub-periods. Rare Initial Jomon sites are located on some islands in the Seto Inland Sea, such as Inujima

(Okayama city) and Kishima (Setouchi city). These sites are mainly composed of shells of the brackish-water *Corbicula japonica* and seem to correspond to short occupations (Matsumoto et al., 2015). In the Early and Middle Jomon periods, as a consequence of the development of shallow water environments, numerous shell middens, mostly composed of saltwater mollusc shells, were formed on the inner coast, as exemplified by Hikozaki (Okayama city), Isonomori or Funamoto (Kurashiki city) (Tajima, 2015a). The proportion of shell middens in the settlement system achieved the highest level and funerary areas seem to have appeared for the first time during this phase (Yamamoto, 2004). In the Late and Final Jomon periods, shell middens were also formed in alluvial plain areas (Yamamoto, 2004), as exemplified by the sites of Asanebana and Hyakkengawa Sawada. The highest number of shell middens was achieved in the Late Jomon period, although many cases were small sites or occupations that were continued from preceding periods. In addition, the number of non-shell midden sites (littoral and inland sites) increased and the proportion of shell middens in the settlement system decreased when compared to the Early and Middle Jomon periods (Yamamoto, 2004). During the Final Jomon period, the number and dimension of shell middens in the region decreased dramatically, a phenomenon that has been attributed to sea regression (Yamamoto, 2004; Tajima, 2014; 2015a; Yamamoto et al., 2018).

In addition to the shell middens, other littoral sites and inland sites in the mountainous areas were formed during the Jomon period in the Okayama region (Yamamoto, 2004). According to Tajima (2015a, p. 48), in general the sites from the Early/Middle Jomon phase are fewer and reveal a relatively high mobility of the groups, while the number and density of sites from the Late/Final Jomon phase are higher. In the Late/Final Jomon phase, the occupations extended to the alluvial plains, the funerary areas became larger, the ritual practices became more complex and extensive raw-material exchange networks were developed. The changes detected in the Okayama region seem also to have occurred in the settlement systems in western Japan in general (Yamamoto, 2004), notably the increment of population densities and residential stability during the Late Jomon period (Seguchi, 2009; Matsumoto et al., 2017).

It has been suggested that a subsistence system with a higher dependency on plant food was developed in western Japan during the Late Jomon period (Matsumoto et al., 2017). This shift is evidenced by the archaeological record of the Okayama region, although the formation of shell middens persisted in the Late Jomon, revealing a continuity of a balanced subsistence based on plant and animal sources (Yamamoto, 2004, p. 85; Kusaka et al., 2010). The development of mixed diets of terrestrial and marine protein was also suggested by the stable isotope data from Tsukumo (Kasaoka city), mainly occupied in the Late and Final Jomon, and Funamoto shell midden (Kurashiki city), occupied in the Middle Jomon (Kusaka et al., 2010). A slightly lower proportion of consumption of marine fish at Tsukumo was indicated, when compared to the Funamoto shell midden, a difference that was interpreted as a possible result of the shift in subsistence towards a higher consumption of plant food (Kusaka et al., 2010, p. 1974). The existence of inter-regional differences in dietary patterns was also suggested by the same study, with the data indicating a higher relevance of marine and freshwater fish in diets in the Okayama region than in the Tokai region, where the consumption of marine shellfish would be more relevant. However, it is thought that the

importance of plant food sources in the two regions would be similar. More isotope studies, based on a larger quantity of archaeological sites, are still required to better understand the dietary patterns of the Jomon populations from the Okayama region and western Japan in general.

In the following sections, data from several shell middens in the Okayama region that had occupations between the end of the Initial Jomon and the end of the Late Jomon period³ are presented and reviewed, first highlighting the most informative sites (Hikozaki, Tsukumo and Asanebana) concerning shell midden formal traits and contents, site structure and function.

4.3.1.2.1. Hikozaki

Hikozaki (Hikozaki, Minami-ku, Okayama city) is a large Jomon shell midden in the Seto Inland Sea region, with an area of shell distribution estimated to be more than 10000 m² (Tajima et al., 2008). The site is located at the north-west part of the ancient Kojima Bay, over a coastal terrace approximately 6 m in altitude, at the end of an estuary (*Appendices – Table A24*) (Figure 64). During the Jomon period, the site faced the inland sea towards the north. Other shell middens formed nearby, such as Fukuda, Funamoto, Isonomori and Funatsubara (Kurashiki city), attesting to the richness of the shallow bay environment at that time.

Archaeological research at the site began in 1921. Several excavations were carried out, notably in 1948–1949 by teams from Tokyo University directed by Nakao Sakazume and Hisashi Suzuki, and after, from Hiroshima University, directed by Jiro Ikeda (Tajima et al., 2013). These first works resulted in the discovery of more than 20 human skeletons, which were mostly attributed to the Early Jomon (Ikehasu, 1971; Yamasaki and Takahashi, 2007). The most recent excavations were undertaken in 2003–2004, 2006 and 2008–2011 by the former Nadasaki City Board of Education and current Okayama City Board of Education and allowed researchers to identify occupations on two tablelands (A and B) (see Chapter 5). According to the reports (Tajima et al., 2006; 2007; 2008; 2013), Hikozaki would have been occupied from the Initial to the Final Jomon, more than 5000 years. The main tableland of the site (B) revealed a sequence of shell layers from the Early to the Final Jomon whose composition changed through time but was mostly dominated by oyster shells. The greatest thickness of shell accumulation was recorded in the Early Jomon phase (1.7 m), when the shell midden would have achieved an extent of 8000 m² in area. Initial and Early Jomon layers without shells were also identified. At tableland A, layers from the Yayoi period were superposed into a Final Jomon layer, but shell layers were not detected. Overall, a huge quantity of archaeological material (e.g., pottery, bone/antler/shell tools, including fishing tools, lithics, terrestrial fauna, bird, fish, malacological and macrobotanical remains) and several structures (e.g., hearths, storage and other pits, possible postholes, pottery concentrations, human graves and ritual features, such as pottery deposits with animal remains) were found, attesting to the practice of a wide range of activities at the site. At least 34 human skeletons were identified. Burials were detected in Early, Middle and Late Jomon contexts, being apparently organised in groups and placed in specific areas of the site. It was

³ Some of these sites had several phases of occupation including the Final Jomon period.

suggested that the absence of cross-cutting relationships between the Early and Middle Jomon graves could be indicative of intentional maintenance of the preceding funerary spaces (Tajima et al., 2008, p. 69). In addition, at least 21 hearths were identified, demonstrating the importance of combustion activities. Although dwellings were not detected, it was suggested that residential features probably existed outside of the shell accumulations (Tajima et al., 2013, fig. 81).



Figure 64: Hikozaiki, Okayama prefecture – a) view of the site (photo by author); b) surface of the site before the excavations of 2003–2004 (photo courtesy of Okayama City Board of Education); c) stratigraphic section of Trench 23, excavated in 2003–2004 (photo courtesy of Okayama City Board of Education).

Hikozaiki was considered to be a long-term residential and funerary site where hunting, gathering and fishing activities took place. However, according to a proposal by Tajima and collaborators, the following diachronic changes were documented (Tajima et al., 2008; 2013):

- 1) After a first short-term use of the site in the Initial Jomon period, the shell midden started to be formed in the Early Jomon. It achieved its largest extent in the Late Early Jomon Hikozaiki Z1 pottery phase, which was dated to the beginning of the 6th millennium cal BP (Onbe et al., 2007). The earliest human graves were found in the middle and the eastern part of the site, being attributed to the Late Early Jomon Hikozaiki Z2 pottery phase (dated to the middle of the 6th millennium cal BP).
- 2) In the Middle Jomon period, the funerary area changed to the southeast area of the shell midden. In the Early and Middle Jomon, non-burial structures (e.g., pits and hearths) seem to have been rare in shell accumulation zones and more concentrated in the zones without shells, suggesting the presence of a residential area nearby.
- 3) In the Late Jomon period, relatively large shell midden areas were formed, particularly in the Hikozaiki K2 pottery phase (dated to the beginning of the 4th millennium cal BP).

BP). Funerary, ritual and other structures were constructed. Additionally, acorn storage pits were identified at the eastern side of the plateau, near a former riverway.

- 4) In the Final Jomon period, the shell midden area became smaller and, apparently, few structures were constructed. Significant changes were observed in the dominant malacological species, which shifted from oyster to blood cockle. These changes were related to the advance of the marine regression and the sandy mud in Kojima Bay at that time.

The available data indicate that the site had a long period of occupation and a persistent accumulation of shell midden deposits from the Early Jomon to the Final Jomon period. In addition, different types of activities, such as shell deposition, food processing, tool production and ritual practice, seem to have been undertaken in close proximity (Tajima et al., 2013, fig. 81). The access and consumption of aquatic food resources would have strongly contributed to the durability and intensity of the occupations, even if a wide range of food sources were exploited and diverse activities undertaken. Food processing was considered by the excavators as a relevant activity carried out at the site through its sequence of occupation, as evidenced by the abundance of flakes, scrapers and other lithic tools, and the importance of hunting and fishing tools in the material assemblages (Tajima et al., 2006, p. 217). In addition, the continuity of funerary and other ritual activities is particularly expressive of the symbolic relevance of the Hikozaki shell midden for the Jomon groups. This relevance would not be dissociated from the high productivity provided by the surrounding ecosystem, and the strategic position of the site in exchange networks between the seashore and inland zones of the Seto Inland Sea region.

4.3.1.2.2. Tsukumo

The Tsukumo shell midden (Nishiojima, Kasaoka city) is located in Kasaoka Bay, southeast of Kasaoka city (*Appendices – Table A25*). It is situated on a gentle slope of a low hill rising above an alluvial plain (Figure 65). It is thought that, at the time of occupation, the site was located on the seashore, near the end of an estuary (Kiyono et al., 1920; Shimada et al., 1920; Kawase, 2006; Yamaguchi et al., 2015; Koizumi, 2016). The site was identified in 1870, although the first scientific reports were only known later (Kiyono et al., 1920; Shimada et al., 1920). Successive excavations took place in 1915–1921, with the main purpose of recovering human skeletons (Kiyono, 1969; Kamaki, 1986). The discovery of abundant burials made the site famous at a national level. More recently, smaller excavations were undertaken in 2006 and 2013–2014, with the main purpose of defining the limits of the site (Ando et al., 2020).

The shells are currently distributed over 40 m west–east and 60 m south–north, but the site likely extended further as evidenced by the presence of cultural remains outside the areas of shell accumulation, including preserved stratigraphic levels attributed to the Final Jomon period at north-west of the shell midden (Kawase, 2006; Ando et al., 2020). According to the pioneer excavators (Kiyono et al., 1920, p. 2), the site had few signs of shells on the surface in the past. The last published compilation of the shell middens of Okayama described that the shell layer at Tsukumo presented a thickness of 0.10–0.90 m (Yamaguchi et al., 2015). However, in the excavation report of 1920, it was mentioned there was a thickness variation

of 0.30–0.60 m, with the layer being thicker at the north-west zone (Kiyono et al., 1920, p. 2). The shell layer was composed of at least 11 malacological species, mainly typical of saltwater, such as *Cyclina sinensis*, *Meretrix lusoria*, *Ruditapes philippinarum* and *Tegillarca granosa*. It was noted that shells were mixed with black sediment, being very rare in some places. This layer was overlapped by a layer of black soil with 0.15 m–0.45 m thick, which was under the topsoil. Under the shell layer, another black soil was detected, which was overlying the natural soil. Cultural remains were mainly detected in the black soil and shell layer, and some in the disturbed top soil (Kiyono et al., 1920, p. 2).



Figure 65: Tsukumo, Okayama prefecture (photo by author).

Evidence from the Initial Jomon to the Final Jomon period was documented, but the main occupations at the site were attributed to the Late Jomon and Final Jomon periods. Only funerary structures were found in the site – several human grave pits, mostly with a single burial and located at the bottom part of the shell layer, and one cinerary urn with an infant skeleton (Kiyono et al., 1920) (see Chapter 5). At least 170 individuals were recovered (Kamaki, 1986; Yamaguchi et al., 2015; Ando et al., 2020), which is a high number compared to the rest of Japan. The graves seem to have been organised in groups and formed a cemetery (or a group of cemeteries) that was possibly used by individuals from different settlement sites but belonging to the same family group (Yamada, 2009; Ando et al., 2020). The display of the skeletons also suggests some spatial division by gender and grave goods and a preferential orientation of the body towards the north and east (Kawase, 2006; Ando et al., 2020). The majority of these burials seems to have occurred without affecting each other, although some intersections were detected. The presence of charcoal was identified near some skeletons, indicating possible combustion activities (Kiyono et al., 1920). In addition, ritual tooth ablation was found in many individuals, with differences being documented between genders and ages. The most recently obtained radiocarbon data indicate that the majority of the burials are from a Final Jomon chronology, although some skeletons were dated to the Middle and Late Jomon periods (Ando et al., 2020). While the isotope data obtained from some individuals indicated mixed diets of terrestrial and marine protein, a slightly lower proportion of aquatic food, notably marine fish, was suggested when compared with the Middle Jomon site of Funamoto (Kusaka et al., 2010, p. 1974), although

the number of analysed samples from the site of Tsukumo were much more abundant. However, a recent analysis of a human skeleton from Tsukumo identified the presence of numerous lesions suggesting that the individual was attacked by a shark (White et al., 2021), a singular situation that also confirms the exploitation of aquatic resources by these buried people.

A huge quantity of pottery remains (mostly from the Late and Final Jomon), diverse lithic tools (cores, flakes, arrowheads, axes, scrapers, weights and others), figurines and bone/antler/shell artefacts were recovered, notably fishing tools and personal ornaments such as beads, earrings and shell bracelets, some of which were still associated with the skeletons. Terrestrial faunal remains were dominated by wild boar and Japanese deer. The presence of some reptile, bird, fish and marine mammal remains was also recorded (Kiyono et al., 1920; Ando et al., 2020).

Overall, it seems clear that the shell midden of Tsukumo had an important role in the regional settlement context during the Late–Final Jomon period. At least in the Final Jomon period, the occupation was apparently focused on funerary and ritual activities, considering the high density of human burials and ritual-related materials that were found, and the absence of identified non-burial features in the site. At approximately 1 km east from Tsukumo, a small shell midden is known at the foot of a hill – Hara shell midden (Nishiojima, Kasaoka city). However, the site provided evidence of its main occupation in the Early Jomon period, although pottery remains from the Middle and Late Jomon were also recovered (Takahashi, 1986; Yamaguchi et al., 2015). It also yielded human skeletons, but the exact numbers and contexts are unknown. Other nearby shell middens in Kasaoka Bay, such as Arida (Arida, Kasaoka city), Higashimura (Kamijima, Kasaoka city) and Jomi (Higashiodo, Kasaoka city), were occupied in the Late Jomon period. Some of them provided human skeletons, but similarly, little information is available (Yamaguchi et al., 2015). In the case of the Tsukumo shell midden, the available data indicate that the funerary activity was concentrated in the beginning of the formation of the shell midden, although it continued through time (Kiyono et al., 1920). The burials seem to have tended to follow some spatial organisation, mostly without affecting previous inhumations. Remains of hunting, gathering, fishing and processing activities were found, indicating that the site was not used exclusively for funerary purposes, but no dwelling evidence was identified so far.

4.3.1.2.3. Asanebana

The Asanebana site (Tsushima East, Okayama city) is located in the western side of the alluvial plain of the Asahi river basin, at the foot of a hill (*Appendices – Table A26*) (Figure 66). In 1998, an area of 140 m² was excavated through an emergency operation. According to a short report (Kake Gakuen Maizo Bunkazai Chosa-shitsu, 1998), the site provided evidence of occupation from the Early Jomon to the Modern period. Shell midden layers with different densities from the Late Jomon period were identified (level 4), being mostly composed of shells of *Corbicula japonica*, which indicated the exploitation of the estuarine/lagoon environment nearby. However, remains of riverine, estuarine and marine fish species were also recovered, revealing the exploitation of a wide range of aquatic environments. The Late Jomon layers also included lithic remains, pottery sherds, mammal fauna (with a

predominance of wild boar and Japanese deer), reptile and bird remains. In addition, a layer from the Early Jomon was identified at the bottom of the stratigraphy (level 10a), revealing a high concentration of archaeological materials, notably terrestrial fauna, ceramic sherds and lithics (which included arrowheads, splintered pieces, cores, flakes and chips).



Figure 66: Asanebana, Okayama prefecture – location of the site (currently not visible) at the foot of a hill (photo by author).

Although domestic features were not identified, an urn burial filled with shell-rich sediment and faunal remains (a fragmented skull of a juvenile Japanese macaque, *Macaca fuscata*) was identified in shell layer 4g. Cutting or firing marks were not detected, leading the authors to classify these bone remains as an intentional faunal deposit inside a Jomon deep-bowl (Kake Gakuen Maizo Bunkazai Chosa-shitsu, 1998, p. 3). Contrary to this, the other mammal faunal remains recovered at the site presented a high incidence of lithic cut marks, indicating the practice of meat processing activities.

It has been considered that the Asanebana shell midden would have been contemporaneous with the site of Tsushima Okadai, a large, extensively excavated residential site located nearby during the Late Jomon (Yamamoto, 2004). The two sites would have been part of the same settlement (Figure 67). The residential area of Tsushima Okadai was found in the north-eastern zone of the site, close to the shell midden (100–150 m away), comprising two pit-dwellings, hearths, storage pits, other negative structures and a debitage area. These features indicate the practice of several types of activities near the shell midden, notably residential activity, food processing and storage. In addition, net sinkers were found at the site, attesting to the practice of fishing activities.

To summarise, it can be highlighted that, despite the marginal location and small dimensions of the Asanebana site in the context of the settlement area, ritual activities were undertaken at the shell midden, which suggest that the place was more than an area for food debris. Also, despite an increase in the importance of plant food in the Late Jomon period, evidenced, in this case, by the high quantity of storage pits found at Tsushima Okadai (Yamamoto, 2004), the evidence from Asanebana suggests that mollusc gathering and fishing was still relevant for these groups.

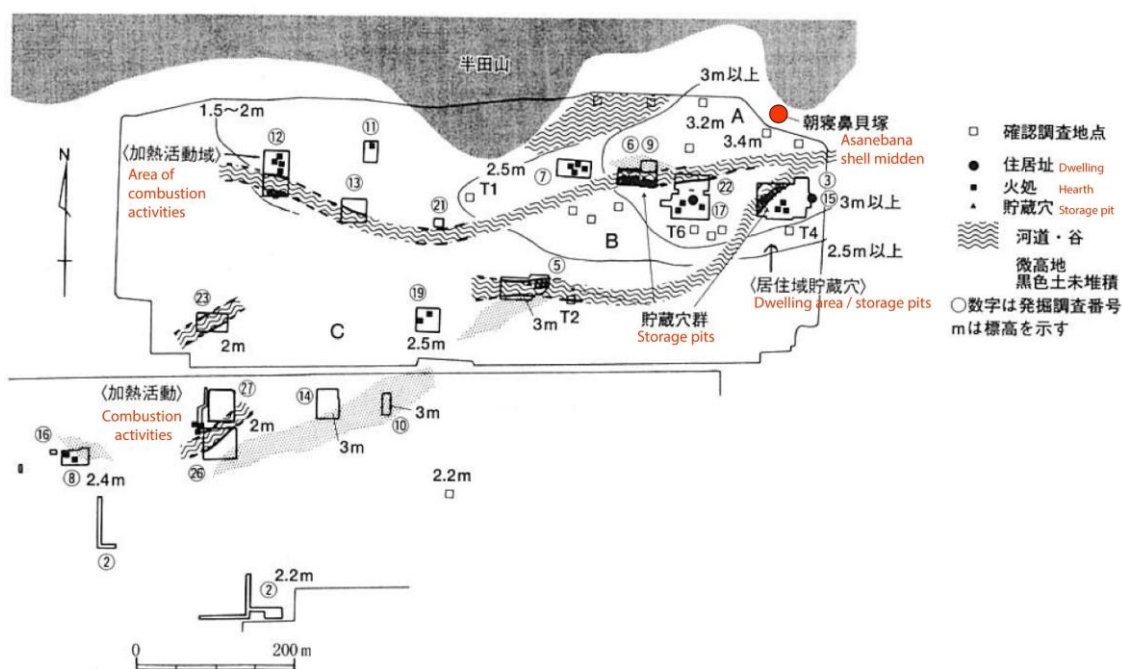


Figure 67: Tsushima Okadai, Okayama prefecture – site plan with the location of some of the excavated areas, features and the Asanebana shell midden (adapted from Yamamoto, 2004, fig. 13).

4.3.1.2.4. Other sites

Despite presenting some variability, the other shell middens in Okayama are, in most cases, relatively small, containing a single shell layer with less than 0.50 m of thickness. The available data about the functional and spatial aspects are limited, due to the lack of detailed information from old excavations, the reduced areas that were excavated and the characteristics of the deposits. For example, regarding lithic tools, only the presence of retouched tools is known in many cases, possibly because of selective recovery in the field. Similarly, the absence of fish remains at many sites could be due to the lack of sieving procedures in the excavations.

Residential sites with associated shell middens

In the eastern half of the ancient Kojima Bay, in addition to Tsushima Okadai/Asanebana, at least three residential sites with associated small shell middens and chronologies between the second half of the Middle Jomon and the Late Jomon periods are known:

- 1) *Hyakkengawa Sawada* (Sawada, Okayama city) is located on the right bank of the Asahi River, in the Okayama alluvial plain, at less than 4 km southeast from Asanebana shell midden and the site of Tsushima Okadai (*Appendices – Table A27*). It is a large settlement site that was successively excavated from 1977 until 2004 (Kensetsusho Okayama Kasen Koji Jimusho and Okayama-ken Kodai Kibi Bunkazai Senta, 1993; Okayama-ken Kodai Kibi Bunkazai Senta and Okayama-ken Kyoiku Inkai, 1997). The site was mainly occupied in the Yayoi period, but it comprised occupations from the Middle Jomon until the modern period. A small, spot-type shell deposit attributed to the Late Jomon phase, with about 0.10 m of thickness and mainly composed of *Corbicula japonica*, was identified at the settlement site, near storage pits and other

negative structures, fireplaces and pottery concentrations (Figure 68). The shell midden did not contain any artefacts, but some material remains were recorded in the vicinity, notably bone and ash remains. Dwellings were not recorded in the Late Jomon contexts of the site, although it is thought that they probably existed (Yamamoto, 2004, p. 81). Another small shell deposit, with 0.20 m thickness and mainly composed of *Tegillarca granosa*, was found associated with Final Jomon contexts. Despite the small dimension of the shell middens compared to other examples from the Okayama region, both cases testify the continuity of the exploitation of aquatic resources, including shellfish, in a changing lagoon environment and a settlement site context where a wide range of resources were consumed.

- 2) *Yabeokuda* (Yabe, Kurashiki city) is a site located on a slope of a plateau, at approximately 17–18 m altitude and 11 km west of Asanebana/Tsushima Okadai, in the Ashimori river basin (*Appendices – Table A28*). It was occupied from the Jomon to the Medieval period (Okayama-ken Kodai Kibi Bunkazai Senta, 1993). During the excavations in 1984–1987, a shell midden was partially detected on a small surface of 10.5 m² (which probably extended over 30 m). It was characterised as a single and dense layer of shells with a maximum of 1 m thick, which would have been formed between the second half of the Middle Jomon and the middle of Late Jomon period (Okayama-ken Kodai Kibi Bunkazai Senta, 1993). The malacological species were dominated by *Corbicula japonica*, attesting to the exploitation of a mainly brackish water environment. Several fish, reptile and terrestrial mammal remains were identified (mostly of wild boar, followed by Japanese macaque). Pottery, lithic remains and bone tools were also found inside the shell midden. Two shallow pits (with less than 30 cm depth) were detected outside, but near the shell midden. It was suggested that the Jomon residential area was probably located in the central area of the plateau, before being destroyed by subsequent occupations. Apparently, some human remains were found at the site, but the numbers are unknown. It seems that the small shell midden integrated a multi-functional site which probably included residential activity, as found at Hyakkengawa Sawada site.
- 3) *Naganawate* (Nishikatakami, Bizen city) is located on an alluvial fan, in the eastern part of Okayama prefecture. According to the investigations, it was a residential site occupied between the end of the Middle Jomon and the beginning of the Late Jomon period, which probably had a small shell midden (Okayama-ken Kodai Kibi Bunkazai Senta, 2005). Three dwellings, pits, hearths, a stone concentration, as well as lithic tools and pottery remains were detected in the most recent excavations. However, the existence of a thin shell midden is only recorded in some old references and its exact location is unknown.

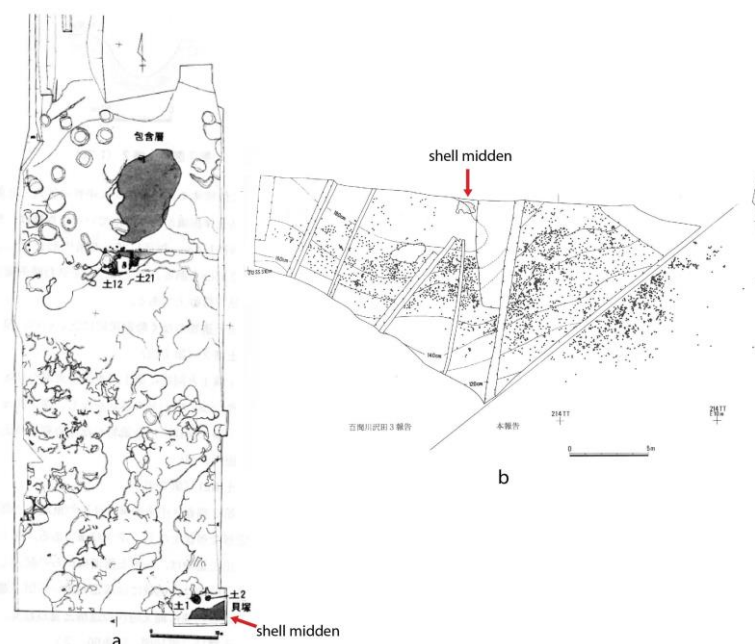


Figure 68: Yabeokuda and Hyakkengawa Sawada, Okayama prefecture – a) plan of the Jomon features found at Yabeokuda with the shell midden in the south-eastern zone (adapted from Okayama-ken Kodai Kibi Bunkazai Senta, 1993, fig. 6); b) plan with the location of the Late Jomon pottery remains and the small shell midden found at Hyakkengawa Sawada (adapted from Kensetsusho Okayama Kasen Koji Jimusho and Okayama-ken Kodai Kibi Bunkazai Senta, 1993, fig. 139).

Funerary shell middens in Kurashiki city

Despite the relative abundance of shell middens with funerary activity in the Okayama region, data on site function and spatial organisation is quite limited, apart from the information known from Hikozaki and Tsukumo shell middens. Despite this, some sites in Kurashiki city should be mentioned:

- 1) *Nakatsu* (Tamashima, Kurashiki city) is a site located over a low terrace, which was occupied between the Incipient Jomon and the Final Jomon period (*Appendices – Table A29*) (Figure 69). Six human burials, attributed to the Late Jomon, were found concentrated at the edge of the shell midden in the past (Suzuki, 1986). Recent excavations were undertaken at the site between 2020–2022 (Ono and Fujiwara, 2021), which allowed researchers to confirm that the shell midden accumulation mainly occurred in the Late Jomon period, although the strong disturbance of the upper parts of the site did not become possible to understand the entire sequence of occupation. Also, another four burials were identified. One skeleton was dated to the Final Jomon period (Seike et al., 2021), indicating that the funerary activity at the site extended to that later period. According to the researchers, burials were concentrated in a specific zone in the northern part of the shell midden. In addition, the finding of a substantial quantity of lithic material in one of the burial pits was related to possible ritual activity (Ono and Fujiwara, 2021, pp. 45–47).



Figure 69: Nakatsu, Okayama prefecture (photo by author).

- 2) *Suzumimatsu* (Tamajima, Kurashiki city) is located 8 km of Nakatsu shell midden, on a low terrace. It was mainly occupied between the end of the Early Jomon and the Late Jomon (*Appendices – Table A30*). 15 skeletons were found at the site, mostly in the shell midden deposit (dark sediment with some shells with about 0.10–0.30 m of thickness) and near each other (Figure 70). It was also observed that stones were put over or near the skeletons (Makabe, 2012; Yamaguchi et al., 2015).

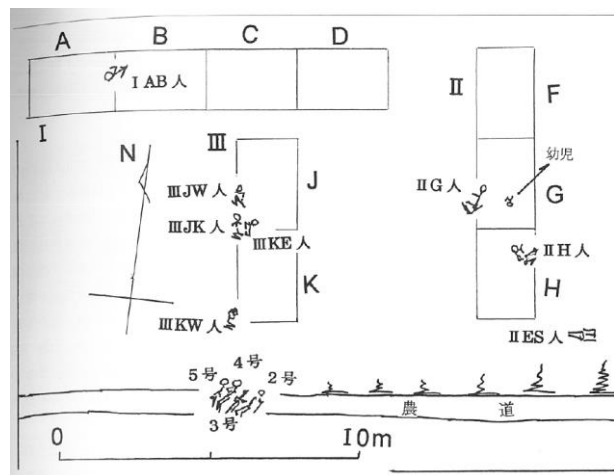


Figure 70: Suzumimatsu, Okayama prefecture – plan of the excavated area in 1964 with the location of the skeletons (reproduced from Makabe, 2012, fig. 5).

- 3) *Satogi* (Funaocho, Kurashiki city) was, at the time of occupation and according to the excavators, located on a beach sandbank, in front of the shallow sea, and about 2000 m² (Makabe, 1971) (*Appendices – Table A31*). Occupation evidence from the Early to the beginning of the Final Jomon period was found. However, the main shell layers, with between 0.30–0.70 m of thickness, were attributed to the Middle Jomon period (Figure 71). The main shell layers were characterised by a dense, shell-rich sediment, which were deposited over sandy layers with some shells dated to the Early and beginning of the Middle Jomon period. The burials were attributed to the end of the Middle Jomon and beginning of the Late Jomon. It was noticed that the skeletons were deposited inside pits that were dug into the Middle Jomon layer and

concentrated in the thinnest part of the shell midden (Makabe, 1971). Similarly to Tsukumo and Hikozaki, at Satogi shell midden, the individuals seem to have been organised in groups (Yamada, 2009, p. 34). It was highlighted that the funerary area was at a significant distance from the main area of deposition of the midden (Makabe, 1971, p. 119). Despite the existence of old references to burnt soils, dwellings were not identified at the site. Terrestrial faunal remains, pottery, lithics, bone tools (including fishing tools) and several personal ornaments were found, demonstrating the importance of hunting, gathering, fishing and food processing activities.

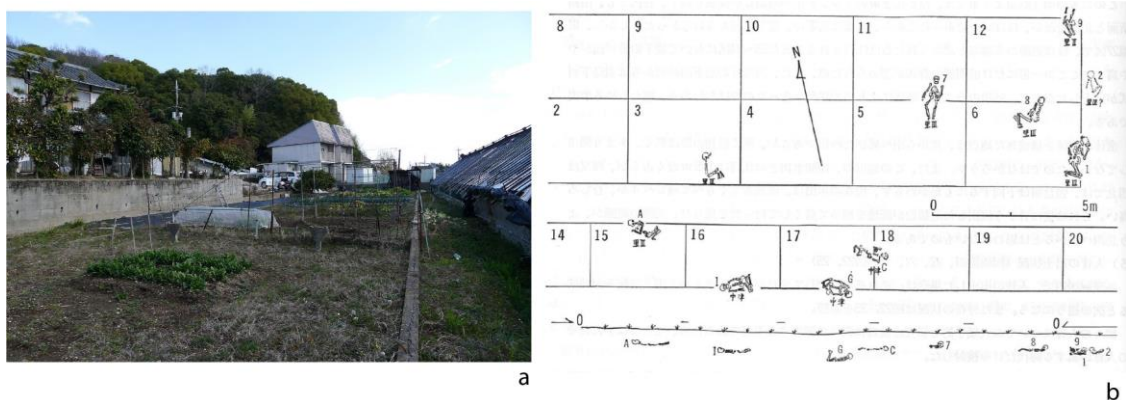


Figure 71: Satogi, Okayama prefecture – a) view of the site (photo by author); b) plan with human skeletons found in the excavations of the western zone in 1969 (reproduced from Makabe, 1971, fig. 22).

- 4) *Funagura* (Funagura, Kurashiki city) is located at the foot of a low hill and was excavated in relatively recent times, in 1991 (Ono et al., 1999) (*Appendices – Table A32*). Field work showed that the site was occupied from the Initial to the Late Jomon period, but the shell midden formation would have only started in the Early Jomon phase. The shell midden layers, approximately 0.30–0.40 m in thickness, were described as ‘shell layers with sediment’ and included a high component of sand and gravel. Three grave pits with human remains were detected under the shell layer. In addition, a pit and a ditch were identified in the shell midden.
- 5) *Fukuda* (Fukuda, Kurashiki city) is also located at a foot of a hill (Figure 72). It contained a shell layer from the Late Jomon period about 0.75–1 m in thickness, which seems to have been divided by a thin sandy layer (Nara Kokuritsu Bunkazai Kenkyujo, 1989) (*Appendices – Table A33*). Only two skeletons were recovered. However, remains of various molluscs (from salt and brackish water environments), terrestrial fauna, fish, reptiles and bird remains were identified, suggesting the exploitation of a large variety of food sources. Pottery, lithics and bone tools, as well as figurine remains were found, indicating various activities and ritual practices at the site.

Other sites with funerary remains are known in the Kurashiki region, such as Nishimotohama, Nishioka, Hashima, Funamoto and Isonomori (Yamaguchi et al., 2015). However, despite the relatively large dimensions of the shell middens and high number of skeletons that were found in some cases, the contextual information is unknown. For

example, at the shell midden of Nishioka, shells were distributed over an area of 3000 m² and more than 36 individuals were found (Kiyono, 1969).

It is clear from the examples above from Kurashiki city that the shell middens were very different from each other, notably in the density of shell deposits, despite the proximity of the sites and the similarities found at the site location and formation of the shell layers. Apparently, there were also some shared spatial arrangements, such as the location of burials in specific areas of the sites (in the thinnest parts of the shell midden in some cases), without disturbing previous inhumations.

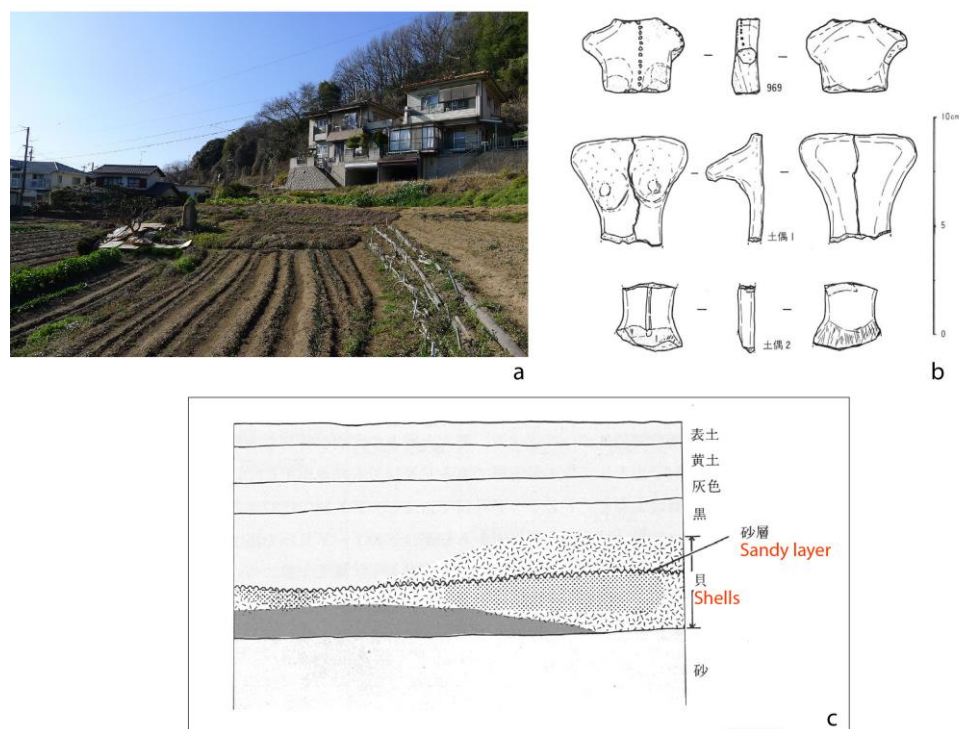


Figure 72: Fukuda, Okayama prefecture – a) view of the site (photo by author); b) clay figurine remains found in 1950 (reproduced from Nara Kokuritsu Bunkazai Kenkyujo, 1989, fig. 52); c) schematic representation of the stratigraphic section from the excavations of 1950 (adapted from Nara Kokuritsu Bunkazai Kenkyujo, 1989, fig. 5).

Ōhashi shell midden (Setouchi city)

The shell midden of Ōhashi (Okuchō, Setouchi city) is a large site with an estimated area of 3750 m² located in the eastern part of Okayama prefecture, on a slope of a low hill (Okayama-ken Kyoiku Iinkai, 1979). The site was situated in an estuarine environment near the sea and occupied from the Early to the Late Jomon period (*Appendices – Table A34*). During the excavations in 1978, it was observed that the shell midden was composed of multiple dense shell layers, achieving more than 2 m of thickness in total in the central part (Figure 73). The eastern zone was excavated at that time, allowing the identification of shell layers about 0.30 m in thickness and two human burials (one in primary position), indicating the existence of funerary activity. As other shell middens, several terrestrial faunal remains (notably deer and wild boar), pottery sherds, bone and lithic tools (including fishing weights) were found, attesting to the practice of several activities at the site. The identified shell species

were dominated by *Corbiculidae*, but also included other species, indicating the exploitation of both brackish and saltwater environments.

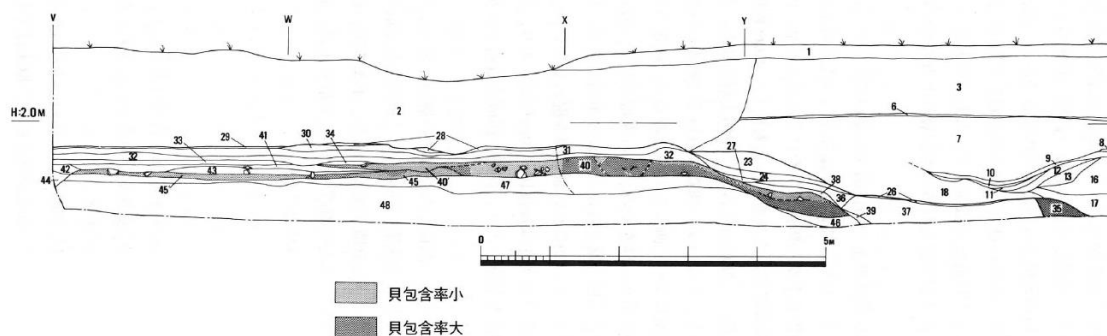


Figure 73: Ōhashi, Okayama prefecture – stratigraphic section from the excavations of 1978, with the shell layers filled with dark colours (adapted from Okayama-ken Kyoiku Inkai, 1979, fig. 5).

4.3.1.2.5. Analysis of general trends

The analysis of the general parameters from the 52 Jomon shell middens in the Okayama region (*Appendices – Table A35*) reveals that the sites were mostly located at low altitudes (a mean of 8 m) and less than 2 km of the main water source in the past. Most sites (62%) were associated with a saltwater environment (inner bay), notably with Kojima and Kasaoka bays. In addition, some sites (29%) were associated with brackish water and inner bay environments. The shell accumulations can be mostly characterised as layers (46%), while a few cases (three sites) are classifiable as mounds (Figure 74). The shell accumulations at these sites were relatively thin, with a mean thickness of 0.67 m (value based on 20 sites). However, thickness values of the shell deposits are generally higher for the sites that are associated with a saltwater environment (Figure 75). The mean area of distribution of shells is 1938 m² (based on minimal values from 12 sites).

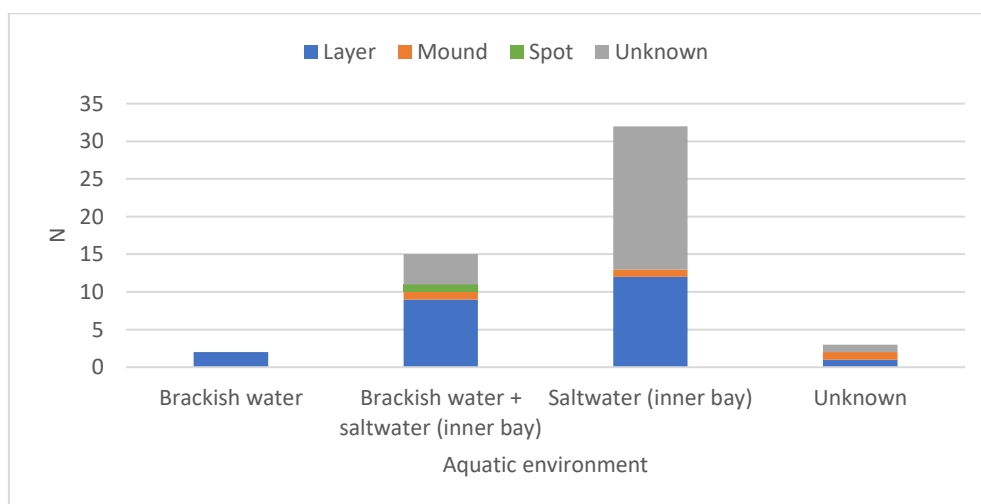


Figure 74: Distribution of shell midden types by main aquatic environment (associated with the site or exploited) in the Okayama region (n=52).

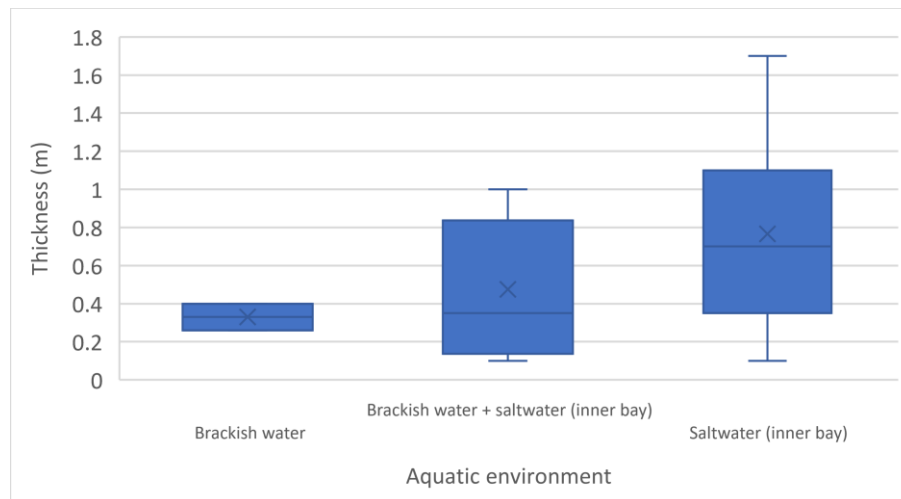


Figure 75: Total thickness of the shell deposits (minimum estimate) by shell midden group (classified according to the main aquatic environment associated with the site or exploited) in the Okayama region (n=19).

A significant quantity of sites provided remains of a limited number of animal classes (56%). Also, the number of identified malacological species for each site can be considered as limited in at least 48% of the sites. However, these relatively high values probably reflect the absence of detailed faunal/malacological studies for these sites. The presence of diverse fauna was observed in only 15% of the sites, whereas 23% of the sites contained a high number of mollusc species. The artefacts from these sites can be classified as diverse in 48% of the cases, but for a significant number of sites (23%), there are no available data about this element. Data on chipped stone tools are generally rare. A substantial number of sites (37%) revealed the presence of a limited number of categories (often only retouched tools), which in some cases could be the effect of selective recovery in the field. At many sites, chipped lithic remains are unknown or absent (50%). Human burials were detected at 31% of the sites and recorded in abundant number at eight sites (50% of the sites with human remains). However, the presence of non-burial features was only recorded at nine sites (17%) and mostly in small quantities. Residential features were only identified at one site (Naganawate), but the association with a shell midden was not recorded. A possible feature structured by some postholes was identified at the site of Kuroshima, Setouchi city, occupied in the Initial Jomon (Kondo, 1986), but detailed information is not available.

Overall, the activities undertaken at these shell middens or associated with them can be characterised as diverse in several cases (35%), although unknown situations (35%) were observed due to lack of enough data. In several cases, it is not possible to verify if tool production was undertaken at the sites, despite the presence of pottery sherds and some lithic remains. The presence of few pottery sherds in some sites, without detailed information, cannot be considered for the characterisation of site activity diversity in this analysis, since it can reflect different situations, such as transport, artefact production, processing or even ritual activities.

The analysis of the relationship between parameters indicates that diverse activities were more frequent at the sites mainly associated with a saltwater environment (72%), while the

sites with limited activities were mainly associated with saltwater and brackish water environments (62%) (Figure 76). The sites with diverse activities tended to contain diverse artefact types (89%). Contrary to this, sites with limited activities mainly presented remains from a small number of animal classes (85%), artefact types (62%) and chipped lithic categories (54%). Most sites with diverse activities contained human burials (67%), while the majority of sites with limited activities did not comprise any burial feature (92%). In addition, non-burial features were totally absent at sites with limited activities.

The occupation of most of these sites (54%) seems to have been long (more than 1000 years), considering the presence of pottery types from different chronologies. However, for many sites, there are not enough data at this moment to characterise the period of formation of the shell accumulations. Concerning the site of Hikozaki, the available chronological information suggests that the shell midden formation took more than 1000 years, but for other sites the estimations are still difficult to obtain.

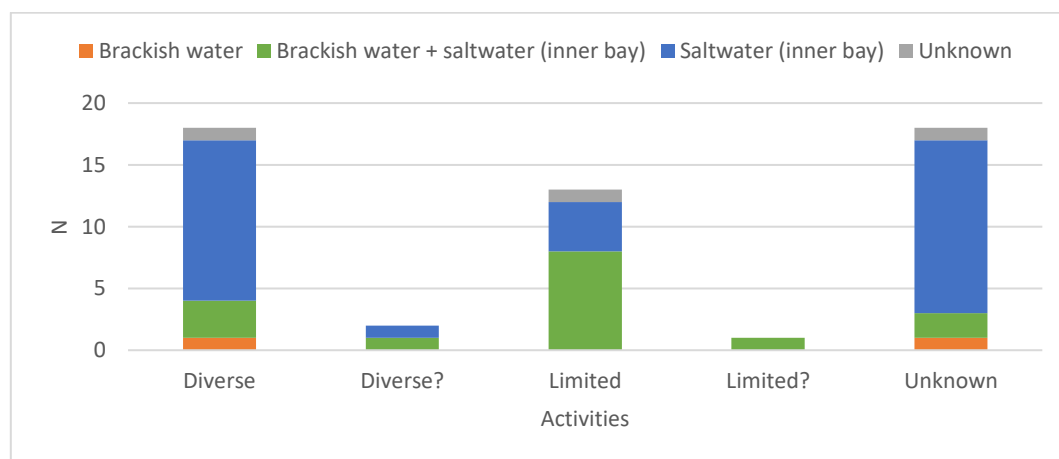


Figure 76: Distribution of main aquatic environment types (associated with the site or exploited) by shell midden group classified by site activity characteristics in the Okayama region (n=52).

4.3.1.2.6. Discussion

Despite the lack of information from many sites, it seems clear that the formation of Jomon shell middens in the Okayama region, which tended to occur on low hills, terraces and sandbanks, was closely associated with the exploitation of estuarine/lagoon and shallow bay environments created during the Jomon transgression. These locations on ecotone areas often provided easy access to the rivers, estuaries and/or shallow sea, and also to the forest/hills, offering the opportunity to exploit not only molluscs, but also fish, terrestrial fauna, birds, reptiles and plant sources. The variability of resources that was exploited is attested to by the diversity of faunal remains that have been found at these sites, but also by the high frequency of hunting, fishing and processing tools among the lithic and bone material assemblages (Tajima et al., 2006, p. 219; Sartini and Ferre, 2017). The relevance of food processing activities in these sites is also suggested by the presence of some features, such as hearths and (although being less frequent) storage pits. The relatively high frequency of funerary and ritual activities is also indicative of the multi-functional character and particular social meaning of some of these shell middens in the settlement system. The absence of 'specialised' shell middens in shell gathering and processing activities seems

relevant, although it should not be forgotten that a number of littoral non-shell midden sites is also known in the region during the Jomon period. In this sense, shell middens can be seen as specific littoral sites where mollusc gathering activities achieved a significant importance. The particular relevance of mollusc gathering is also indicated by the prolonged use of some sites, such as the case of Hikozaki shell midden, whose shell layers were formed from the Early Jomon until the Final Jomon period.

Despite these general tendencies, it is evident that substantial differences can be observed between the Jomon shell middens in the region. In some cases, the shell middens correspond to small shell deposits with a variable quantity of other materials and associated with a contiguous, large settlement site, as seen for Asanebana, Hyakkengawa Sawada, Yabeokuda and, probably, Naganawate. In other cases, large and relatively thick shell deposits are known to comprise features and other evidence of diverse activities, such as the shell middens of Hikozaki, Tsukumo, Satogi and Ōhashi.

Regarding the small shell middens integrated in larger settlement sites, it seems clear that the shell deposit was placed in a specific area at some distance from other features, such as dwellings, pits or hearths. This situation seems to have been more frequent in the Late Jomon period, probably resulting from the increasing spatial structuration of the settlement sites occurring in this period (Yamamoto, 2004). The intra-site spatial organisation of the middens themselves is more difficult to interpret. The frequency of inhumation in specific areas of the sites and the predominance of primary and individual burials suggest that the funerary space was often defined and generally respected, without being disturbed by subsequent inhumations. However, a proximity of remains from different types of activities to each other has been observed. For example, combustion evidence located near or over burial features was frequent in Hikozaki shell midden, but it is not clear whether these remains were a result of ritual activities or not (Tajima et al., 2006; 2007).

Apart from the possible dwelling feature identified in Kuroshima shell midden, the absence of identified dwellings inside or under shell midden layers, or immediately close to the shell deposits, can be highlighted in the Okayama region, a tendency that is often observed in other regions of western Japan (Koizumi, 2016). Despite that, the residential function of many of these sites has been assumed, considering the variety of material evidence that has been found, as exemplified by Hikozaki shell midden (Tajima et al., 2013). More extensive excavations outside the shell deposits are needed to better interpret the archaeological absence of dwellings at these sites.

4.3.1.3. Comparative analysis of general trends of the shell middens from Portugal/France and Okayama

The results of joint analysis of the parameters from the Jomon shell middens in Okayama and the Late Mesolithic sites in Portugal and France (n=96) (*Appendices – Table A36*) indicates that the majority of these shell middens were located at a close distance (less than 2 km) from the main water environment in the past (82%). The shell middens in Okayama were mostly associated with the exploitation of a saltwater (inner bay) environment, in some cases in conjunction with a brackish water environment (estuary or lagoon), while in Portugal the association with large estuaries was dominant. In both cases, it can be found that there was

a predominant preference for relatively sheltered environments. The location on open coast is absent in Okayama region (being generally rare in Japan), while it has some frequency in Atlantic Europe, as exemplified by the French sites and some Portuguese shell middens.

Layer-type shell middens are more frequent (more than 50%), while mound-type middens are rare (less than 10%) in the complexes of Okayama and Portugal/France, although the typology cannot be classified for more than 33% of the sites (Figure 77). The obtained values of the mean area of the distribution of shells are quite similar between the two groups (2232 m² in Portugal/France and 1938 m² in Okayama) (Figure 78). The mean value for the thickness of the shell deposits is considerably higher in the European sites (1.12 m) compared to the cluster in Okayama (0.67 m), although the median values are similar between the two groups (Figure 79).

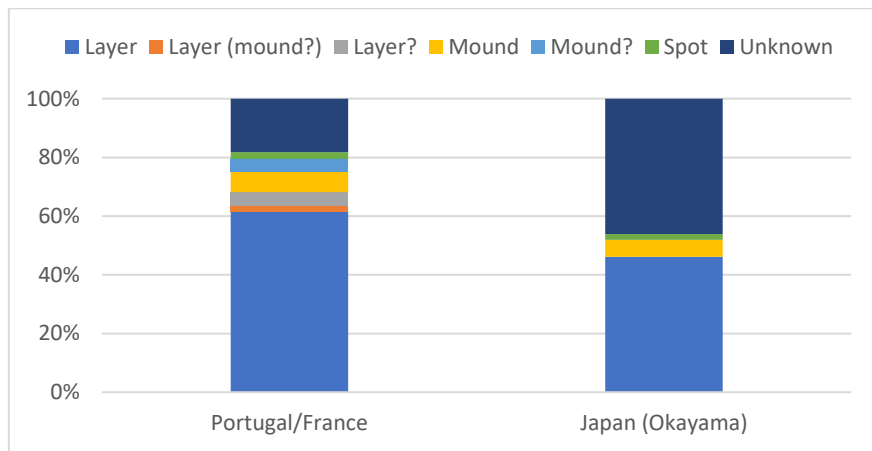


Figure 77: Distribution of shell midden types by region (n=96).

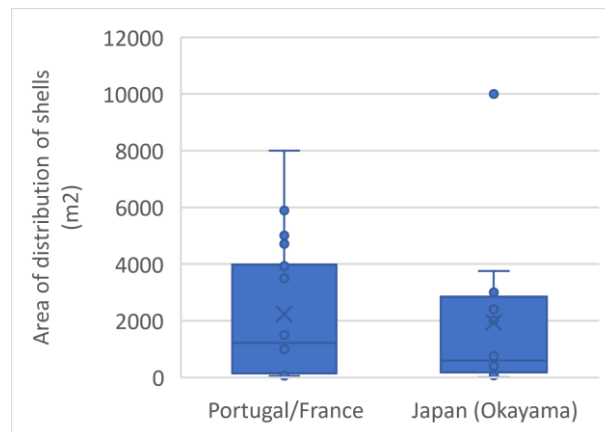


Figure 78: Area of distribution of shells (minimum estimate) by region (n=32).

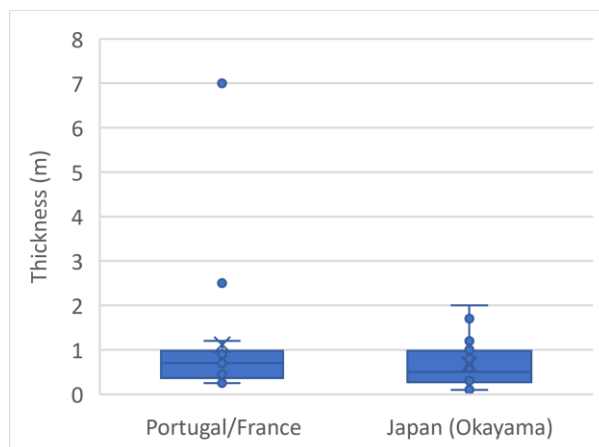


Figure 79: Total thickness of the shell deposits (minimum estimate) by region (n=40).

The percentages of sites comprising remains from diverse animal classes and mollusc species are considerably higher among the Portuguese and French shell middens (32% and 39%, respectively) when compared to the Okayama sites (15% and 23%, respectively). However, the absence of detailed information for several Okayama shell middens is certainly influencing these numbers. Diverse artefacts are more frequent among the Okayama shell middens (48%) compared to the European sites (32%). In part, this difference can be explained by the frequent presence of pottery remains in the Jomon sites (in addition to lithic tools), which is residual in the Late Mesolithic sites and not considered for this analysis. Regarding the characteristics of the chipped stone tools, diverse assemblages are more frequent in Portugal/France (more than 59% of the sites), while a substantial number of sites in Okayama (37%) presents limited assemblages of these materials, often being only composed of some retouched tools. Interestingly, the frequency of human burials is similar in both areas (34% in Portugal/France and 31% in Okayama). The frequency of abundant burials at these sites is slightly higher in Portugal/France (23% against 15% in Okayama). However, a striking difference in the presence of non-burial features can be observed, which is more frequent in the Portuguese/French sites (43% against 14% in Okayama), despite the larger number of considered sites from Okayama. Yet, the presence of dwelling features is rare in both areas. While most sites in Portugal and France with human burials contain non-burial features (73%), the same tendency cannot be observed for Okayama sites.

Overall, the analysis indicates that, in Portugal/France and Okayama regions, shell middens with diverse activities are more frequent than those with limited activities, although the number of unknown cases is significant in both regions (between 27% to 35% of the sites). The percentage of sites with diverse activities is slightly higher in Portugal/France (43%) than in Okayama (35%), but these differences can be related to the limitations of data from several sites from Okayama. In addition, some general tendencies in both regions can be observed (*Appendices – Table A37*), notably:

- 1) Mound-type shell middens are often associated with the practice of diverse activities (83%) (Figure 80). Also, shell middens with thicker shell accumulations are more frequently associated with the practice of diverse activities.
- 2) In most shell middens with evidence of diverse activities, the presence of diverse mollusc species (60%), artefacts (78%) and chipped stone tools (60%) was found.

However, although the presence of diverse animal classes is significant at these sites (54%), there is also a significant number of cases in which faunal remains are limited (38%), indicating that both situations are recurrent. Despite these considerations, it is highly probable that the lack of detailed strategies of recovery and studies of faunal remains is influencing these numbers. Naturally, the presence of features (including burial features) is recurrent at the sites with diverse activities. Furthermore, all sites with records of a high number of burials provided evidence of the practice of diverse activities, a situation that can indicate that a stronger funerary use of these sites was not related to specialised occupations, but rather to more intensive occupations in general, which included the practice of multiple types of activities (such as those related to resource acquisition and processing).

- 3) Most shell middens classified as sites with limited activities tend to present a restricted number of animal classes (81%), mollusc species (62%) and artefact types (77%). The majority of the sites with limited activities do not include any burials (85%) or non-burial features (92%).

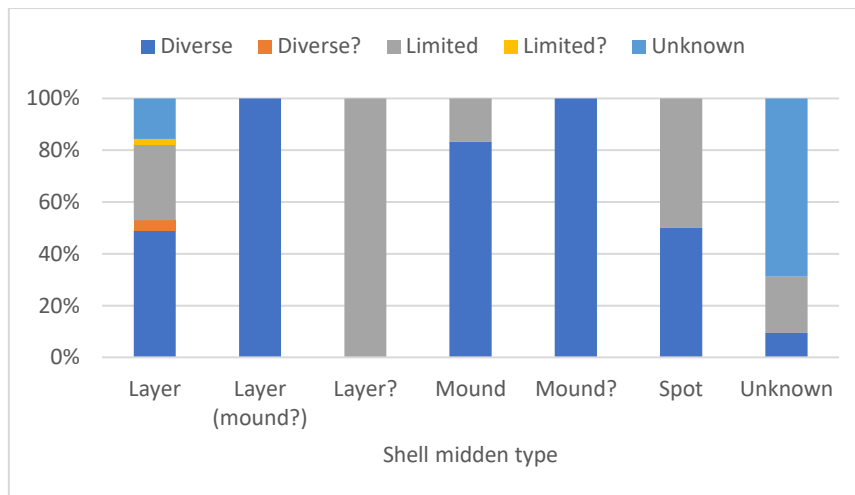


Figure 80: Distribution of site activity characteristics by shell midden type in Portugal/France and Japan (Okayama) (n=96).

4.3.1.4. Submerged shell middens

In this section, two well-known cases of submerged Jomon shell middens in western Japan are approached, considering the exceptionally rich information provided by these sites on several topics, including on site structure and function – Higashimyo, in Kyushu region, and Awazu, in west-central Honshu region.

4.3.1.4.1. Higashimyo, Kyushu region

Higashimyo (Saga city, Saga prefecture) is a large-scale site located in the Saga plain, in northern Kyushu, at approximately 28 km inland from the present-day coastline of Ariake sea (Matsui, 2013; Nakamura et al., 2013; Nishida et al., 2016b; 2016a; Saga-Shi Kyoiku Inkai [Saga City Board of Education], 2017) (Figure 81). The site was occupied during the latter half of the Initial Jomon period (roughly between 7950–7400 cal BP), at an early stage of the

maximum transgression. Although today the site is situated in a wetland area and buried under an alluvial deposit, it was originally on a high terrace, facing the estuary of a river that flowed into the Ariake Sea. The covering of the site with a thick marine clay deposit as a result of the transgression, soon after its abandonment, provided the unusual preservation of organic material. Excavations were conducted in 1993–1996 and 2002–2007, in the context of the construction of a river reservoir. The results of these works have been published through several volumes of reports (e.g., Nishida et al., 2016b), articles (e.g., Matsui, 2013; Nakamura et al., 2013; Noshiro et al., 2019) and books for a general audience (e.g., Saga-Shi Kyoiku Linkai [Saga City Board of Education], 2017). Overall, the Higashimyo site has provided an exceptionally large amount of information concerning Jomon groups in western Japan.

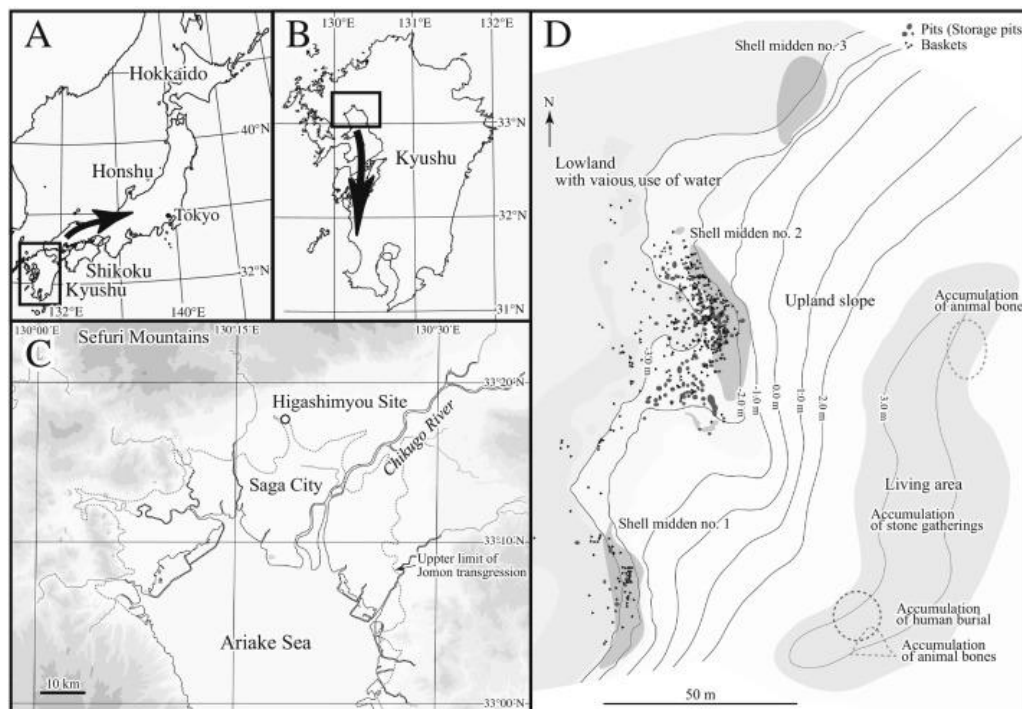


Figure 81: Higashimyo, Saga prefecture – location (A, B, C) and plan of the site (D) with the shell middens, main areas of activity and features (reproduced from Noshiro et al., 2019, fig. 1).

The excavations allowed the identification of a residential area on a high terrace, a small area with human burials, a lower-lying complex of shell middens and numerous adjacent storage pits. A total of 171 stone concentrations were found at the site, from which 167 features were located in the residential area. It was not possible to determine if these charred stone concentrations also existed in the shell midden area, since the upper parts of the deposits were destroyed by heavy machinery. These concentrations were classified into several types according to the dimension of the pebbles. It was considered that many of these features were used as surface hearths (Nishida et al., 2016b). Some concentrations of lithic tools were also found in the residential area. In addition, graves from eight individuals, probably forming a burial ground, were identified in the south-west part of the residential area. Despite the discovery of several types of remains, no dwelling evidence was found in the residential area. The researchers suggested that this archaeological absence can be

explained by the probable use of surface dwellings, which usually leave few or any traces in the ground (Saga-Shi Kyoiku Inkai [Saga City Board of Education], 2017, p. 220).

Six waterlogged shell middens were discovered at the site along the eastern bank of the former river channel, 40–50 m from the residential area. The shell middens were formed at approximately 4 m below the level of the residential area, on a sloping surface, showing that the deposition occurred from the upper portion of the site. The middens extended over 500 m in a south–north direction and covered a total surface of more than 1700 m². Each midden occupied an area between 40 and 400 m² (Nishida et al., 2016b). Only part of shell midden no. 1 and the totality of shell midden no. 2 were excavated (Figure 82), while the other four middens were preserved *in situ*. These shell middens are the oldest known in the Kyushu region. They were formed by dense deposits with a maximum recorded thickness of 1.5 m and dominated by shell fragments of the brackish Japanese corbicula clam (*Corbicula japonica*), followed by *Tegillarca granosa* (haigai cockle), *Sinonovacula constricta* (agemaki clam) and Japanese oyster (*Crassostrea gigas*, *Crassostrea ariakesis*), which are typical of tidal mudflats. The deposits contained layers with different shell densities. According to the observations of the researchers, each layer was relatively thin, comprising a low diversity of species and indicating the occurrence of rapid deposition. It was also observed that the shell layers on the terrace side mostly corresponded to primary deposits (intentional accumulation). However, the middens in general suffered significantly from tidal action (destruction or redeposition of deposits), notably the deposits in the lowest areas of the site, being sometimes partially submerged. As a consequence, situations of alternated deposition of shell layers (primary deposits) and layers with clayey sediments (formed by tidal action) were found in the stratigraphic sequences (Nishida et al., 2016b; 2016a). The shell middens seem to have been mostly contemporaneous and formed during a short period, since the available radiocarbon data indicate a period of 100–250 years of accumulation (around 7950–7400 cal BP) and basically only two pottery types were identified (Nakamura et al., 2013; Nishida et al., 2016b). However, considering the differences in shell composition and deposition rates between the middens, it was suggested that they were possibly constructed by distinct groups, and the place of deposition suffered slight changes through the time (Nishida et al., 2016b, p. 12).

The shell middens at Higashimyo were interspersed with pits. At least 155 pits were identified, mostly in the area of shell midden no. 2. Some pits were dug into the shell midden deposits, but the majority was distributed in the intertidal zone, through the margins of the middens or even beneath them and dug into the clay sediments of the lower-lying areas. It is likely that most of these structures were subject to groundwater seepage. Inside most of the features, remains of woven baskets, wood containers, ropes and other fibrous raw materials were found. More than 750 baskets were identified at the site, demonstrating the use of a wide variety of weaving techniques (Noshiro et al., 2019). Nut remains, notably acorns from evergreen oak (*Quercus gilva*), were also detected inside the pits, as well as other objects such as combs, digging sticks and even a wooden mask. It has been interpreted that most of these pits were related to the storage of nuts, which would have been put inside the baskets before being placed in the pits. Many researchers argued that the storage in waterlogged conditions intended to prevent spoilage by bacteria (Matsui, 2013). It was also noted, however, that the presence of several other artefacts inside suggests that the pits could have been used not only

for nut storage, but also for soaking tools and materials (Nishida et al., 2016b, p. 20). Despite discussions, it seems likely that the formation of shell middens and storage activity were spatially related and, at least in some cases, contemporaneous. Interestingly, it was also suggested that the shell middens could have been used to prevent the grass growing or as a foothold (Saga-Shi Kyoiku Inkai [Saga City Board of Education], 2017, p. 85).



Figure 82: Higashimyo, Saga prefecture – a) stratigraphic section of shell midden no.2; b) example of a pit (SK2056) with remains of a basket inside; c) example of a stone concentration (SX1042) (photos courtesy of Saga City Board of Education).

Apart from the high number of woven baskets and wooden artefacts (plates, containers, combs, among others), a large quantity of pottery remains and flaked stone artefacts on sanukite and obsidian was identified, such as arrowheads, knives, drills and polished and chipped axes. Slabs and grinding stones were also found and are thought to have been used for processing acorns. Bone, antler and shell-made ornaments were particularly numerous. Among the terrestrial mammal fauna remains, sika deer and wild boar were the most represented species. The presence of reptiles, some fish and marine mammals was also detected, attesting to the exploitation of a wide range of food sources. Stable isotope analyses were also undertaken and the results indicated that the individuals from Higashimyo had a mixed diet of terrestrial and aquatic food (Nishida et al., 2016b, p. 189), which agrees with the faunal evidence. In addition, the obtained data on seasonality (terrestrial fauna, malacological fauna and isotope data) suggested that the site was occupied year-round.

Concerning the spatial organisation of the site, some aspects were observed through the distribution of the lithic remains (Nishida et al., 2016b, p. 189). It was found that lithic tools and stone concentrations were more frequent in the residential area compared to the shell midden area, suggesting that the activities of lithic production and use had a higher incidence in the residential area. Processing tools were dominant in both areas, although scrapers were

more frequent in the residential area. This difference was interpreted as a possible result of a more intensive food processing and woodworking activities in the residential area, which was also indicated by the presence of stone concentrations related to combustion activities. On the contrary, the researchers suggested that the shell midden area would have been used for the first immediate food processing activities (after mollusc gathering) and deposition of waste. It was found that hunting tools (arrowheads) were more frequent in the shell midden area, although, according to the researchers, the difference possibly resulted from the use of sieving during the excavation of the middens. It was also highlighted that a substantial distance between the residential area and the shell middens was kept (between 40–50 m), possibly due to the topography, the smell of the waste or the tendency to undertake mollusc processing activities near the shell middens (Nishida et al., 2016b, p. 12).

To summarise, Higashimyo is one of the oldest wetland shell midden sites in the Japanese archipelago. The unusual richness in organic materials at the site was possible due to the accumulation of shell middens, but also the swampy conditions of the site. The detailed investigation of the site provided important information concerning the diversity of subsistence activities in the Initial Jomon period, including the sophistication of craft work. In addition, the rapid covering of the site also allowed its preservation with a low level of disturbance, which was crucial to know more about the aspects of the internal spatial organisation, notably the distribution of the different types of features in specific areas. Finally, the high cultural level attested to by the archaeological record of Higashimyo contributed to better understanding the Jomon communities in western Japan, which have been traditionally less valued by researchers in comparison with those from eastern Japan.

4.3.1.4.2. Awazu, west-central Honshu region

The Awazu site (Ōtsu city, Shiga prefecture) is located in west-central Honshu, on the bottom of Lake Biwa, the largest freshwater lake in Japan (Iba et al., 1997; Iba, 2005; Seguchi et al., 2013; Seguchi, 2014; 2016) (Figure 83). It is an ancient lake of tectonic origin, being surrounded by mountains. The site, occupying an area of 370 m west–east and 400 m north–south, was found at the southern end point of the lake, from which the Seta River flows into Osaka Bay. It is considered to be the world’s largest freshwater shell midden complex, where abundant nut remains were also exceptionally well-preserved due to the waterlogged conditions. It is thought that Awazu and other sites known on the bottom of the Lake Biwa were submerged due to the rise of the water levels of the Seta River caused by tectonics or natural submersion (Seguchi, 2016, pp. 7–8).

In the 1950s, underwater surveys confirmed the existence of the Awazu site. Additional surveys and small excavations occurred between 1980–1989. However, extensive excavations were only undertaken in 1990–1991, before the dredging of a ship channel. The excavation area was enclosed by a cofferdam, a procedure that allowed pumping out the lake water and creating a dry land surface.

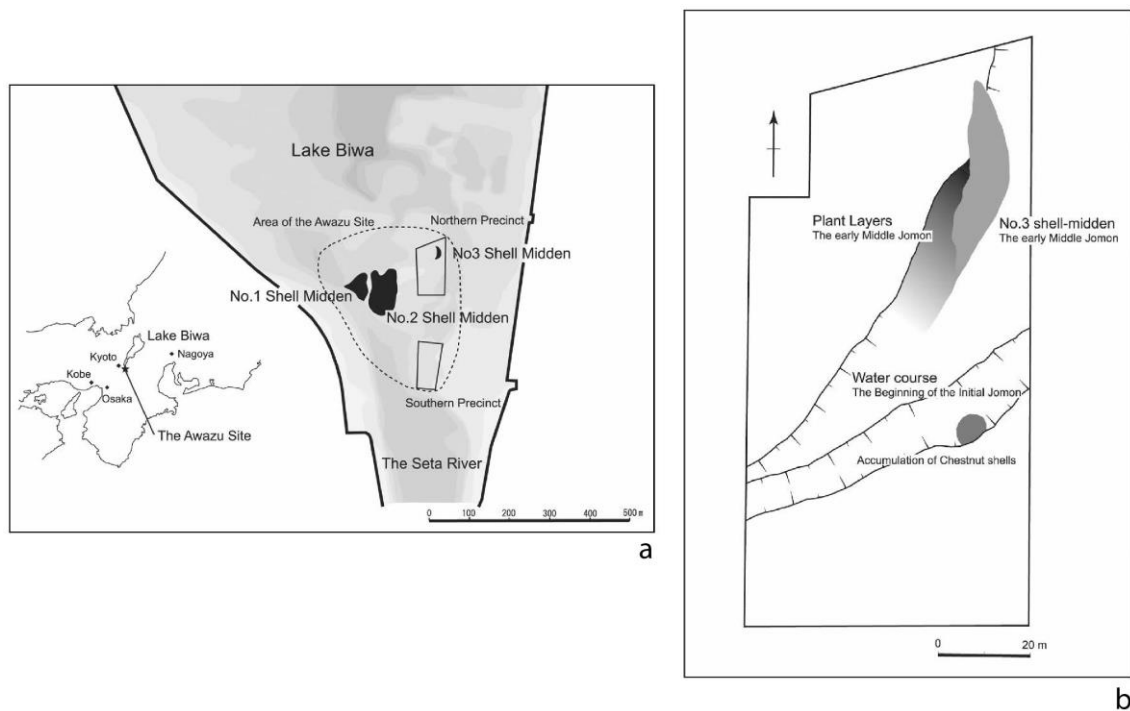


Figure 83: Awazu, Shiga prefecture – a) location and plan of the site with the identified shell middens; b) detailed plan of shell midden no.3 (reproduced from Iba, 2005, figs. 1 and 3).

Two large shell middens, occupying a flat area at least 110 m in length and 100 m in width, were identified at the centre of the site and dated to the period from the early Initial Jomon to the early Middle Jomon (11500–5000 cal BP). It was observed that the formation of shell midden no. 1, located on the western side, started in the early Initial Jomon period, while shell midden no. 2 was relatively more recent, with the beginning of the formation at the end of the Initial Jomon. At about 100 m east of shell midden no. 2, two areas were excavated and provided occupation evidence (including plant remains) from the early Initial Jomon to the final Initial Jomon/beginning of the Early Jomon period. A small shell midden from the early Middle Jomon period (no. 3) was also identified on a slightly inclined surface. In addition, an accumulation of nut shells, mostly composed of chestnut (*Castanea crenata*), was detected south of shell midden no. 3 and attributed to the beginning of the Initial Jomon period. It is thought that, during the Jomon period, the water level of Lake Biwa was lower than at present and the shell middens were located on a low elevation, at the eastern shore of the lake (Iba et al., 1997).

The only fully excavated midden of the complex was shell midden no. 3, which had a crescent-shaped outline (35 m long, 15 m wide and approximately 50 cm thick) (Iba et al., 1997; Seguchi et al., 2013; Seguchi, 2016). Approximately 150 layers were distinguished, which included dense shell layers, layers with plant remains, sand layers and shell layers with sands (Figure 84). The layers revealed a high inclination due to the topography. It was noticed that the upper part of the midden was affected by erosion and secondary deposition. According to the excavators, the disposal of shells and nutshells was originally undertaken at different and designated places, but the growth of the shell deposits gradually caused the displacement of shell dumping to the south, reaching the area of the nutshell deposits. The accumulation would have started with the deposition of plant remains in the south-western

part, which was followed by the deposition of shells in the north-western end. Then, the shell deposits would have progressively expanded to south, while the plant remains continued to accumulate in the southern part of the midden. After this initial phase, layers of shells and nutshells of various types (mainly acorns, horse chestnuts and water chestnuts) were deposited in alternation at the same area. The stratigraphy and the results of growth line analysis of shells indicated a seasonal alternation between the deposition of nut remains (autumn–winter) and shellfish (mainly gathered in spring–summer).

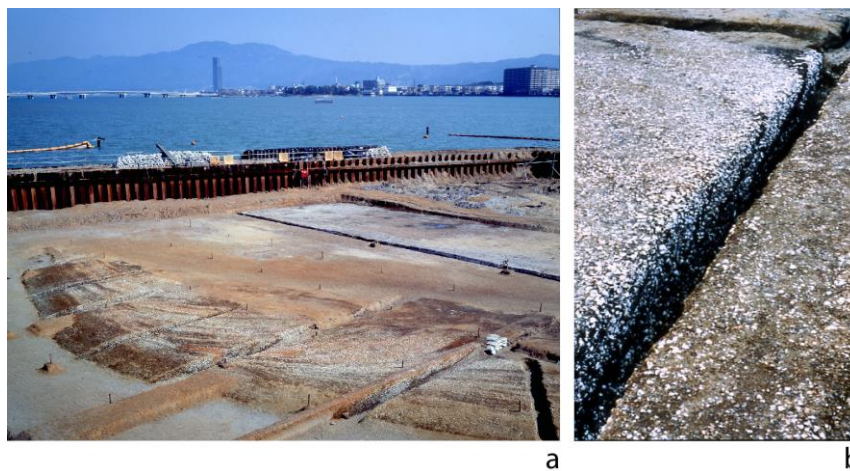


Figure 84: Awazu – a) general view of shell midden no.3 during the excavations of 1990–1991; b) detail of a stratigraphic section with layers of shells and macrobotanical remains (photos courtesy of Prof. Shinji Seguchi, Shiga Prefectural Azuchi Castle Archaeological Museum).

The shell midden contained a large number of nutshells and mollusc shells, mostly from *setashijimi*/seta freshwater clam (*Corbicula sandai*). It is thought that the shell midden formation probably occurred during a short period and resulted from intensive activities of shellfish and nut processing in the area. Despite the low numbers, freshwater fish (mostly from the carp family), reptiles, terrestrial mammal bones (mainly of wild boar and sika deer), as well as Middle Jomon pottery remains, lithic tools, bone and shell tools, ornaments and other materials were identified. Under the shell midden and inside a nut layer, some human bones were discovered, possibly corresponding to a secondary burial of individuals that would have been brought in from elsewhere. According to the researchers, the small number of artefacts other than pottery remains suggests that the shell midden was located in the periphery of a settlement site and at some distance from the centre where most domestic activities would have occurred, including residential activity.

The location of Awazu site at the interface between the lake shore and woodlands allowed the exploitation of seasonally and locally available food sources through the annual ecological cycle (Seguchi, 2014). The long occupation of the site, with shell middens being formed from the Initial Jomon to the Middle Jomon period, also highlights the importance of this type of location in ecotone areas through time. Other shell middens less than 2 km from Awazu were documented throughout the Seta River – Ishiyama and Hotarudani shell middens (Otsu city) (Shiga-Ken Kyoiku Inkaikai Bunka-bu Bunkazai Hogo-ka, 1991), occupied between the Initial Jomon and the beginning of the Early Jomon period. In addition, a large number of

Jomon sites were found in the borders of Biwa Lake or below (Seguchi et al., 2013, pp. 8–9), attesting to the richness of the lake/riverine environment, which persists today. The results of the excavations at the Awazu site, notably the evidence of dumping of abundant remains of horse chestnuts, contributed to better understand the importance of nuts in the overall Jomon diet and the use of sophisticated processing techniques to remove the tannic acid by these groups (Iba et al., 1997). The absence of identified features apart from the shell deposits is favourable to the functional interpretation of the site as a processing specialised site, although the presence of human remains suggests that other types of activities with a ritual nature would have also occurred, at least during the first phase of occupation.

4.3.1.5. Discussion

Despite the relatively low quantity of shell middens known in western Japan, the sites are diverse in various aspects such as location, dimension, stratigraphy, chronology, materials and features. In this chapter, only the sites from the Okayama region and the waterlogged shell middens were approached in detail, but Jomon shell middens are also known in other regions in western Japan. For example, on Kyushu Island, some concentrations are identified, particularly in the Ariake Sea and the northern region, which attest to an exploitation of several environments, including open coasts in some cases.

The amount of information provided by the shell middens detailed in this chapter differs according to several factors, notably the extent of the excavated area, the period when the field work took place or the conditions of site preservation. In many cases, the excavated areas were too small, constraining the understanding of the entire site. In general, radiocarbon data from these sites are rare and restrict the analysis of site formation. In this context, the waterlogged shell middens are highly informative sites concerning several aspects, including site formation and organisation.

Most shell middens in western Japan testify an exploitation of a wide-range of terrestrial and aquatic food resources, which was enabled by the location of the sites in ecotone areas with easy access to forest-estuary-shallow sea or forest-lake-river environments, and thus suitable for the development of broad spectrum economies. The practice of several activities in these sites is systematically documented. In particular, funerary activities are frequently attested, mainly through primary burials. Even the case of the Awazu shell midden revealed the presence of human remains, despite the evident importance of mollusc and nut processing activities at the site. A multi-functional character of many of these shell middens is thus clear, and, in some cases, the available evidence suggests that the activities were clearly organised in the space, with preferential areas for shell discarding, combustion or burial. Despite the rarity of dwelling remains in these contexts, some data indicate that the residential areas were separated from the shell deposits, as in the case of Tsushima Okadai/Asanebana sites in Okayama prefecture, and possibly the wetland shell middens of Higashimyo and Awazu. The same could have occurred at the sites of Hyakkengawa Sawada, Yabeokuda, Naganawate and Hikozaiki in Okayama.

4.3.2. Shell middens in eastern Japan

4.3.2.1. Overview

The majority of Jomon shell middens (about 83%) have been identified in eastern Japan (Bunkacho Bunkazai-bu Kinenbutsu-ka [Agency for Cultural Affairs, Monuments and Sites Division], 2017). The heavier presence of shell middens in eastern Japan corresponds to a greater density and larger size of Jomon sites in general, which are thought to reflect a higher population density, residential stability and economic intensification in the region (Akazawa, 1986; Habu et al., 2011; Matsumoto et al., 2017).

Still, the distribution of Jomon shell middens is not uniform throughout all of eastern Japan. The Kanto region is the densest area, comprising about 60% of the known shell middens in Japan (Nishino et al., 2017). Other areas with numerous sites are, for example, Sendai Bay, in the Tohoku region, and Hunka Bay in Hokkaido (Matsui, 1999; Habu et al., 2011; Toizumi, 2014). To the south of Kanto, shell middens are much less abundant, although those concentrated in Ise and Mikawa Bays, in the Tokai region, also provided important archaeological evidence (Kusaka et al., 2010; Habu et al., 2011).

The shell middens in the Kanto region reveal regional and temporal variability. They are mainly located in three zones: the western half of Tokyo Bay (Tokyo and Kanagawa prefectures), the eastern half of Tokyo Bay (Chiba prefecture) and the Lake Kasumigaura (Ibaraki prefecture) (Habu et al., 2011). Due to the Holocene marine transgression, at the end of the Initial Jomon period, Tokyo Bay penetrated further inland compared to the present day, and a large shallow sea environment with several inlets was created. Vast and productive tidelands progressively developed near the estuaries and the innermost parts of the bay (Toizumi, 1999), which are thought to have supported the formation of large numbers of shell middens in the Middle and Late Jomon periods.

Due to the huge number of known sites and the focus of this research on western Japan, it was not possible to investigate all Jomon shell middens from the Kanto region in detail in this thesis. The following section only presents some of the most interesting cases in Tokyo Bay for the discussion of shell midden site structure and function (Figure 85).



Figure 85: The Tokyo Bay area and location of the Kasori, Saihiro and Nakazato shell middens (according to Tsuruoka et al., 2007; Nishino et al., 2017; Nakajima et al., 2018) (image by author).

4.3.2.2. The large shell middens of the eastern half of Tokyo Bay

The Bōsō Peninsula (corresponding to what is now Chiba prefecture) borders the east Tokyo Bay area. It is characterised by two main zones – a lowland area close to the sea and a flat plateau area in the east – which are connected by several small rivers. A total of 648 Jomon shell middens are identified in Chiba prefecture (Bunkacho Bunkazai-bu Kinenbutsuka [Agency for Cultural Affairs, Monuments and Sites Division], 2018), corresponding to nearly one-third of the total number of known shell middens in Japan (Figure 86). In addition to their high density, the large dimensions of many of these sites has been highlighted (Nishino, 2007; Murata, 2013; Nishino et al., 2017; Takanashi, 2018; 2019). This remarkable development of shell middens and mollusc gathering activities in the region has been interpreted as a result of the formation of extremely rich aquatic environments, notably vast tidelands where abundant shellfish resources could be easily collected. The location of the sites on low plateaus allowed an easy access to fishing grounds through the small rivers flowing to the bay and the exploitation of forest resources as well (Toizumi, 1999; Nishino, 2005; Ogawa, 2012).



Figure 86: Distribution of the Jomon shell middens in Tokyo Bay with the coastline at the maximum transgression (adapted from Ito et al., 2016, fig. 2).

Although most shell middens in the Bōsō Peninsula are identified on hills, some sites are also known in lowland areas, showing diversity in site location (Uetsuki, 2001) (Figure 87). The oldest known shell middens in the region are dated to the Initial Jomon, but the majority are attributed to the Middle and Late Jomon periods, when the population density would have been the greatest in the Kanto region (Matsumoto et al., 2017). During this phase, approximately 90 large circular shell middens were formed in the eastern half of Tokyo Bay (Nishino et al., 2017, p. 25), mostly along the area of Ichikawa, Funabashi, Chiba, Ichihara,

Sodegaura and Kisarazu cities (Ogawa, 2012; Abe, 2014b; Nishino et al., 2017). A significant part of these large shell middens developed during the demographic peak of the Kanto region in the second half of the Middle Jomon period, as exemplified by the sites of Kasori North (Chiba city) (Murata, 2013; Nishino et al., 2017), Ariyoshi North (Chiba city), Kusakari (Ichihara city) and Ubayama (Ichikawa city). After a short decline of the general site frequency in the Kanto region (shell middens included) at the end of the Middle Jomon, the numbers increased again in the first half of the Late Jomon period. The formation of large shell middens achieved a new peak in the eastern half of Tokyo Bay (Habu et al., 2011; Abe, 2014a; Toizumi, 2014), with the development of well-known sites such as Horinouchi (Ichikawa city), Soya (Ichikawa city), Kasori South (Chiba city), Rokutsu (Chiba city), Gionbara (Ichihara city), Saihiro (Ichihara city) and Sanya (Sodegaura city). The number of small shell middens also increased and achieved their highest levels. This trend ended between the end of the Late Jomon and the Final Jomon periods, when a strong decrease on the number of shell middens and other sites was recorded and the formation of large sites basically ceased in the Kanto region (Tozawa, 1989; Toizumi, 1999; Ogawa, 2012).

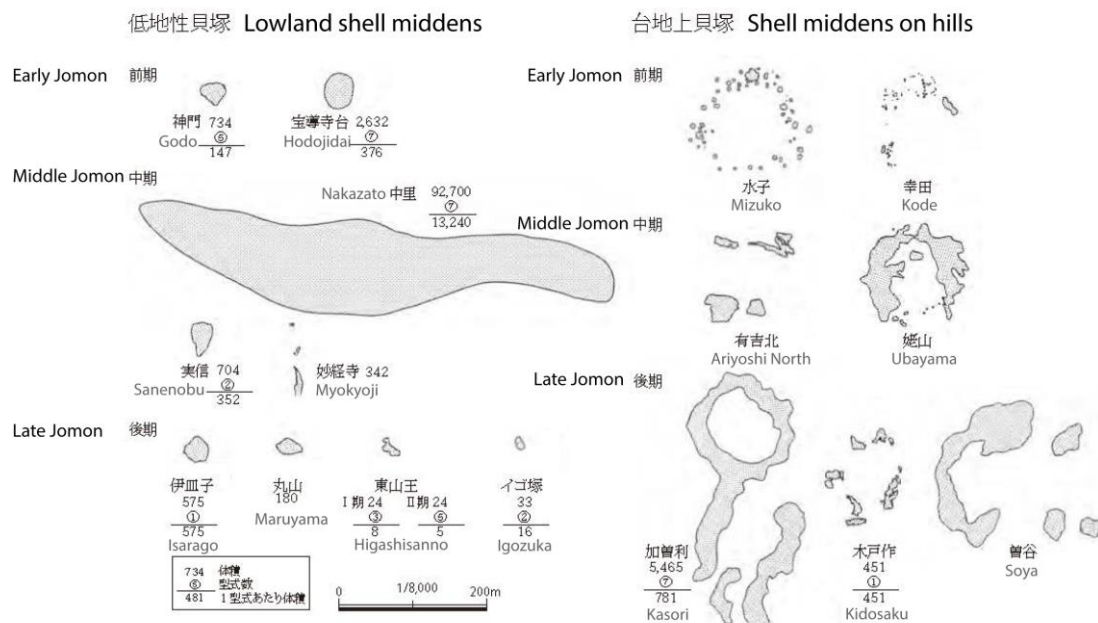


Figure 87: Schematic representation of the diverse types of shell middens in Tokyo Bay (in plan), with the lowland shell middens on the left and the shell middens on hills on the right side (adapted from Nakajima et al., 2018, fig. 124 after Uetsuki, 2001).

The large circular shell midden phenomenon that mainly developed in the Middle and Late Jomon periods has been widely investigated and discussed (e.g., Tozawa, 1989; Nishino, 2007; Ogawa, 2012; Abe, 2014b; 2014a; Takanashi, 2018; 2019). A large quantity of information is available from extensive excavations undertaken at several sites. ‘Large shell middens’ (*ōgata kaiizuka*), ‘circular shell middens’ or ‘large circular shell middens’ (*kanjō kaiizuka* or *ōgata kanjō kaiizuka*) can be defined as large circular settlement sites which comprise continuous or discontinuous shell midden deposits defining a circular, horseshoe or double-arc plan around a central plaza, as well as other features, such as pit-dwellings,

storage pits and burials, that are also organised in a concentric configuration (Nishino, 2007; Takanashi, 2018). In the eastern half of Tokyo Bay, these sites are typically located on hilltops or slopes, on the margins of the uppermost parts of the valleys, at 30–32 m of altitude and several kilometres from the coast (5–10 km in the past). In addition, these shell middens are often organised in clusters. The middens are over 100 m in diameter and the shell deposits are usually found inside or very close to the residential areas, near dwellings or over dwelling pits and other pits (Abe, 2007; 2014b; Murata, 2013; Takanashi, 2019). The deposits are recurrently characterised by a high density of shells, mostly of small periwinkles or *ibokisago* (*Umbolinum moniliferum*) and, with much less significance, common oriental clams or *hamaguri* (*Meretrix lusoria*) and *asari* (*Ruditapes philippinarum*) (Figure 88). It is thought that the transport of shellfish to the hills would have occurred through the valleys using dugout canoes, whose direct evidence has been found in the alluvial plains (Matsui, 1999; Abe, 2014b). Pit-dwellings are common at these sites, varying in number from some dozens to more than one hundred features. In addition, the frequent presence of ritual artefacts (such as clay figurines and stone rods), items transported through long distances, burials and particularly large dwellings has been highlighted (Tozawa, 1989; Takanashi, 1998).



Figure 88: Some large circular shell middens of the eastern half of Tokyo Bay: a) Sanya (Sodegaura city); b) Horinouchi (Ichikawa city); Rokutsu (Chiba city) (photos by author).

It has been generally accepted that the high density and huge dimensions of these sites resulted from the intensification and prolonged exploitation of shellfish and aquatic resources in general, which can be related to the increase of the available resources and the demographic growth of the Middle and Late Jomon periods (Suzuki, 1989; Toizumi, 1999; Ogawa, 2012; Koike, 2017). Cases of overexploitation of the collected mollusc species are

suggested by some situations where there has been a decrease in shell size over time. For example, the large shell middens from the Middle Jomon period are characterised by the presence of *hamaguri* clams of small dimensions (Abe, 2014b, p. 94). The research undertaken on materials from the Sanya shell midden also found that the shells of almost all mollusc species from the beginning of the Late Jomon were small, a situation that probably resulted from resource pressure (Ito et al., 2016, p. 285).

According to the traditional perspective of Kazutami Goto (1973), the presence of a high quantity of shells and combustion features in the large circular shell middens would have resulted from an intensive production of dried shellfish to export to inland locations, in exchange for lithic materials that was lacking in the Chiba region. Following this line, Hiroko Koike also considered that the large quantities of shellfish at these sites would not have resulted from auto-consumption alone (Koike, 2017, p. 152). However, further research led several scholars to criticise this view based on various arguments (as described by Takanashi, 2018 in detail), notably the evidence of prolonged occupations at these sites and the absence of data that can sustain the idea of shellfish exchange for lithic resources (large non-shell midden settlement sites comprising similar materials are also known in the region). Some researchers also argued that the dominant small *ibokisago* snails were not adequate for producing dried shellfish meat; instead, it would be useful for other purposes such as seasoning food (e.g., Nishino, 2005).

Moreover, the exploitation of diverse food sources of terrestrial and marine origin and the practice of various types of activities in large circular shell middens have been demonstrated by several data:

- 1) Diverse faunal remains (molluscs, fish and terrestrial fauna such as wild boar and sika deer) and macrobotanical remains, notably walnuts (*Juglans mandschurica*), chestnuts (*Castanea crenata*), horse chestnuts (*Aesculus turbinata*) and azuki beans (*Vigna*) were found at these sites (Nishino et al., 2017).
- 2) A high frequency of stone tools for hunting, digging and nut processing and features, such as nut storage pits, were also recorded (Ogawa, 2012; Abe, 2014b; Nishino et al., 2017).
- 3) The isotope data obtained from human skeletons in some of these shell middens suggest that, in general, these individuals had a mixed diet of aquatic and terrestrial food sources (Tsuruoka et al., 2007; Ito et al., 2016).
- 4) Several analyses also allowed the identification of diverse mollusc species and evidence of year-round exploitation for auto-consumption at these sites. The results of shell-ring analysis undertaken on *Meretrix lusoria* samples suggest a year-round exploitation of molluscs (Ogawa, 2012; Abe, 2014b; 2014a), contradicting the idea of a specialised, seasonal activity. It was also observed that the dimension of the shells was relatively small, in contrast with specialised sites, such as Nakazato, where a selective gathering of large specimens of restricted mollusc types would have occurred (Abe, 2014a).
- 5) The presence of numerous burials, ritual objects and some particularly large features suggest that these sites had relevant funerary and ritual functions. According to some

researchers, the abundant *ibokisago* snails in the shell layers, whose function has been discussed, were possibly related to funerary activity (Takanashi, 1998).

- 6) The chronological data from pottery typology and radiocarbon analyses indicate a long period of occupation and accumulation for these sites (Suzuki, 1989; Tozawa, 1989; Ogawa, 2012). For example, the shell midden of Kasori, known as the largest residential shell midden in Japan, would have been occupied for approximately 2000 years (Nishino et al., 2017).
- 7) Shell middens on lowland areas and closer to the sea (such as the Nakazato shell midden) in Tokyo Bay are more likely to have been specialised in mollusc gathering and processing. They present clear differences from the large shell middens on the plateaus, notably the rare occurrence of material remains other than shells, the presence of a limited number of shellfish species, the rarity of features and the total absence of dwelling remains (Uetsuki, 2001; Abe, 2014b; 2014a).

Many researchers have stated that the high density of sites (sometimes located at less than 2 km from each other), the large dimension of shell deposits, the diversity of exploited food sources (indicating year-round exploitation) and the high number of pit-dwellings frequently found at these circular shell middens are indicative of a significant degree of sedentism in the groups that left them (Nishino, 2007; Ogawa, 2012). The archaeological record of these sites contrasts with what is known in western Japan, where circular or horseshoe-shaped shell middens (and circular settlement sites in general) are practically absent, and pit-dwellings found in shell middens are rare (Koizumi, 2016). This deep difference suggests the existence of a much higher population density, social complexity and degree of sedentism in the Kanto region, a view that is also supported by other archaeological evidence, which includes numerous circular settlement sites without shell middens (Taniguchi, 2005; Matsumoto et al., 2017). However, the archaeological record from the Kanto region also indicates that several changes occurred in settlement systems during the Middle and Late Jomon periods, showing that the trajectories of the communities did not always tend towards greater sedentism or complexity in a simple way.

It has been considered that the circular form and internal organisation of the large shell middens reflect the layout of the Jomon circular settlement sites in general (*kanjo shuraku*) (Taniguchi, 2005; Abe, 2014b; Takanashi, 2019). The circular settlement sites started to appear at the end of the Initial Jomon/beginning of the Early Jomon period and mainly developed during the Middle and Late Jomon periods in the Kanto, Chubu and Tohoku regions (Taniguchi, 2005). It has been a common understanding that the form of the settlements as observed today is a cumulative result of successive occupations. Some authors have argued that the circular layout of the shell middens did not result from an initial intention of construction (Tozawa, 1989), while others have considered that the layout had been planned since the beginning of the formation (Murata, 2013; Takanashi, 2018). It seems clear, at least, that the maintenance of the circular configuration of pit-dwellings, burials and other features surrounding a central area over a long period is indicative of the existence of spatial rules and ideological views shared by several generations at the same location (Matsumoto et al., 2017). The Kasori shell middens exemplify this situation, considering that, despite the formation of the southern shell midden in the Late Jomon period, features did

not affect the central area of the northern shell midden, which was formed before (Murata, 2013, p. 141). These central areas/plazas – containing almost barely any features in some cases (open space), and presenting burials or pits in others – have been subject of discussion for a long time (Goto, 1973; Taniguchi, 2005; Matsumoto, 2011). Several researchers have suggested that these areas had a ritual purpose, possibly related to the funerary activities (Murata, 2013). According to Toshio Takanashi, the formation of huge and continuous shell accumulations around a central plaza could have resulted from an intention to protect/hide the central space (Takanashi, 2018, p. 6). However, more extensive excavations and detailed analyses are required to better understand the formation processes of the shell middens and the central areas. In addition to the circular configuration, a pattern of dual division of the sites has been observed in some large shell middens, as found in the circular settlement sites in general (Kobayashi, 2001; Taniguchi, 2005). This duality is visible in the position of some elements, notably the shell deposits. For example, the surfaces of Ubayama (Middle and Late Jomon) and the Horinouchi shell midden (Late and Final Jomon), at Ichikawa city, have a horseshoe layout divided into two main deposits (Kobayashi, 2001). In the case of Ariyoshi South shell midden, at Chiba city, an additional internal division can be observed, being the site formed by four main shell deposits (Taniguchi, 2005, p. 69). It has been thought that the dualistic layout of the sites reflects a kinship system with dual organisation of the societies, with each subdivision representing a lineage or clan (Taniguchi, 2005; Kuroo, 2009; Matsumoto, 2011).

Several authors have also supported the idea that these large shell middens had relevant ritual/symbolic functions, considering the huge dimension of the sites and the existence of the central ‘plazas’, but also the high quantity of funerary features and ritual artefacts that are often found (Tozawa, 1989; Takanashi, 1998; Murata, 2013; Tomioka, 2020). A large quantity of human burials has been identified below or inside the shell deposits, evidencing the relevance of the dead at these sites and its proximity to living people. Some authors have suggested that possibly Jomon groups already knew that the shells provided a good preservation of bones and intentionally deposited them to cover the dead (Takanashi, 1998; 2018). For Toshio Takanashi (2018; 2019), the circular shell middens exhibit a clear and intentional monumentality and their configuration reflects the Jomon circular and genealogical view of life and death. In this sense, the construction of henge monuments or earthen mounds without shell deposits, in the Late Jomon period, would be part of the same ideological view underneath the circular configuration. The large shell middens would not be only central base camps in the settlement systems, but also constructed monuments with collective burial grounds, where continued communal ritual activities associated with the beliefs of regeneration and ancestor worship would have been undertaken. Naoto Tomioka (2020) also argued that several large Jomon shell middens were monuments, although the author suggested that the sites were associated with the purpose of signalling group memory and cohesion, instead of regeneration beliefs.

Despite the availability of abundant data that attest to the practice of a multiplicity of activities, the evidence of a clear internal spatial structuration and the unequivocal importance of these sites in the regional settlement systems of the eastern half of Tokyo Bay, it is still difficult to understand the exact meaning of the internal organisation and the

functions of the large circular shell middens. Two outstanding cases are described in detail below.

Kasori, Chiba city

The Kasori shell midden (Chiba city, Chiba prefecture) is considered to be the largest residential shell midden in Japan (Nishino et al., 2017). The site is located at the centre of the Shimosa plateau, at 30–32 m of altitude. It is estimated that the site was situated approximately 5 km from the coast at the time of occupation. In fact, it consists of two linked mound or henge-type shell middens with sunken central areas, forming an ‘8’ shape (Figure 89, Figure 90). Kasori North is a 140 m circular shell midden dated to the Middle Jomon–early Late Jomon period. Kasori South is a horseshoe-shaped shell midden (with three main deposits) developed in the Late Jomon period, presenting a diameter of 190 m and two open areas at the north-east and south-west zones. It is estimated that the two shell middens reached an area of 21067 m² and a volume of more than 10000 m³ in total (Murata, 2013). While the shell middens were mostly formed on the flat area of the plateau, settlement remains were also found on the slopes. Several other Jomon shell middens are known in the immediate surroundings of the site, less than 2 km away.

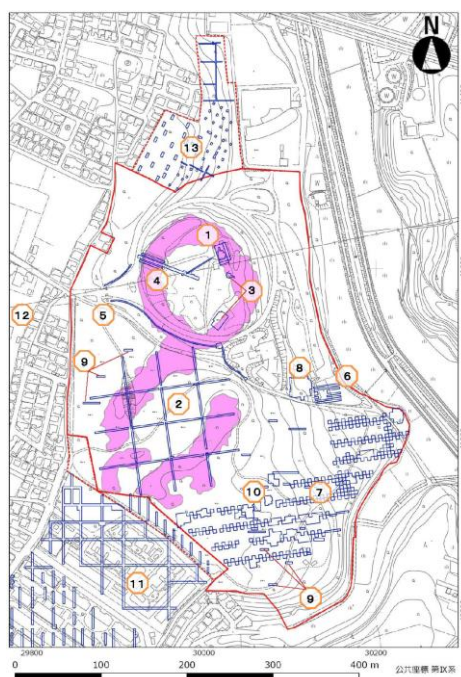


Figure 89: Kasori, Chiba prefecture – plan of the site with indication of the shell deposits (violet) and excavated areas until 2014 (circles with numbers) (reproduced from Chiba-Shi Kyoiku Iinkai [Chiba City Board of Education] Jimukyoku Shogai Gakushu-bu Bunkazai-ka, 2017, figs. 2–6).

The site was already known at the end of the nineteenth century and has been excavated since the 1920s. The excavations started out focusing on the discovery of human skeletons and progressed to providing an important historical contribution to the development of Jomon pottery typologies and settlement archaeology. Large extensions of the site were excavated in the 1960s and 1970s under the national movement for the protection of the

archaeological site that was developed at that time. The results of these excavations were analysed by several researchers in a significant number of publications (e.g., Goto, 1973; Murata, 2013; Takanashi, 2018). Since the classification of Kasori as a ‘special historic site’ in 2017, important research has been carried out based on the review of accumulated data from past excavations and new field work, resulting in the publication of new synthesis reports (Nishino et al., 2017) and numerous public outreach activities. However, most excavations have been undertaken through trenches and small areas and less than 10% of the site has been excavated so far, a limitation that poses difficulties for the global understanding of this huge shell midden.

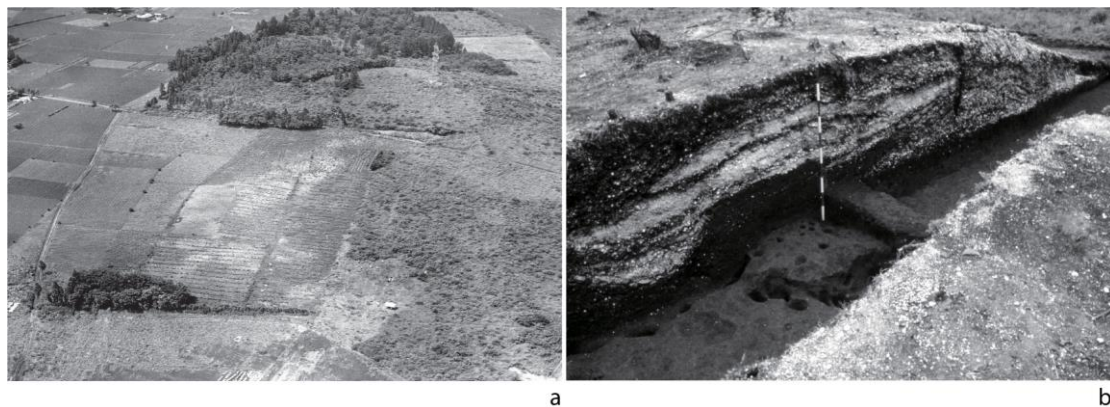


Figure 90: Kasori, Chiba prefecture – a) view of the Kasori South shell midden in 1964; b) stratigraphic section of the Kasori North shell midden (Nishino et al., 2017, fig. zuhan 2 and 5. Photos courtesy of Mr. Masato Nishino).

It is thought that the Kasori shell midden was occupied for about 2000 years (between approximately 5000 cal BP and 3000 cal BP), from the Middle Jomon to the Final Jomon period. Short occupations from the Initial Jomon to the beginning of the Middle Jomon would have occurred at the site before the formation of the shell accumulations, as evidenced by the presence of a few pottery remains. According to the available data (Abe, 2007; Nishino et al., 2017; Takanashi, 2019), the accumulation of the Kasori North shell midden only started in the middle phase of the Middle Jomon period, when the formation of the circular settlement begun, as seen from the organisation of storage pits and dwellings. During this first phase, the features were concentrated in the shell midden area. More specifically, the shell midden deposits accumulated inside and near the dwelling pits. After, the shell deposits expanded to other areas of the site, notably to the eastern slope. It was observed that the Kasori North shell midden’s ring was open at the north-eastern part during the Middle Jomon and was only closed in the Late Jomon period, when it acquired a complete circular form. During the Late Jomon, the Kasori South midden was formed and became a central part of the site, with dwellings being constructed in the midden area. Features continued to be constructed in the Kasori North midden area, without affecting its central ‘plaza’. The settlement site also existed in the Final Jomon period, although without the formation of shell deposits. According to Murata, the circular layout of the Kasori North shell midden had been planned from the beginning of its formation and the importance of the form is shown by the maintenance of the central area without suffering any visible disturbance in the

Late Jomon period (Murata, 2013, p. 141). For Takanashi, who advocates that the site had a significant ritual role, the original opening into the north-east direction of the two shell middens was possibly related to the summer solstice sunrise (Takanashi, 2019, p. 7).

The shell middens comprised multiple deposits with different shell densities and configurations. Some were formed inside pits and dwelling pits under the main shell middens or outside their areas (Nishino et al., 2017, p. 858) (Figure 91). In the case of Kasori North, the accumulation of shells achieved at least approximately 1.8 m in thickness, as observable today through the stratigraphic section conserved in the museum facility. The researchers described a continuous vertical superimposition of thin shell layers (of a few centimetres) of *hamaguri* clams and *ibokisago* over a relatively large area, indicating a fast deposition. It was also observed that the shell deposition started to occur in abandoned dwelling pits and gradually transcended the limits of the features (Abe, 2007). In the case of Kasori South, a stratigraphy of 2 m was formed by shell lens 0.30–0.50 m in thickness which alternated with sediment layers and spread over some meters in length. In this case, the deposition of shells seems to have been more concentrated, but also more horizontal, changing successively in location and generating several shell blocks (Murata, 2013). In addition, evidence of combustion, dwelling construction and surface flattening was identified in the shell layers, as seen from the levelling of some shell deposits which was followed by the deposition of sediment without shells (Murata, 2013, p. 111). Overall, the stratigraphy of the Kasori shell middens indicates that the accumulations were not a result of simple shell disposal activities and the two middens were formed through different processes. It seems clear that some residential activities took place on the shell layers. In addition, some researchers have suggested that there was an intentional construction of visible piles (Nishino et al., 2017, p. 882; Takanashi, 2018, p. 6).

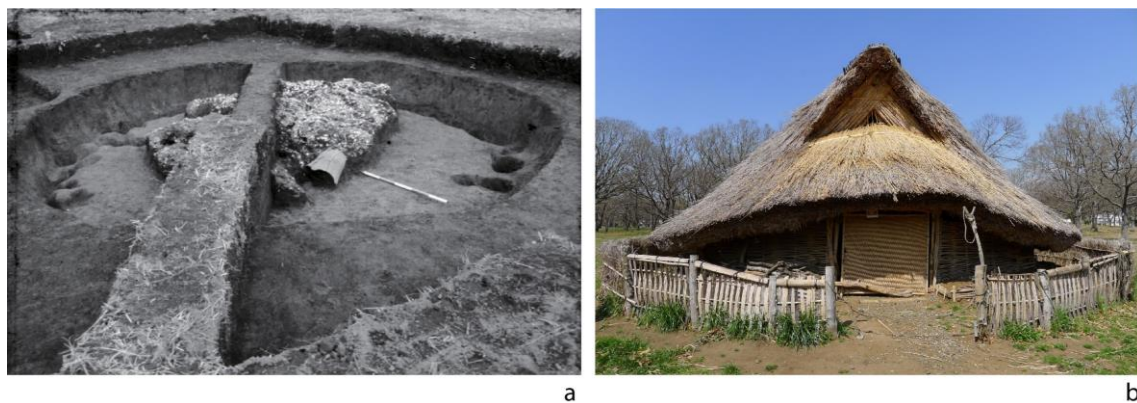


Figure 91: Kasori, Chiba prefecture: a) example of a shell deposit formed inside a dwelling pit (Nishino et al., 2017, fig. zuhan 12. Photo courtesy of Mr. Masato Nishino); b) reconstruction of a Jomon pit-dwelling, at the Kasori Shell Mounds Museum (photo by author).

According to the latest synthesis report (Nishino et al., 2017), more than 68 malacological species were identified at the site. The dominant species was *ibokisago* (*Umbolinum moniliferum*), representing more than 80% of the shells. The following most frequent species were *hamaguri* (*Meretrix lusoria*), *asari* (*Ruditapes philippinarum*) and *shiofuki* (*Macra veneriformis*), a situation that is typical of the Middle and Late Jomon large shell middens of the region. The presence of

items made from shells that were brought in from distant locations was also detected, such as bracelets made on *Patella optima*. In addition to the molluscs, the presence of other fauna is known in the site (terrestrial animals such as red deer and wild boar and some fish and bird remains). Some macrobotanical remains were also identified, including charred chestnuts inside a pit.

The quantity and diversity of the recovered artefacts is impressive. A large number of pottery remains (from the Initial to the Final Jomon periods) was found, as well as chipped, ground and polished lithics, clay artefacts (such as figurines, tablets, earrings and fishing weights) and bone/antler and shell tools (such as shell blades and bracelets), among other things. Some prestige items from distant regions were also identified.

Concerning the features, numerous pit-dwellings were found (at least 138 dwellings). In addition, several features associated with storage, funerary and combustion activities were identified. Data from the oldest excavations indicate that some pit-dwellings and hearths were identified in the shell layers, although little information is known (Nishino et al., 2017, p. 858). Many pit-dwellings and pits were found below the shell layers of the site, cutting into the loamy level, and in several cases, these features were filled with individual shell deposits. Some situations are difficult to interpret, such as the case of a pit-dwelling that cut into the shell layers of the Kasori North shell midden and was filled with dense shell layers that alternated with layers of crushed shells of *ibokisago* snails (Murata, 2013, p. 145). In addition, some particularly large pit-dwelling features were identified. For example, dwelling no.112, located on the eastern slope, reached 19 m x 16 m of dimension and contained a central hearth and a number of associated ritual artefacts. This feature was considered to be a structure with a ritual purpose, possibly used not only by the individuals that inhabited the Kasori site, but also by other groups from the surroundings (Nishino et al., 2017, p. 868).

With respect to the funerary activity at the site, at least 231 human skeletons were identified, which is a high number even in the context of the large shell middens of the Kanto region. 70 individuals were found still articulated. Most remains were identified in the shell layers or in the layers and features below. Adult burials were dominant, although a significant number of child burials was detected. A total of 14–15 dog burials were also found, which was considered to be a large number for the excavated area (Nishino et al., 2017, p. 658). According to the researchers, possibly there was a specific area for dog burial in the western area of Kasori South, where human burials were relatively rare.

Researchers are relatively unanimous in considering the Kasori shell midden to be a central and long-term residential site with a high importance in the regional settlement system. It has been stressed that Kasori was strategically located between littoral and inland sites (Nishino et al., 2017, p. 892) and received many items from long-distance exchanges. According to Takanashi (2018), Kasori would also have an important religious role in the regional settlement system, being the centre of the Jomon ‘shell midden culture’ that developed in the eastern half of Tokyo Bay (Takanashi, 2018, p. 9). The idea that symbolic/ritual activities were carried out at the site by groups from different settlement sites of the region was also underlined by Murata, although the author argued that the production of dried shellfish was undertaken at the same time as another collective and shared activity (Murata, 2013, p. 140).

Saihiro, Ichihara city

The Saihiro shell midden (Ichihara city, Chiba prefecture) is located on the Saihiro plateau and was mainly occupied from the end of the Middle Jomon to the Final Jomon (Yasui et al., 2005; Tsuruoka et al., 2007). Several other large shell middens and settlement sites are known in the area, mostly on hills (such as Gionbara, less than 2 km away), although some lowland shell middens have also been identified. The Saihiro shell midden started to be excavated in the 1930s, but the main excavations were undertaken between 1972–1987 because of urban construction works. An area of 12500 m² was excavated and all shell layers were sampled. The site was almost totally excavated, except for the central zone, which was only partially dug. A systematic study of the recovered materials started in 1997 and took more than 10 years.

The site is a horseshoe-shaped shell midden 150 m in diameter and an opening in the southern zone. The excavations allowed the identification of two main areas of accumulation – a western deposit on a slope and an eastern deposit on the flat area (Figure 92). The obtained data indicated that the accumulation of deposits started on the flat area during the end of the Middle Jomon period, but the formation of the horseshoe-shaped settlement mainly occurred in the early and middle phases of the Late Jomon.

The deposit on the flat area was relatively thin (maximum 0.50 m thick), but reached a vast area of 60 m. It was found that, in the beginning of the Late Jomon period, separated shell accumulations were associated with the pit-dwellings, surrounding the central area of the site. After their abandonment, the pits were quickly filled and, progressively, the shell deposits exceeded the limits of the features. A large quantity of pottery remains was recovered inside and below this shell midden. In addition to the dwellings, human burials were also found inside and below the shell layers in this area. A particularly large dwelling contained an infant jar burial in a pit, which was associated with a *Cypraea* sea snail with wear marks. Red painted shells and a wild boar skull were also identified near the central hearth of the dwelling.

Contrary to the eastern deposit, the Late Jomon deposit on the western slope was particularly dense, spreading over 50 m and achieving a maximum thickness of 2 m. Despite the incline of the terrain, some pit-dwellings and burials were also found in this area, in and under the shell layers. An adjacent and small shell midden deposit from the Final Jomon was identified at the north of the Late Jomon deposit, without superposition. Additionally, in the south-western zone of the site, a large dwelling feature from the Late Jomon period was identified, which was probably rebuilt several times, as indicated by numerous postholes and hearths. It is known that, originally, a shell midden deposit also existed on the southern slope, but it was destroyed without being excavated.

Overall, the site provided large quantities of pottery, lithic and bone/antler/shell tool remains. Shell adornments were especially abundant. In addition, a substantial number of ritual artefacts was recovered, including clay figurines, tablets and stone rods. Faunal remains from diverse animals were identified, notably molluscs, fish, birds and mammals. The terrestrial faunal remains were dominated by deer and wild boar bones. The malacological fauna was mostly composed of *ibokisago* snails (*Umbonium moniliferum*), which was followed

by *hamaguri* (*Meretrix lusoria*), *asari* (*Ruditapes philippinarum*), and *shiofuki* (*Macra veneriformis*), indicating that the molluscs were mostly collected from the tideland near the site. Some fish remains (such as sardines) were also recovered.

A total of 35 pit-dwellings were identified, mostly presenting a circular form of 4–10 m in diameter and several postholes close to the wall. 42 pits, three hearth-pits outside the dwellings and one ditch were identified, among other small features. It was noted that the number of features is relatively low for the period of occupation and dimension of the site, and also when compared to other central settlement sites in the vicinity, such as Gionbara shell midden (Yasui et al., 2005, p. 423). At least 72 buried individuals were detected at the site, mainly corresponding to individual inhumations. In addition, six dog burials, one wild boar burial and another from a raccoon were discovered, mostly on the flat area (Yasui et al., 2005, p. 426), revealing some diversity in the funerary rituals.



Figure 92: Saihiro, Chiba prefecture: a) general plan of the site with indication of the main shell deposits (adapted from Tsuruoka et al., 2007, fig. 1); distribution of the ritual artefacts found in the excavations (reproduced from Tsuruoka et al., 2007, fig. 867).

The distribution of material remains at the site revealed some interesting patterns. Clear concentrations of deer and wild boar bones, resembling small middens, were found near the central ‘plaza’ without shells. Ritual artefacts such as clay figurines, tablets and stone rods were concentrated in the central ‘plaza’ and the northern part of the western shell deposit, at the edge of the midden. These ritual/symbolic artefacts were mostly fragmented, suggesting that intentional fragmentation was part of the ritual behaviour. Pottery remains were more frequently found in the eastern shell deposit, while bone, shell and flaked stone tools were more densely distributed in the western slope shell deposit. Overall, the variations observed in the distribution of the artefacts suggest that there were differences in the discard according

to the areas of the site and the object types. Considering this, the researchers highlighted the relation between the central areas of the large shell middens with ritual activities, and also the symbolic importance of the areas occupied by the shell midden (Tsuruoka et al., 2007, p. 1430).

In summary, the Saihiro shell midden revealed a long time span of occupation and the practice of multiple types of activities, including residential and ritual activities. The midden was mainly formed during the Late Jomon period, when the horseshoe-shape was completed. It comprised different types of shell deposits, with some located on the slopes and others on the flat plateau area, including inside the dwelling pits. Despite these differences in the deposits, it should be noted that dwelling and burial features were found in both shell midden zones. However, several pieces of evidence, notably the distribution of material remains, suggests the existence of different functional areas and specific discard behaviours according to the material types. It seems also clear that ritual activities were undertaken in different areas of the site, including inside dwelling features. Those rituals were not limited to humans and human bodies, but also comprised animals, as shown by the inhumation of certain species, the intentional deposition of specific fragments of animals (such as skulls), the creation of preferential areas of deposition of faunal remains or the symbolic use of some types of shells. The special symbolism of the central 'plaza' was demonstrated by a large quantity of ritual artefacts in that specific space.

4.3.2.3. Specialised shell middens in Tokyo Bay

In Tokyo Bay, in addition to the well-known residential sites formed on plateaus, shell middens are also known in relatively low areas close to the coast, such as terraces and alluvial plains (Uetsuki, 2001; Abe, 2014a). According to the proposal of Manabu Uetsuki (2001), the lowland sites also have some diversity and can be divided into two categories: simple (temporary/mollusc processing specialised sites) and complex sites (settlement sites with multiple functions). The sites from both categories do not present a standardised form in plan as found in the large circular shell middens. There is also some variety within each category, notably on the dimensions of the sites. According to the available evidence, shellfish was gathered and processed at specialised sites, and then probably transported to more inland settlement sites (Nakajima et al., 2018, p. 180).

The case of Nakazato shell midden, Tokyo city

An important contribution to the understanding of mollusc processing specialised Jomon sites was provided by the investigation of the Nakazato shell midden (Tokyo city), located below the cliff line of Musashino plateau, on the western side of Tokyo Bay (Uetsuki, 2001; Abe, 2014a; Nakajima et al., 2018). It is a lowland site situated at 5 m of altitude, close to an estuary, and dated to the second half of the Middle Jomon and the beginning of the Late Jomon period. At the time of formation, the site was located at the entrance of the inner part of Tokyo Bay (*Oku-Tokyo* Bay) and mudflats would have developed nearby, followed by sand flats. Nakazato corresponds to the thickest and one of the largest shell middens in the Kanto region. It comprises a dense band of shells formed along the seashore, with a maximum thickness of 4.5 m (varying from 1–4 m in most parts), about 600–700 m of length and more

than 100 m in width (Figure 93). It is estimated that the volume of the site was 10–20 times higher than the large settlement shell middens of Chiba prefecture, such as Kasori.

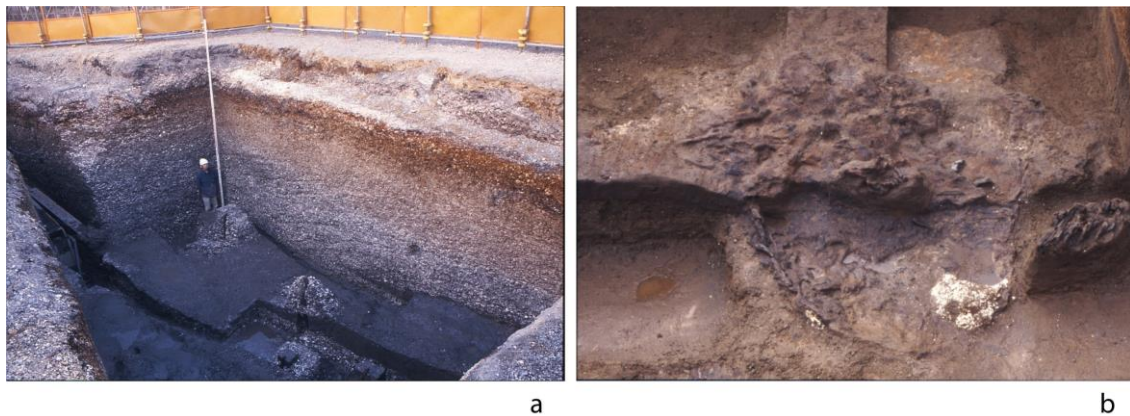


Figure 93: Nakazato shell midden, Tokyo – a) view of the shell midden; b) mollusc processing feature (no.1) (photos courtesy of Kita City Asukayama Museum).

The site has been known since the end of the nineteenth century, but it was only formally excavated from 1983 because of urban construction works. The excavations continued until 2015 and provided the opportunity to investigate the nature of the site and the variety of the Jomon shell middens in the Kanto region. The classification of Nakazato as national historic site in 2000 reinforced the importance of this shell midden for knowledge about Jomon lifeways.

The site was formed by a dense shell accumulation containing several layers, which were clearly dominated by oysters (*Crasostrea gigas*), followed by *hamaguri*/oriental clams (*Meretrix lusoria*). The two species comprised more than 98% of the analysed shell samples, revealing that a strict number of mollusc types were exploited. In some parts of the stratigraphy, it was observed that layers of oysters and *hamaguri* were deposited in alternation (Figure 94). It was considered that the molluscs at the site had a large dimension, due to a continuous and intentional process of selection of large specimens for gathering, which would have worked as a strategy of resource management (Nakajima et al., 2018, p. 181). The shell growth-ring analyses indicated that *hamaguri* clams were gathered at the spring/summer season, while oysters were probably collected in the end of autumn/winter. Consequently, although shell gathering seems to have been undertaken throughout the entire year, the collection of each main species would have occurred in a specific season. In addition, the collected species had a substantial difference in preferential habitats – oysters would have been collected from mudflats near the site and *hamaguri* clams from the sandy tidal flat zone.

Despite the dimensions of the Nakazato shell midden, few associated artefacts and features were found, contrary to other known lowland shell middens, such as Higashimyo in Saga prefecture. Residential features were totally absent. Two negative features containing wooden frames, fire-cracked rocks, burnt shells and charcoal were found, suggesting the practice of shellfish steaming, notably oysters. In addition, some combustion features were identified through the presence of concentrations of burnt shells, ash and charcoal. The researchers argued that the processing of oyster and *hamaguri* shellfish meat would have occurred at the site through simple heating procedures that did not require the use of pottery

containers. Once separated from the shells, the shellfish meat would have been sun-dried. In this sense, shell disposal and shellfish processing activities would have occurred in close proximity. Overall, it has been considered that shellfish collection and processing were the main purposes of the site. Faunal remains other than shells were rarely found, although a few fish species were identified, suggesting that hunting activities were not undertaken, and fishing was rare at the site.

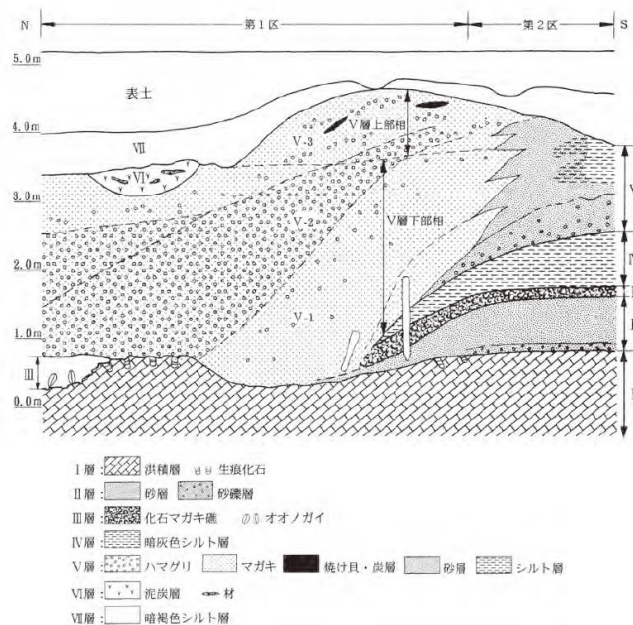


Figure 94: Nakazato shell midden, Tokyo – schematic representation of the stratigraphy. The level 5 is divided into several layers of *hamaguri* clams and oysters (reproduced from Nakajima et al., 2018, fig. 27).

Nakazato has been considered to be a specialised shell midden which formed over approximately 800 years, between c. 5200 and 4400 cal BP. According to the available data, the site essentially worked as a place to collect and process shellfish, without residential activities. The existence of settlement sites nearby, including other shell middens, on the Musashino plateau, suggested to the researchers that, in the western Tokyo Bay region, there was a relationship between processing-specialised shell middens located on the coast and near the tidelands (*hama kaiizuka*), and residential shell middens located more inland (*mura kaiizuka*) (Abe, 2014a). According to this perspective, the Jomon groups would have kept the residential sites in relatively inland locations, undertaking shellfish gathering and first processing activities at coastal sites. Logistical movements would have been developed between the two site-types, including the transportation of processed mollusc meat to the settlements inland. Due to the high density of shells at Nakazato, it has been thought that the shellfish from this site was not consumed by a single group, being carried to several large settlements located inland, possibly 20–30 km away. Exchanges of food items between coastal and inland sites were probably frequent on the western side of Tokyo Bay, resulting in the formation of large lowland and specialised shell middens, such as the case of Nakazato. In contrast, it has been argued that shellfish collection undertaken from the large shell middens of the eastern side of Tokyo Bay, such as Kasori, was predominantly for auto-

consumption at the sites, based on the diversity of collected species and the small dimensions of the identified shells.

To summarise, the archaeological record from Nakazato shell midden reflects a stable, complex and sedentary character of Middle and early Late Jomon groups that seem to have developed strategies of resource control, specific food processing techniques and logistical movements between residential and specialised sites in the western Tokyo Bay region (Nakajima et al., 2018, p. 181).

4.3.2.4. Discussion

The archaeological data from the Jomon shell middens in the Tokyo Bay region strongly contrast with those from western Japan in quantity, diversity and complexity. It can be said that the development of numerous shell middens in the Tokyo Bay region, with large dimensions in many cases, resulted from processes of intensification of aquatic resource exploitation that occurred in the Jomon period, notably in the Middle and Late Jomon sub-periods. It seems probable that this intensification mainly resulted from an increase of aquatic food consumption in a highly productive region. However, other uses of shells are documented at the residential shell middens, from the production of shell tools/adornments and symbolic items (such as painted shells) to the intentional accumulation of shell heaps of large dimensions. It is also possible that shells were used for symbolic/ritual functions in funerary activities. In addition, the formation of several types of shell deposits with different characteristics (e.g., shell density, composition) was frequently found at each site, such as deposits on flat areas, inside dwelling pits or on slopes. This heterogeneity suggests that shell deposition could have different functions or meanings within the same site.

Moreover, available data from the large residential shell midden sites of the region indicate that the accumulation of shell deposits and the construction of other features did not occur in a random way. Instead, it was organised in the space through what tended to be a circular layout around a central area, which was kept for relatively long periods. Through the investigation of the Saihiro shell midden, it was possible to observe that the distribution of artefacts also followed some patterns according to the material types, suggesting the existence of variations in discard behaviour and a particular importance of the central area. A pattern of dual organisation was also found at many of these large sites. Overall, the idea of a simple accumulation of waste can be dismissed considering the complexity of the evidence provided by these shell middens.

Furthermore, the information obtained so far from lowland shell middens, such as Nakazato, has been crucial to better understand the diversity of shell middens in the Tokyo Bay region, which is not limited to settlement sites located on hills. The Nakazato shell midden provided an unusual example of a large, specialised shell midden for mollusc gathering and processing with specific features that can be related to these activities.

The archaeological record for large circular shell middens and lowland specialised shell middens in the Tokyo Bay indicates the existence of clear differences in intra-site organisation and functions between these sites, although both types of shell middens contain large accumulations of shells and testify an intensification in the use of aquatic resources. It seems evident that, in the case of large circular shell middens, mollusc shells were clearly

more than food remains, being part of the symbolic practices of these communities. These activities are still difficult to interpret and require more efforts into specific investigation.

Despite the long history of research of shell middens in the Tokyo Bay region and the quantity of information that has been generated so far about these sites, the acquisition of additional data on site formation is also necessary, notably through new excavations to obtain stratigraphic information from more extensive areas (including the intriguing central areas of large circular shell middens), geoarchaeological studies and radiocarbon analyses.

4.4. Comparative reflections and conclusions

The quantity and quality of the available information about shell middens vary according to the sites and several factors, such as the extent of the excavated areas, the methods of research used in the field and the post-excavation analyses that were undertaken. The data on site structure and function of the Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan are particularly influenced by these conditions.

The site structure and function of small shell middens with few materials have been more difficult to characterise, due to these sites frequently being affected by erosion, the scarcity of materials other than shells and features, the limited areas of shell accumulation, and the recurrent small dimensions of the excavated areas. There has been a tendency to consider these shell middens to be temporary and/or mollusc processing specialised sites, but the importance attributed to the archaeological absence of certain materials or features should be more carefully analysed for the functional classification of the sites. Also, it can be highlighted that the lack of certain type of evidence at the sites does not necessarily mean that the shell accumulations were formed in a random way. The Jomon archaeological record includes some large sites with dense concentrations of shells that were extensively excavated and would have been mostly used for processing activities – the cases of Nakazato, in Tokyo, and Awazu, in Shiga, revealed the existence of some internal patterns of shell deposition.

In general, the largest sites provide more abundant data on shell midden site structure. Funerary activity was frequent at Late Mesolithic and Jomon shell middens with larger dimensions, resulting in the formation of cemeteries in several cases. It is clear in many situations that spatial rules were followed, as indicated by the concentration of burials in specific areas, or the distribution of graves following a layout and/or a distribution by group. Non-burial features were also constructed with some frequency and followed similar patterns of organisation in several cases (concentration in certain areas, clustering by types and distribution forming specific layouts). Therefore, burying the dead, opening a pit or constructing a house at shell midden sites seem to have been actions conditioned by certain spatial determinations that were maintained, in some cases, through several generations. The deposition of shells also seems to have been spatially conditioned in several cases. In addition, in some shell middens, it has been possible to understand that shell discard actions with distinct purposes would have occurred at the same site. The distribution of material remains at the sites has been more difficult to evaluate – in some cases, certain concentrations or distinct patterns of distribution have been identified, indicating different discard behaviours or activities. This aspect has been more complex to analyse in the Mesolithic shell middens

of Atlantic Europe, since small lithics are often the dominant artefact remains and post-depositional processes affecting the sites is recurrent.

The large and circular shell middens in Tokyo Bay exhibit clear patterns of spatial organisation of the shell deposits, features and materials that were preserved over centuries, contrasting with the sites in western Japan and Atlantic Europe, in which the identified patterns are, in general, less obvious. This difference can be explained by a higher demographic density, sedentism, economic intensification and social complexity achieved by the Jomon groups of eastern Japan, in the Middle and Late Jomon periods, which are reflected in a larger quantity of features, a more evident spatial structuration, and probably, a more complex and monumental ritual activity in large circular shell middens. It has been considered that these large sites had a relevant economic and social role in regional settlement systems.

Despite the variability of the contexts, many shell middens in the Late Mesolithic of Atlantic Europe, notably in Portugal and France, and the Jomon period in western and eastern Japan have in common the fact that they were multifunctional sites, where the practice of multiple activities of a different nature (such as resource acquisition and processing, tool production, residential activity, funerary activities and other ritual activities) took place. The chronological relationship between residential and funerary activities have been investigated – for some sites, the existence of chronological differences between funerary and residential phases has been suggested; however, in most cases, a general contemporaneity between different types of activities during the occupations has been observed. Despite possible disagreements on this topic, it seems clear that there was a strong physical proximity between the living and dead in many multifunctional shell middens, which resulted from the conscious decisions of people in the past regarding the placement of their ancestors, living activities and shell deposits.

In this regard, it can be questioned if these multifunctional shell middens were *special* littoral sites in the past or if, instead, they are only *especially well-preserved* littoral sites. Several arguments can be pointed out to support the idea that a significant number of shell middens with diverse activities in Late Mesolithic Atlantic Europe and Jomon Japan, notably those with funerary activity, were littoral sites with a particular relevance in social and ritual aspects: (1) several pieces of evidence for the use of shells for diverse purposes have been found (e.g., shell tools, adornments and other symbolic items), suggesting that molluscs and shells were more than food and waste in the modern concept; (2) a significant number of sites contain huge shell accumulations that acquired particular forms and monumentality in the past (e.g., the large circular shell middens in Tokyo Bay in Japan; some sites in the Tejo valley in Portugal); (3) evidence of funerary and ritual activity has been frequently identified; (4) funerary activity often resulted on the formation of burial grounds/cemeteries at these sites; (5) many of these sites were occupied for centuries and frequented by different generations, even if abandonment episodes were seen in some cases.

Chapter 5 Document and archaeological material spatial analysis: case studies on shell middens from the Late Mesolithic of Atlantic Europe and the Jomon of western Japan

5.1. Analytical methods

In order to obtain further information on site structure and function of Late Mesolithic and Jomon shell middens, some sites from the Sado valley in southern Portugal, the Brittany region in north-west France and Okayama region in western Japan were selected to undertake a more detailed examination of the available written and graphic documents from past excavations, and to perform a spatial analysis of material remains that were identified in the most recent works.

The analysis of written and graphic documentation was based on excavation reports, photos, drawings and other records from field research, with a particular focus on old excavations of Late Mesolithic shell middens from the Sado valley and Brittany region that took place between the first half and the beginning of the second half of the twentieth century. Concerning the Sado shell middens (Poças de São Bento, Cabeço do Pez, Vale de Romeiras and Arapouco), graphic and written documents from the Personal Archive of Manuel Heleno (Arquivo Pessoal de Manuel Heleno – APMH) about field work carried out in the 1950s–1960s, were analysed at the National Museum of Archaeology, in Lisbon (Museu Nacional de Arqueologia – MNA), which included photos, site plans and individual drawings, as well as reports and letters received by Manuel Heleno (director of the Museum at the time) from Jaime Roldão, the main excavator of the sites. Regarding the sites from the Brittany region (Beg-er-Vil, Beg-an-Dorchenn, Téviec and Höedic), monographs, articles and field reports containing the oldest information about the sites were analysed. A significant part of these records is currently accessible online. Additionally, some field drawings, notes and photos from the excavations in the 1980s at Beg-an-Dorchenn, directed by Olivier Kayser, were analysed at the CReAAH laboratory (Rennes). With respect to the shell middens from the Okayama region, published reports, monographs and short articles from the Hikozaki and Tsukumo shell middens were analysed, which included photos and drawings from the old excavations undertaken in the first half of the twentieth century.

The spatial analysis of archaeological materials was centred on lithic tools and undertaken on collections from three shell middens located in different regions: Poças de São Bento, Sado valley (southern Portugal), Beg-er-Vil, Brittany (north-west France) and Hikozaki, Okayama (western Japan). The three sites have been largely excavated and, despite belonging to different geographic and cultural contexts, they are characterised by relatively large dimensions, significant shell accumulations and evidence of diverse activities related to a subsistence completely or mainly based on hunting, gathering and fishing, which included the production of abundant flaked lithic tools with a high presence of small projectile points. Chipped lithics are by no means the most frequent material found in Mesolithic shell middens, after shells. As mentioned before, Poças de São Bento and Beg-er-Vil are both dated to the Late Mesolithic period and the chipped stone industries found at these sites reveal some similarities, being integrated into the so-called technocomplex of blade and trapeze industries from the south-western regions of Europe (Marchand and Perrin, 2017). With respect to the

Jomon sites, despite the high quantity of material that is usually found in the excavations, chipped lithics have been less studied when compared to other elements of material culture, such as pottery. However, the analysis of lithic tools from Jomon contexts has been increasingly considered as a necessary task to better understand Jomon technology and societies (Uemine, 2018). Hikozaki is a site occupied from the Initial Jomon to the Final Jomon period where abundant flaked lithic material was detected, mostly on sanukite, a rock that was typically used in the knapped lithic industries from western Japan, notably in the Chugoku and Shikoku regions (Takehiro, 2003; Uemine, 2018). In this study, the lithic analyses were performed on materials from the most recent excavations at these sites, for which adequate stratigraphic and spatial information was available. The lithic materials from the three sites were firstly classified according to their typological and technological characteristics, following the principles of the lithic *chaîne opératoire* (Inizian et al., 1999) and adapting the classification schemes used in the specific literature of the concerned regions, chronologies and material types and, when applicable, the standards defined by ongoing projects or previous research undertaken on the selected sites (explained in detail in each section). The obtained information was then recorded in databases. Afterwards, spatial analysis of the remains was undertaken by correlating the available spatial and contextual information with the obtained typological and technological data. GIS software (*Quantum GIS*) was used for map rendering of the material distributions. The purpose of these analyses was to obtain additional data on technological and typological aspects of the lithic production, and its spatial and diachronic variation at these sites, in order to better understand intra-site organisation (concerning artefact production, use and deposition/discard) and site function.

5.2. Shell middens of the Sado valley, southern Portugal

5.2.1. Poças de São Bento

5.2.1.1. Document analysis

The excavations in the 1960s

The shell midden of Poças de São Bento was firstly excavated by the team with the director of the National Museum of Archaeology in Portugal, Manuel Heleno, in 1960 and 1964, on an area of about 60 m², located in the eastern part of the site (Arnaud and Larsson, 1987; Arnaud, 1989; Peyroteo Stjerna, 2016). Concerning these excavations, there is little currently available documentation from the Personal Archive of Manuel Heleno/National Museum of Archaeology – a total of 68 photos (from which a significant number were repeated) and some fieldnotes and personal letters from the museum's staff, Jaime Roldão. Two site plans and some sketches of the findings are also known and conserved at the museum. One of the main objectives of the works in the 1960s was to define the area of the shell midden through the excavation of small trenches, which were represented in the plans. A total of 10 trenches (from 'Sonda' 1 to 10) were opened of 8–21 m of length, surrounding a rectangular central area ('Talhão T') (Figure 95). According to the site plan from 1960 (MNA, Archive A, A119), the following five sedimentary layers were identified from top to bottom: brown sediment (surface), yellowish-brown sediment, dark sediment, greyish sediment with shells and white sand. The documents from the archive indicate that the shell layers had between 0.60 and 0.80 m of thickness in the areas of Sonda 1, 2 and 3.

The photos from the Personal Archive of Manuel Heleno are in a fragile state of preservation, posing difficulties for observation. The majority corresponds to records of human skeletons, which are also represented in the drawings. Exceptionally, one photo shows a deer antler found over a shell layer (APMH/2/11/57-5/68), although the exact context is not indicated (Figure 96). It can be noted that the personal letters from Roldão also highlight the discovery of antler fragments among the faunal material found in the area of Sonda 2, in the south-east zone of the site (PT/MNA/APMH/5/1/654/58, Água Derramada, 18/09/1960).

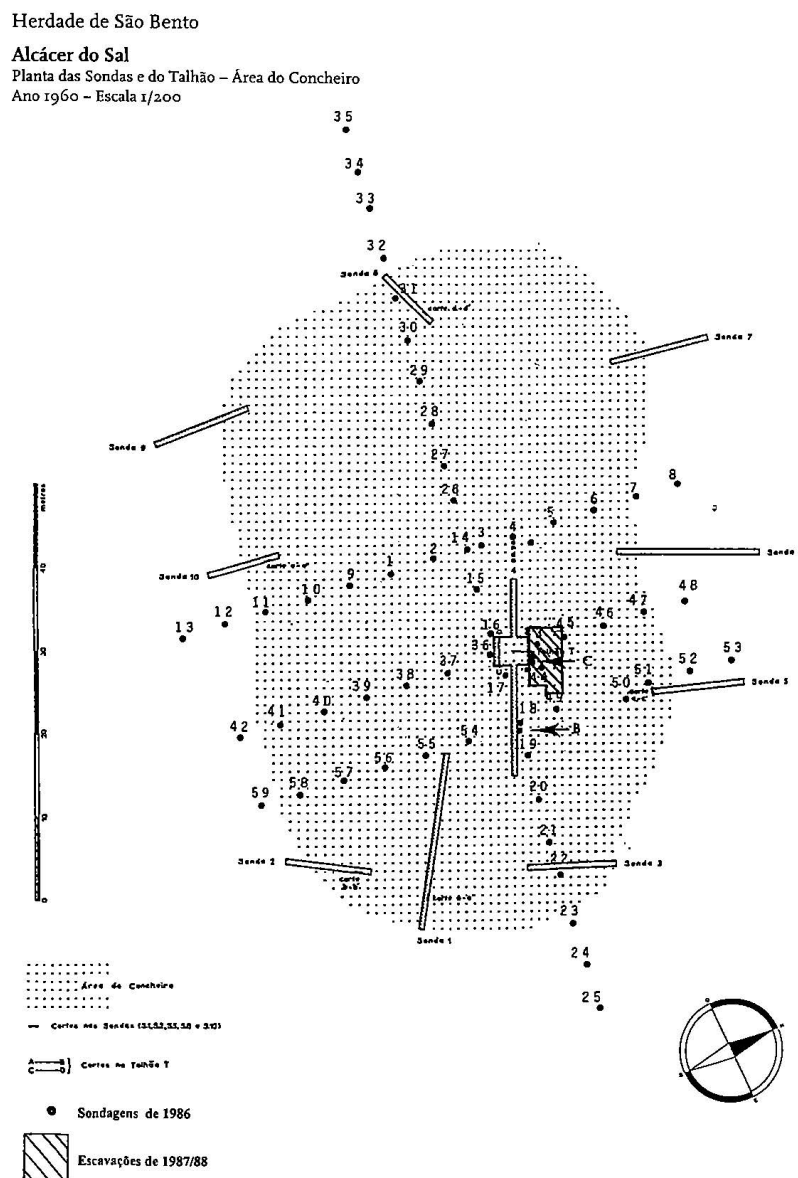


Figure 95: Poças de São Bento – site plan with the excavated areas by Heleno and Arnaud & Larsson's teams over the original drawing of Dario de Sousa archived in MNA (National Museum of Archaeology) (reproduced from Arnaud, 2000, fig. 7).



Figure 96: Poças de São Bento – antler found in a shell layer in 1960 (Personal Archive of Manuel Heleno/National Museum of Archaeology - APMH/2/11/ 57-5/68).

Generally, it can be observed that the letters from Roldão contain few details about the excavations (PT/MNA/APMH/5/1/654/54 to 69). The main concerns of the excavators were the limits of the shell midden, the stratigraphic differences between the excavated areas and the discovery of material remains and skeletons. Although precise quantitative data are not provided, the differences in the descriptions indicate that the areas of Sonda 1, 2, 3 and 4 (the eastern part of the site) were the most significant in artefact density, thickness of the shell layers and stratigraphic depth. Concerning the area of Sonda 6, in the northern part of the site, it is mentioned that the closest zone to the shell midden was the densest in material remains. Another relevant note says that the site apparently comprised two middens connected through a layer of dark sediment (without shells) identified in the area of Sonda 4, in the central part of the site (PT/MNA/APMH/5/1/654/61, Água Derramada, 29/09/1960). This observation attests to the irregularity and discontinuity of the shell accumulations, which were also described by other researchers in later times (Arnaud, 2000; Diniz and Arias, 2012).

Contrary to some other shell middens from the Sado valley, the identification of features other than human burials was not recorded or mentioned in the available documents from Poças de São Bento. At least 14 individuals were found in these excavations (Cunha and Umbelino, 2001), concentrated in the central area ("Talhão T") and in the basal sands, but apparently presenting an irregular position and orientation (Figure 97). The presence of some stones associated with these skeletons was observed by the excavators (PT/MNA/APMH/5/1/654/68, Água Derramada, 06/11/1960), but the existence of grave goods was not reported. Numerous artefacts, notably lithic tools, as well as faunal remains were recovered. According to the preliminary study of the archaeological material preserved in the National Museum of Archaeology (Arnaud, 1989), which totalled 9958 remains, the large majority were lithic materials (around 91%), with a high presence of bladelets and microliths, although these categories would be overrepresented due to selective recovery in the field. The collection of the Museum from these excavations also includes artefacts that are clearly from a post-Mesolithic chronology, notably some fragments of pottery and polished stone tools. The finding of a polished axe was highlighted in the letters from Roldão

(PT/MNA/APMH/5/1/654/62, Água Derramada, 02/10/1960), indicating the rarity of this type of discovery.

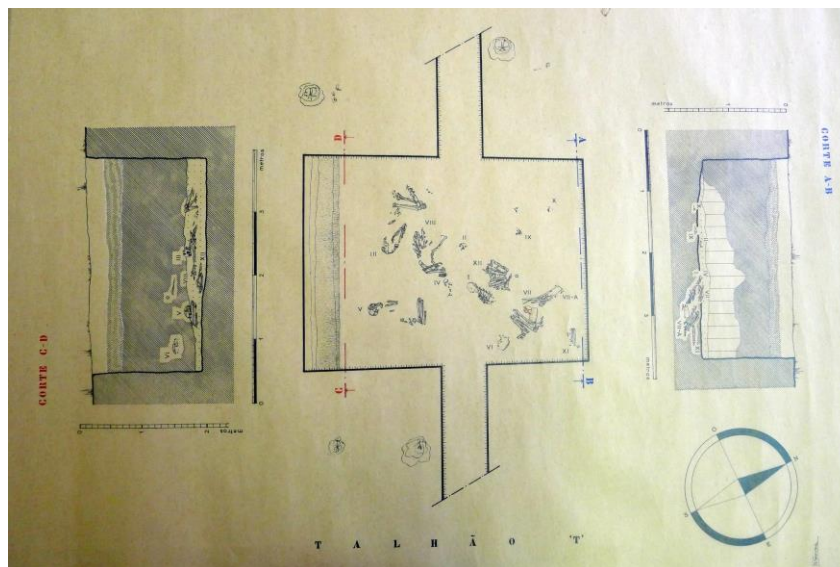


Figure 97: Poças de São Bento – extract of the site plan of 1960, with the representation of ‘Talhão T’, the central area of the excavation, and the stratigraphic sections and human skeletons that were found (MNA, Archive A, A119).

The excavations in 1986–1988

The excavations in 1986–1988, directed by José Arnaud and Lars Larsson, were also undertaken at the eastern part of the site, but in a smaller area of about 26 m² (mentioned here as area ARN-LS) (Figure 98). The results are described in several publications and field reports (Arnaud, 1986a; 1988b; 2000; Arnaud and Larsson, 1987; 1994; Araújo, 1995–1997; Larsson, 2010; 2015). Detailed methods of excavation were applied for the first time at the site (which included the use of systematic sieving) and a multidisciplinary approach of investigation was carried out.

According to the available descriptions, the eastern part of the site presented better preservation, with a lower density of trees and an absence of evidence of recent impacts from agricultural work. The field work confirmed the previous observations about the irregularity of the shell midden in the area of ‘Sonda 4’, in the central zone, where it was found that a layer almost without shells divided two zones with a high density of shells (Arnaud and Larsson, 1994; Larsson, 1996, fig. 2). It was found that the stratigraphy at the site comprised five main units, as observed by the earliest excavators: a surface layer of 20–40 cm with some lithic material and prehistoric pottery remains, a sandy-clayed sediment of dark-brown/dark colour, comprising the majority of lithic remains and shell fragments, a dark layer with about 50 cm of thickness composed of small shell deposits with numerous entire and fragmented shells, and finally, a sandy, brown/yellow sediment corresponding to the natural soil.

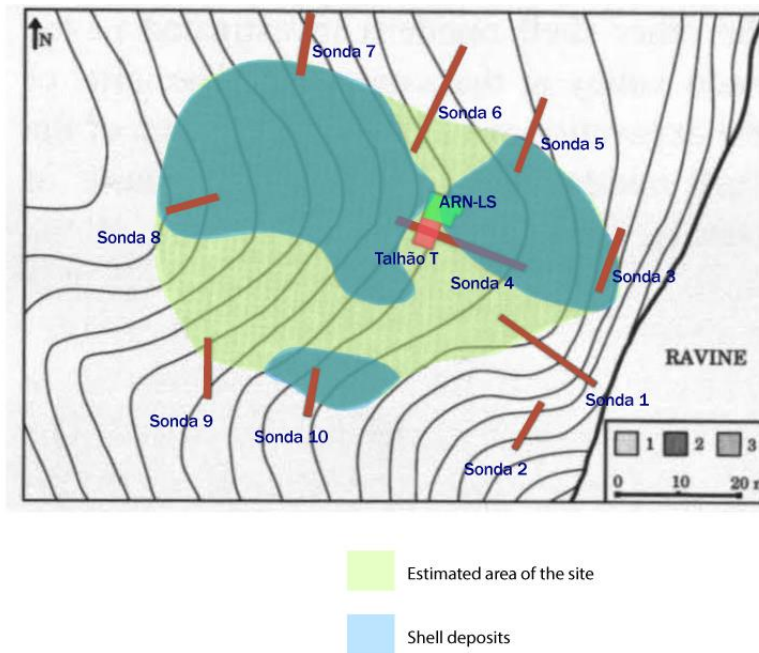


Figure 98: Poças de São Bento – schematic plan of the excavated areas in the 1960s (red) and 1980s (green, indicated as ARN-LS), with the estimated extent of the shell deposits and total area of the site (modified from Larsson, 1996, fig. 2).

The majority of the lithic remains from these excavations was recovered from the two first layers, although the shell midden layer also contained some material. The analysed lithic material totalled 8444 remains (Araújo, 1995–1997), a number that is equivalent to the total of materials recovered in the preceding excavations, despite the much lower dimensions of the excavated area in the 1980s. This situation probably resulted from the application of different methodologies of excavation, notably the use of sieving procedures and a more systematic strategy of recovery of the material remains in the later field work.

Several features were identified, such as a pit with a human skull, one human burial, 17 negative features classified as postholes with about 10–30 cm and 60 cm depth, two pits in the basal sands and some stone concentrations with evidence of firing. The identification of the features classified as postholes and pits was based on the observation of discolorations of the soil, being mostly located below the shell layers and in the basal sands. However, most features were classified with a level of doubt and a pattern of distribution was not identified (Figure 99). There are no mentions of any type of structure and the authors suggested the possibility of there being ‘anomalies’ caused by natural action. In the case of the pit with a skull, attributed to ‘skeleton 11’, the limits of the feature seem unclear in the photos of the reports and the stratigraphic section (Arnaud, 1986a; Arnaud and Larsson, 1987), although the excavators noted the identification of a shallow pit in the basal sands which would have been dug from an almost shell-free layer located above (Arnaud, 1986a; Larsson, 2015, p. 293). However, it can be said that this stratigraphic interpretation is not consistent with the published radiocarbon date of the skull, which indicates it is from the Middle Neolithic, in the second half of the 7th millennium cal BP (Larsson, 2010). With respect to the undated human burial found in 1988 (‘skeleton 13’), it was identified in the shell midden layer, but

the available documentation does not suggest the existence of a formal pit (Arnaud, 1988b; Larsson, 2015, p. 294).

Concerning the stone concentrations, specific information about their precise location or configuration is unknown. It is possible that some of these features corresponded to hearths. However, in the excavation report, the photo of a feature classified as a hearth formed by stones and a dark sediment does not show the presence of large fire-cracked rocks (Arnaud, 1988b). Overall, despite the use of a more careful methodology of excavation, most identified features are poorly defined. In addition, the excavated area was small, providing limited information concerning the organisation of the site.

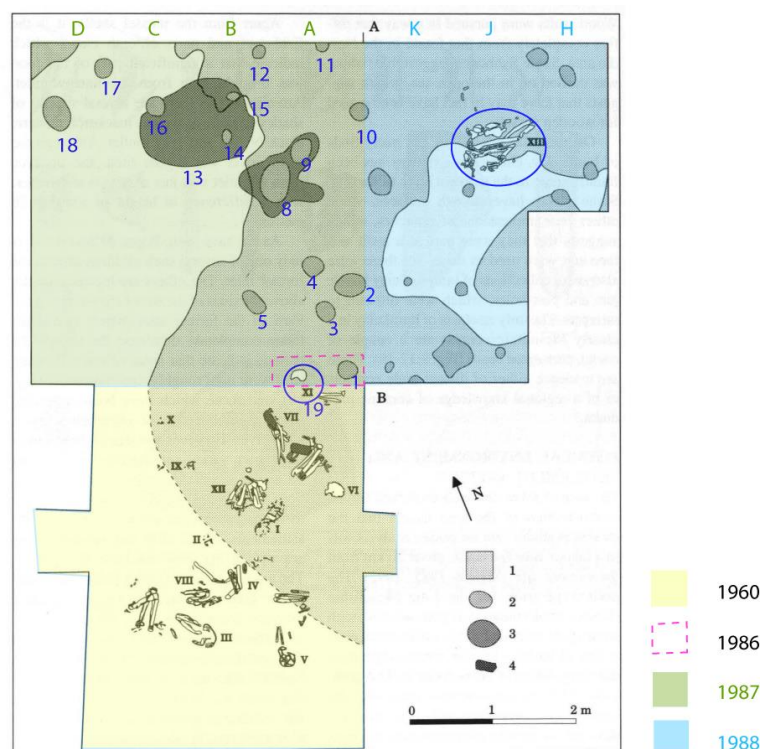


Figure 99: Poças de São Bento - areas excavated by Heleno and Arnaud/Larsson's teams: 1) limits of the shell midden; 2) discolorations caused by putative postholes; 3) pits; 4) large stones (modified from Larsson, 1996, fig. 8, based on Arnaud 2000, fig. 8 and Arnaud, 1988b, fig. 2).

The excavations in 2010-2016

The most recent excavations at Poças de São Bento were undertaken between 2010 and 2016, under the direction of Pablo Arias and Mariana Diniz within the framework of the Sado-Meso research project. 11 areas of different dimensions (from S1 to S11) located in the western and eastern sides of the site were excavated (Diniz and Arias, 2011; Diniz et al., 2012; 2013; 2014; 2015; 2016; 2017) (Figure 100). A detailed protocol was followed, with the implementation of a field laboratory. Stratigraphic units were distinguished, and the respective geometric data were individually collected, while visible archaeological items (larger than 1 cm) were also georeferenced with a total station. Sediments from each stratigraphic unit were completely recovered in 10 dm³ units (adopting the so-called 'bucket shot' system). Coordinates of a central point at the bottom of each unit were taken and then

associated with the archaeological material recovered through sediment water-sieving and sorting (Arias et al., 2015a). In addition, important complementary analyses were undertaken, such as micromorphological studies (Duarte et al., 2017b).

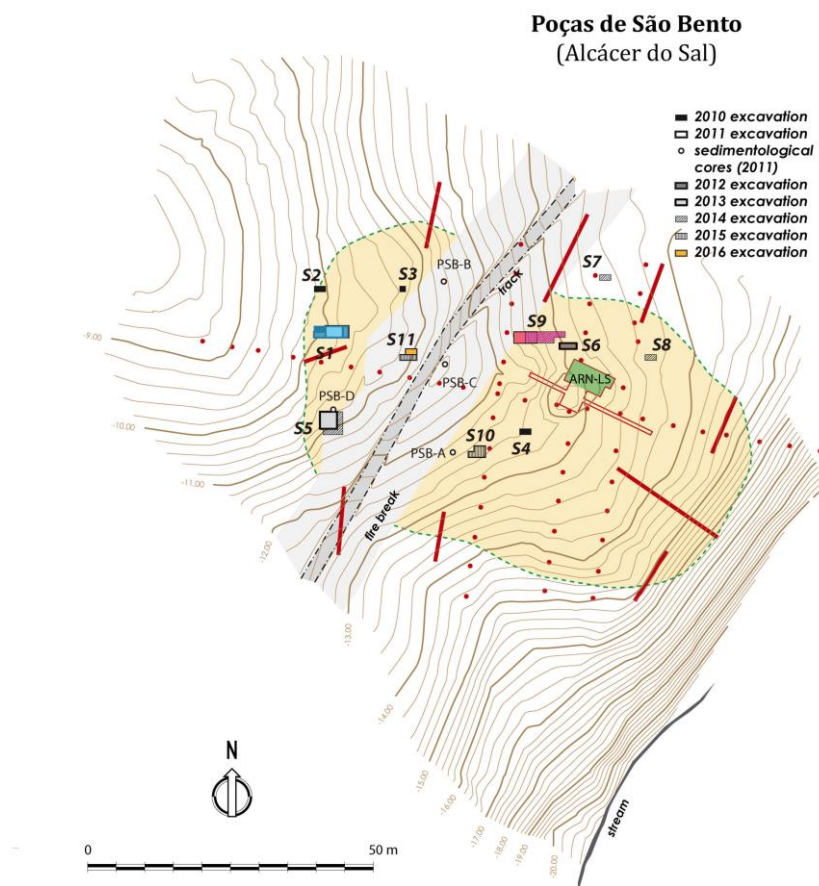


Figure 100: Poças de São Bento – site plan with the excavated areas between 2010 and 2016 (Sado-Meso Project, with modifications highlighting the areas S1, S6, S9 and ARN-LS).

According to the information from the field reports (Diniz and Arias, 2011; Diniz et al., 2012; 2013; 2014; 2015; 2016), the main areas of excavation were S1 and S5 on the western side, and S6 and S9 on the eastern side, near the formerly excavated area:

- 1) The *area S1*, at the western side, was excavated between 2010 and 2013 and reached 12 m² (*Appendices – Figure B1*). Several shell accumulations were detected, revealing some heterogeneity in terms of density and the state of fragmentation of the shells, although they were generally considered to be part of the same stratigraphic unit (SU 3/7). The most relevant features identified in the area were a hearth, a pit filled with shells (*Appendices – Figure B2*) and a dog burial (the only dog burial that was discovered at the site). Numerous lithic material was found (Araújo et al., 2015) (described in detail in the next section).
- 2) To the south of area S1, *area S5*, excavated between 2010 and 2015, also reached 12 m² and contained a large accumulation of shells and several post-depositional

intrusions. Lithic and faunal material was particularly abundant and small concentrations of fire-cracked rocks were also detected. In addition, two pits filled with shells were identified.

- 3) On the eastern side of the site, *area S6* was located at a close distance from the area excavated in the 1980s. The excavation occurred in 2013, after the identification of an anomaly through geophysical survey works (Arias et al., 2017), and reached an area of 3 m². Despite being a small area, it provided a relatively large quantity of lithic material and a human burial, which was found in the sands, at the bottom of the stratigraphy (*Appendices – Figure B3*).
- 4) *Area S9* was excavated between 2014 and 2016 to the north-west of S6, reaching 16 m². It was interpreted as part of the central zone of the shell midden. In addition to the high quantity of lithic material, the presence of large fish remains and fragments of Neolithic pottery was highlighted. A pit, a concentration of fire-cracked rocks, a hearth-related feature with a dense shell deposit and a deposit of faunal remains were identified.

In general, it was observed that the stratigraphy of the site was quite uniform in the excavated areas (Figure 101), although with some variations, notably in the thickness of the shell midden deposits. The shell deposits, dated to the Late Mesolithic (late 9th millennium–8th millennium cal BP), tended to look like a single layer of homogenous accumulations. It was characterised as a sandy, greyish-coloured sediment with fragmented mollusc shells (mainly of *Scrobicularia plana* and, with less importance, *Cerastoderma edule*), some artefacts and bones. However, in the areas S9 and S11, some internal stratification of the shell midden was observed, as exemplified by the presence of lenses formed by complete shell valves. Some cases of particularly dense deposits of shells with complete valves, which apparently were filling pits, were also identified in S5. Contrary to this, the pit found in area S1 was filled with fragmented shells and charcoal. Spatially, the shell midden deposits were quite scattered and presented lateral discontinuities and gradual contact with the under and overlying layers, being difficult to be delimited. The deposits were over the basal sands or, in some cases, over the greyish sands with some shells and lithics. Overlying the shell midden deposits and below the uppermost sediments were blackish sands with few shells and rare archaeological material, including, in some cases, very few Neolithic pottery sherds. These layers, dated to the Neolithic, presented intense bioturbation. Therefore, it can be understood that a Neolithic occupation would have occurred after the formation of the shell midden, since pottery remains were above and not inside the shell midden, but abandonment episodes were not detected, suggesting a continued occupation of the site.

The micromorphological analysis of samples from some excavated areas provided a better understanding of the organisation and activities of the site. Different patterns of shell deposition were found, indicating a differential use of the space (Duarte et al., 2017b; Duarte, 2019). The study showed that the apparently similar and homogenous shell accumulations resulted from activities of deposition of a different nature. It was observed that area S1, in the western part of the site, had intensive occupation, with the shell layers evidencing signs of trampling (occupational surface) over a dumping of reworked activity debris. It was suggested that these secondary deposits could have occurred in order to flatten the surface.

On the contrary, the analysis of area S9, in the eastern part of the site and near the funerary zone, provided evidence of intentional superposition of different types of anthropogenic deposits, little trampling and rapid burial, indicating that it could have been used as a preferential area for food refuse (and primary deposition) and not so intensely frequented as area S1.

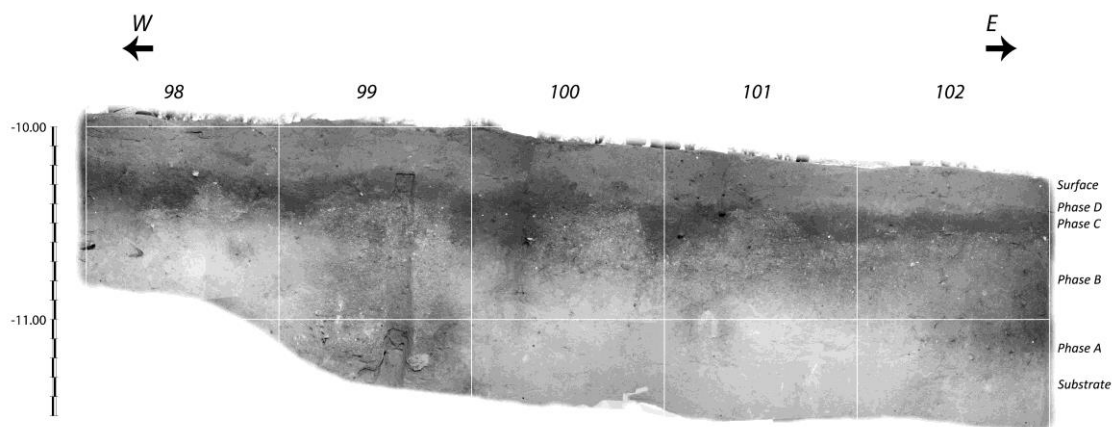


Figure 101: Poças de São Bento, area S1 – north stratigraphic profile (Sado-Meso project) (Arias et al., 2017).

Concerning the material that was found (Diniz and Arias, 2011; Diniz et al., 2012; 2013; 2014; 2015; 2016; Araújo et al., 2015), flaked lithic remains were well-represented through the site, being particularly abundant in the areas with the densest shell accumulations, a situation that was also noticed in the 1960s. On the contrary, the areas that had less shells contained few lithics and other materials. Nevertheless, stratigraphically, the upper levels contained the highest lithic densities in general, although the units located below (including the shell midden contexts) also presented some significant quantities of material.

Although not numerous, a total of 19 features were detected in the excavated areas. However, the descriptions in the reports indicate that only nine features presented a good level of reliability. The following types of features were identified:

- 1) Small negative structures – the features were indicated by dark colours. However, as observed in the preceding excavations, this probably resulted from the effects of post-depositional activities.
- 2) Burials – two burials (a human burial and a dog burial) were detected in different areas of the site and distinct archaeological contexts. The dog burial, dated to the first half of the 8th millennium cal BP, in the Late Mesolithic (Ox-A-26094: 6866±33BP; López-Dóriga et al., 2019), was located on the western side of the site and inside the shell deposit. Contrary to this, the human burial, dated to the end of the 9th/beginning of the 8th millennium cal BP, in the beginning of the Late Mesolithic (OxA-29113: 7238±35BP; López-Dóriga et al., 2019), was found to the east, on the bottom sands, close to the area where other burials were identified in the former excavations. In both cases, associated grave goods were not found. The existence of a burial pit was considered probable, because of the position of the skeletons, although the limits were not clearly identified.

- 3) Pits filled with shells – three pits filled with dense shell deposits were identified on the western side of the site, whose function is difficult to interpret. Differences in the archaeological contexts of these features can be highlighted. The pit from area S1 was excavated in the basal sands and filled with a sediment containing fragmented shells, which was similar to the shell midden layer (*Appendices – Figure B2*). Contrary to this, the other two pits in area S5 cut into the midden and presented significant quantities of whole shells, particularly pit SU 418/419.
- 4) Combustion features – although being difficult to define, three hearths and five possible combustion-related features were identified. Most of these features were indicated by the presence of some fire-cracked rocks and charcoal. In area S9, a feature inside a pit with an irregular form was identified through a dense shell deposit with little sediment, abundant charcoal and shells with colour alterations. However, a stone structure and clearly associated fire-cracked rocks were absent. According to the microstratigraphic analysis, it possibly corresponded to a dismantled combustion feature (Duarte, 2019, p. 286).
- 5) Deposit of animal remains – a concentration of bovine remains without anatomic connection was also detected in area S9, inside a negative feature that was open in the shell midden.

Overall, the most recent field work allowed researchers to understand that the site had diverse activities which were not limited to the burial of dead people. In addition, the identified remains reveal some spatial differentiation, with a clear concentration of human burial activity on the eastern side of the site. The obtained data also suggest that the deposition of shells itself had different characteristics and meanings, depending on the area of the site and the stratigraphic context.

Additional considerations

The excavations undertaken so far at Poças de São Bento showed that the accumulation of shell deposits occurred on both sides of the site, as an irregular and discontinuous layer and some infills of negative features. Situations of primary and secondary deposition of shells were identified, suggesting the existence of some diversity of the activities and spatial differentiation of the site, which are still difficult to explain from a functional point of view.

Overall, the records of the identified features indicate a low effort of construction at the site. Concerning the negative features, despite the differences in reliability that can be attributed to each one, stone structures were absent in all cases, contrary to other examples identified in some Mesolithic shell middens (e.g., in France). If some pits at Poças de São Bento could be identified through the presence of specific types of infills (inhumations, dense concentrations of shells or other deposits), the negative features marked by dark colorations can be considered to be more dubious, due to the absence of structure and their placement in sandy contexts. In addition, the shell-filled pits that were found raise several questions about their function. These features were identified in different contexts (basal sands and a shell midden layer), a situation that is possibly related to distinct purposes. Despite the uncertainties, these pits indicate the occurrence of some deposits of shells in specific and delimited areas of the shell midden site, which is a phenomenon that has been also observed

in several Jomon shell middens. Combustion-related features were found in both sides of the site, revealing diversity, but also simplicity of construction. The presence of structured deposits of terrestrial fauna was rare, but it indicates the existence of some symbolism and ritual related to the animal world – considering the dog burial on the western side of the site and, possibly, the deposit of bovine remains in area S9 and the deposition of a deer antler found in the 1960s. These three situations were identified in shell midden layer contexts, suggesting that shell deposits could have been part of the same symbolic activity.

The available data indicate that human burial activity was concentrated in the eastern part of the site. However, the individual position of the burials does not suggest a visible spatial arrangement between them. Most of the funerary activity at the site would have occurred before the formation of the largest shell deposits, during the Late Mesolithic, considering the stratigraphic position of the majority of the skeletons in the basal sands. However, it is also clear that some inhumations occurred during and after the formation of shell accumulations, as seems to be the case for ‘skeleton 13’ found on the shell midden layer, or the skull dated to the Middle Neolithic (probably belonging to ‘skeleton 11’), which is likely to have been inhumated after the formation of the shell layers. In addition, the dog burial occurred in a shell midden context and during the first half of the 8th millennium cal BP, as indicated by the radiocarbon data. Overall, although rare, the evidence suggests that funerary and ritual activities were part of the shell midden formation during a relatively long period, being not limited to the first phases of occupation. The occurrence of post-Mesolithic occupations at the site was also attested to by the frequency of some findings of pottery remains and polished stone tools in the upper layers.

5.2.1.2. Spatial analysis of material remains

5.2.1.2.1. Previous research and methods of lithic analysis

The most recent excavations at Poças de São Bento in 2010–2016 allowed researchers to identify and recover a large quantity of lithic remains with systematic georeferencing of units of sediment and material remains larger than 1 cm, as well as wet-sieving and sediment sorting (Arias et al., 2015a). The present analysis was undertaken on the lithic material recovered from areas S1, S6 and S9 and focused on flaked lithic remains:

- 1) *Area S1* was excavated on the western side of the site and measured 12 m² in total. Several shell accumulations were detected (stratigraphic units 3/7). The most relevant features found in the area were a hearth, a pit filled with shells and a dog burial. It provided 3931 lithic remains (3180 flaked lithic remains). A previous study of the lithic material from stratigraphic units 7 and 12 (Araújo et al., 2015) showed the occurrence of local lithic production, and identified some refits among the recovered material, leading the authors to suggest that area S1 corresponded to a specific activity area located in a relatively marginal position of the site;
- 2) *Area S6* was located on the eastern side of the site and was 3 m². Despite its small dimension, it provided a large quantity of lithic material, and also a human burial. A total of 1668 lithic remains were recovered (1598 flaked lithic remains);
- 3) *Area S9* was excavated on the eastern side of the site, to the north-west of area S6, reaching 16 m². It was interpreted by the excavators as part of the central zone of the

shell midden (Diniz et al., 2016). In addition to the high quantity of lithic material, numerous fish remains were found. A pit, a concentration of fire-cracked rocks, a combustion-related feature and a deposit of faunal remains were the main identified features. A total of 4201 lithic remains were recovered (4103 flaked lithic remains).

The technological and typological characterisation of the lithic material was undertaken through the analysis of qualitative and metrical attributes proposed by several authors (Araújo, 1995–1997; Inizian et al., 1999; Carvalho, 2008b), which were adapted to the specific assemblage and chronology of the site. The obtained qualitative and quantitative data was linked to the available three-dimensional spatial information from the individually plotted material and units of sediment⁴. Spatial analysis and map rendering of the lithic distribution were supported by GIS software (Quantum GIS).

5.2.1.2.2. Analysis and results

Lithic technology and typology

A total of 9800 lithic remains were recovered from areas S1, S6 and S9 (Table 6). This number included, in addition to the flaked lithic remains (n=8881), a significant quantity of fire-cracked rocks, a polished stone axe found in area S1, a percussive tool from area S6 (*Appendices – Figure B12*) and a schist plaque with use wear from area S9. When the quantities of recovered flaked lithic material and dimensions of the three excavated areas are compared, it is possible to understand that area S6, in the eastern zone of the site, comprised the highest density of lithic remains.

Among the technological categories of chipped lithic remains, it can be found that debris was the most numerous category (45%–63%), being mainly composed of small non-classifiable fragments. Debitage products were the second most numerous category (33%–47%), being in general dominated by flakes (67%–77%). Contrary to this, cores and core preparation and maintenance material were rare in the three analysed areas (2%–4%). Retouched tools were more frequent (2%–5%), although generally rare in the assemblages, particularly in area S6 (Figure 102).

The majority of the remains were collected from the surface levels, notably in areas S1 and S6 (*Appendices – Table B1 and B2*). In area S1, most material was recovered from the stratigraphic units (SU) 2 (47%) and 1 (15%). Despite this, the quantity of remains from SU 12 (20%), a sandy sediment adjacent to the shell layer, and SU 7 (9%), a shell layer, was significant. In area S6, the stratigraphic units with the highest quantities of lithic material were SU 602 (42%) and SU 603 (32%), which were closer to the surface. In areas S1 and S6, shell midden layers as a whole provided a substantial quantity of lithic remains (13% in S1 and 12% in S6), despite the higher number of lithics from the uppermost strata (*Appendices – Table B4*). Area S9 revealed some particularities, since the largest portion of material was recovered in SU 904 (32%), a dark sediment with few shells. Additionally, abundant material was found in SU 921 (11%), while relatively little material was recovered from the shell midden layers (6%). Despite these differences, surface layers SU 903 (20%) and SU 902 (17%) provided significant quantities of material (*Appendices – Table B3*).

⁴ Information from databases provided by the Sado-Meso project.

Table 6: Lithic technological categories from Poças de São Bento (flaked lithic material from areas S1, S6 and S9).

Technological category/Area	S1		S6		S9		Total N	Total %
	N	%	N	%	N	%		
Core	76	2.39%	16	1.00%	93	2.27%	185	2.08%
Core preparation and maintenance	30	0.94%	12	0.75%	53	1.29%	95	1.07%
Core maint. flake (lateral)	1	0.03%	4	0.25%	11	0.27%	16	0.18%
Core maint. flake (longit.)	11	0.35%	5	0.31%	23	0.56%	39	0.44%
Crested blade	2	0.06%	0	0.00%	0	0.00%	2	0.02%
Crested bladelet	5	0.16%	0	0.00%	7	0.17%	12	0.14%
Partial core tablet	11	0.35%	3	0.19%	12	0.29%	26	0.29%
Debitage product	1191	37.45%	520	32.54%	1908	46.50%	3619	40.75%
Blade	12	0.38%	6	0.38%	15	0.37%	33	0.37%
Bladelet	295	9.28%	160	10.01%	415	10.11%	870	9.80%
Flake	882	27.74%	348	21.78%	1461	35.61%	2691	30.30%
Undefined	2	0.06%	6	0.38%	17	0.41%	25	0.28%
Retouched tool	148	4.65%	32	2.00%	195	4.75%	375	4.22%
Splintered piece	1	0.03%	0	0.00%	2	0.05%	3	0.03%
Debris	1724	54.21%	1013	63.39%	1843	44.92%	4580	51.57%
Chip	157	4.94%	160	10.01%	375	9.14%	692	7.79%
Fragment	1560	49.06%	846	52.94%	1457	35.51%	3863	43.50%
Microburin	7	0.22%	7	0.44%	10	0.24%	24	0.27%
Burin spall	0	0.00%	0	0.00%	1	0.02%	1	0.01%
Fire-cracked rock (core)	10	0.31%	5	0.31%	9	0.22%	24	0.27%
Total	3180	100.00%	1598	100.00%	4103	100.00%	8881	100.00%

In general, the variations on how representative the technological categories were between different stratigraphic units were not substantial. For example, despite being associated with a dog burial, SU 8 of area S1 did not have a specific composition in terms of lithic remains, apart from the presence of some fire-cracked rocks. However, some aspects can be pointed out concerning area S1 (*Appendices – Table B5*):

- 1) A significant presence of cores was found in SU 12 (n=30), which represents 5% of the total lithic industry of this unit (n=622) and 40% of the total number of cores recovered in area S1 (n=76);
- 2) Although SU 2 was the unit that provided the largest quantity of lithic remains in the excavated area, it comprised a relatively low quantity of retouched tools (4%) when compared to some other stratigraphic units;

- 3) SU 25 and SU 3 had a higher proportion of debris (more than 60% of the total) when compared to other units with abundant lithic remains. If the material from SU 3 that was spatially found in the pit with shells and SU 5 are counted as a single set attributable to the same feature ($n=113$), the percentage of debris increases to 64% (*Appendices – Table B6*). This high value contrasts, for example, with the much lower percentage found in shell layer SU 7 (47%). Other structures in the site, such as the stratigraphic units associated with the combustion-related feature found in area S9 (SU 916, 928, 930 and 931) did not reveal a specific lithic composition (*Appendices – Table B7*).



Figure 102: Some lithic materials from Poças de S. Bento, area S1 (excavations of 2010–2013) – core (top); geometric microlith/segments (bottom) (photo by author).

The majority of lithic remains was obtained made from silicious rocks (55%–64%), mainly cherts and silicious slates, although a substantial use of quartz (8%–17%) and coarse-grained rocks (14%–27%), such as porphyry and quartzite, can be observed (*Appendices – Table B8; Figure B4*). According to previous analyses, most materials would have been locally available as small pebbles in Paleogenic conglomerate deposits (Pimentel et al., 2015). Differences in the use of raw material in lithic production were observed in former studies about this site (Araújo, 1995–1997; Araújo et al., 2015). The results of the present analysis confirm this perspective, showing that bladelets were preferentially produced on siliceous rocks (73%). However, contrary to the previous study of the material recovered in the 1980s (Araújo, 1995–1997), the assemblages from the most recent excavations do not reveal a preferential

use of non-siliceous rocks for flake production. Instead, it can be shown that flakes were produced either on siliceous rocks or other raw materials, such as porphyry, quartz and quartzite (*Appendices – Table B9*). In addition, it can be observed that a significant quantity of rocks with low quality for knapping were used by the Mesolithic groups, as exemplified by the presence of some igneous rocks and Paleogenic calcareous rocks⁵ among the flaked lithic material. The identification of Paleogenic calcareous rocks among the flaked lithic material – although in low quantity – indicates that there was an intentional introduction of calcareous pebbles to the site, a situation that seems to contradict the perspective advocated by Carlos Duarte, who argued that the presence of some calcareous pebbles in the microstratigraphic samples of the shell deposits would have resulted from non-intentional introduction to the site through shellfish gathering (Duarte, 2019, pp. 261–262).

Cores represented a very small part of the assemblages (1%–2%) from the three analysed areas. Prismatic cores were clearly dominant (63%–72%), notably unipolar cores. Area S1 contained a higher frequency of unipolar cores, although bipolar or multipolar cores were common in the three areas, indicating that reorientations of the core were frequent (*Appendices – Table B10; Figure B4, B8, B10 and B14*). The majority of cores reveal scars of extraction of flakes (42%–57%) or flakes and bladelets (37%–39%). Cores only containing scars from making bladelets are rare.

Core preparation and maintenance material were rare in all analysed areas (1% or less), being mostly limited to a few core maintenance flakes and partial core tablets.

Debitage products were mainly represented by flakes in the three areas (67%–77%) (*Appendices – Table B11*), being mostly characterised by irregular edges (40%–47%) (*Appendices – Figure B4, B6, B9, B11 and B14*). The average lengths indicate the presence of a large number of small flakes (less than 30 mm), but a high variability of the dimensions can be observed (*Appendices – Table B12*). Concerning the complete/nearly complete flakes, siliceous rocks predominate among the small flakes with lengths less than 30 mm, while other raw materials, such as coarse-grained rocks and quartz, are more numerous among the flakes with higher dimensions (*Appendices – Figure B15*). About 89% of the flakes on siliceous rocks have lengths less than 30 mm, while this value decreases to 73% for the other raw materials (*Appendices – Figure B15 and B16*). From a functional point of view, most small flakes on siliceous rocks would have corresponded to debris, such as suggested in the analysis of the collection from the excavations in the 1980s (Araújo, 1995–1997, p. 115). However, some intentional production of flakes on siliceous rocks would have occurred, considering the large dimensions of some pieces and the predominant use of flakes on siliceous rocks among flake-based retouched tools (50%–78%) (*Appendices – Table B14*). Concerning elongated debitage products, bladelets are prevalent (22%–31%) (*Appendices – Table B11; Figure B6, B7, B12 and B13*). Blades are small, irregular and not very represented in the assemblages (1%), so they were likely only sporadically produced.

Concerning the state of fragmentation of the debitage products, in general, flakes and bladelets were significantly less fragmented in the shell midden units, when compared to other stratigraphic units, in areas S6 and S9. This tendency was not found in area S1, where the fragmentation rates were more similar between the different types of contexts (*Appendices*

⁵ Raw material types identified with the help of Prof. Nuno Pimentel (FCUL), to whom I acknowledge.

– Table B16). Despite these differences, general fragmentation rates were quite similar between different areas (85%–91% for bladelets and 64%–69% for flakes) (*Appendices – Tables B17 and B18*).

With respect to retouched tools (Table 7), the use of bladelets as blanks was slightly more frequent than flakes, although with important variations between the excavated areas. In areas S1 and S9, bladelets represented 55% of the retouched tools. This value increases to 72% in area S6, although the proportion of retouched tools among the general lithic assemblage in this area was significantly lower (*Appendices – Table B14*). Overall, there was a relatively equal use of bladelets and flakes as tool blanks. In addition, the use of flakes for tool production occurred either on siliceous rocks or on other materials. Contrary to this, tools made from pebbles were almost absent.

Table 7: Retouched tools from Poças de São Bento (areas S1, S6 and S9).

Retouched tool/Area	S1		S6		S9		Total N	Total %
	N	%	N	%	N	%		
Geometric microlith	52	35.14%	10	31.25%	54	27.69%	116	30.93%
Trapeze	12	8.11%	3	9.38%	21	10.77%	36	9.60%
Triangle	13	8.78%	2	6.25%	11	5.64%	26	6.93%
Segment	17	11.49%	3	9.38%	15	7.69%	35	9.33%
Atypical form	0	0.00%	0	0.00%	2	1.03%	2	0.53%
Undetermined	10	6.76%	2	6.25%	5	2.56%	17	4.53%
Truncated piece	1	0.68%	2	6.25%	9	4.62%	12	3.20%
Truncated piece+Marginal retouch	0	0.00%	0	0.00%	1	0.51%	1	0.27%
Marginal retouch	46	31.08%	12	37.50%	81	41.54%	139	37.07%
Notch	16	10.81%	3	9.38%	17	8.72%	36	9.60%
Notch+Marginal retouch	0	0.00%	0	0.00%	1	0.51%	1	0.27%
Denticulate	6	4.05%	0	0.00%	5	2.56%	11	2.93%
Drill	3	2.03%	0	0.00%	0	0.00%	3	0.80%
Endscraper	3	2.03%	0	0.00%	2	1.03%	5	1.33%
Endscraper-Core	0	0.00%	0	0.00%	1	0.51%	1	0.27%
Sidescraper	1	0.68%	0	0.00%	1	0.51%	2	0.53%
Various	20	13.51%	5	15.63%	23	11.79%	48	12.80%
Total	148	100.00%	32	100.00%	195	100.00%	375	100.00%

Concerning the main typologies, tools with marginal retouch on flakes or bladelets (31%–42%) and geometric microliths (28%–35%) were the most frequent categories (*Appendices – Figure B5, B7, B9, B11, B12 and B13*). Notches (9%–11%) and truncated pieces (1%–6%) had some presence, whereas endscrapers and sidescrapers were very rare. Retouched tools were mainly produced on siliceous rocks, although there were some differences in the proportions between the excavated areas (78% in area S1 and 90% in S9).

Concerning the typology of the geometric microliths, the three main forms were well-represented, although with a higher frequency of trapezes (23%–39%) and segments (28%–33%) in relation to triangles (20%–25%). Segments were more frequent in area S1 (33%),

while in area S9, trapezes were more important (39%), followed by segments (28%). In general, symmetrical forms were the most frequent, notably among segments, although some variations can be mentioned. For example, in area S9, symmetrical and asymmetrical forms were both frequent among trapezes and triangles (*Appendices – Table B15*).

Some microburins were recovered in the three areas, but in a much lower number compared to microliths (Table 6).

Lithic distribution in area S1

The analysis of the lithic distribution in area S1 shows that the density of lithic remains increased from west to east, in part following the incline of the terrain (Figure 103). The main concentrations of lithic remains were mostly related to SU 2, identified in the uppermost part of the stratigraphy, but also SU 7, SU 12 and SU 25, which were below (Figure 104). Concentrations of lithic remains made from siliceous rocks in SU 12 and SU 7 were noticed in the field (Diniz et al., 2012) and can be confirmed through the present analysis. Despite the general density of material from west to east, this tendency seems to have been particularly significant concerning the cores, a situation that can be related, at least in part, to the high prevalence of this category in SU 12. Cores on non-siliceous materials (such as quartz or porphyry) were more concentrated in the central part of the excavated area, notably in SU 7 and SU 2 (square lines 100 and 101). Contrary to this, cores on siliceous rocks seem to have been more concentrated on the eastern side (square lines 102 and 103), particularly in SU 12 (*Appendices – Figure B17*). Other categories of lithic material do not reveal a specific distribution pattern. The analysis of the vertical distribution of cores, flakes and bladelets by size also does not show a specific pattern (*Appendices – Figure B19*).

Concerning the lithic distribution according to the state of fragmentation of the materials, in general, specific patterns are not observed. However, with respect to the zone of the pit filled with shells identified in square 99/100 (SU 3 and SU 5, n=113), the proportion of fragmented debitage products was slightly higher compared to the stratigraphic contexts in general (only 25% of the flakes and 7% of bladelets are intact in the pit, while the general values in area S1 are 36% for flakes and 15% for bladelets) (*Appendices – Figure B2; Table B17*). Considering this situation, and also the high proportion of debris observed in this zone, it seems likely that the lithic remains in the pit area had some particular characteristics that can be associated with a discard activity related to the negative feature. Other stratigraphic units do not provide similar values, such as the case of SU 7, which was also characterised by a high density of shells.

With respect to geometric microliths, different types were distributed in a relatively homogenous way, although an absence of segments in the lowest levels is noticeable (*Appendices – Figure B19*). A concentration of segments in square line 103, in the eastern zone (SU 2, SU 12 and SU 25) can also be found.

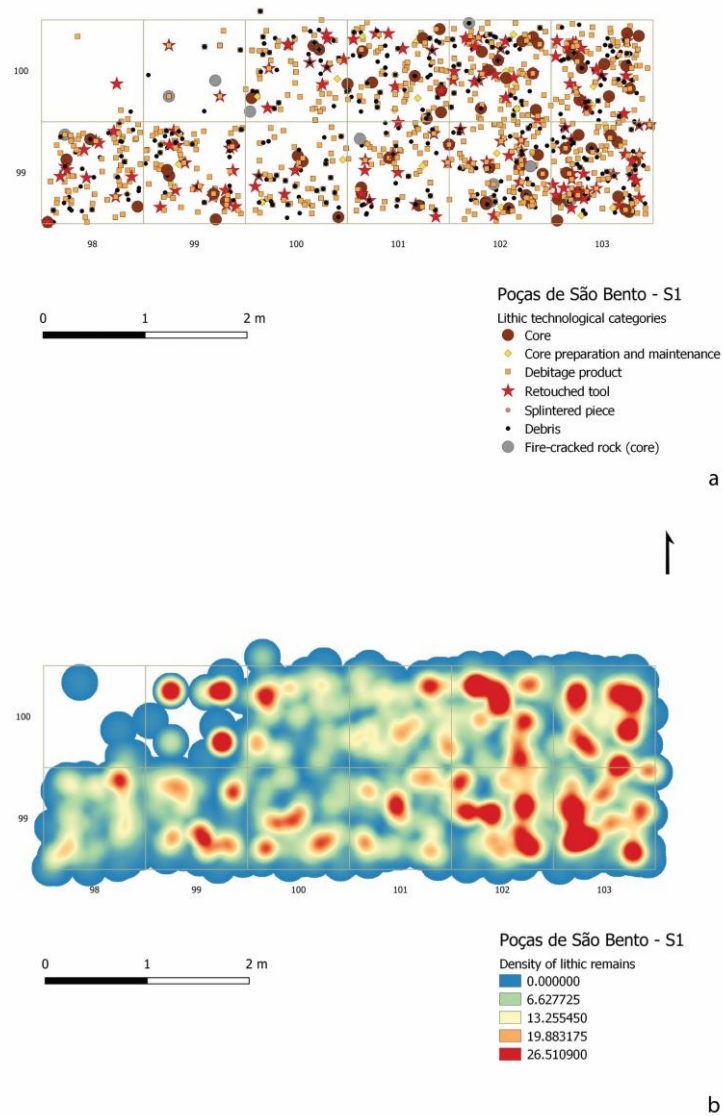


Figure 103: Poças de São Bento, area S1 – horizontal distribution of the lithic material and Kernel Density Estimation showing the material densities (image by author).

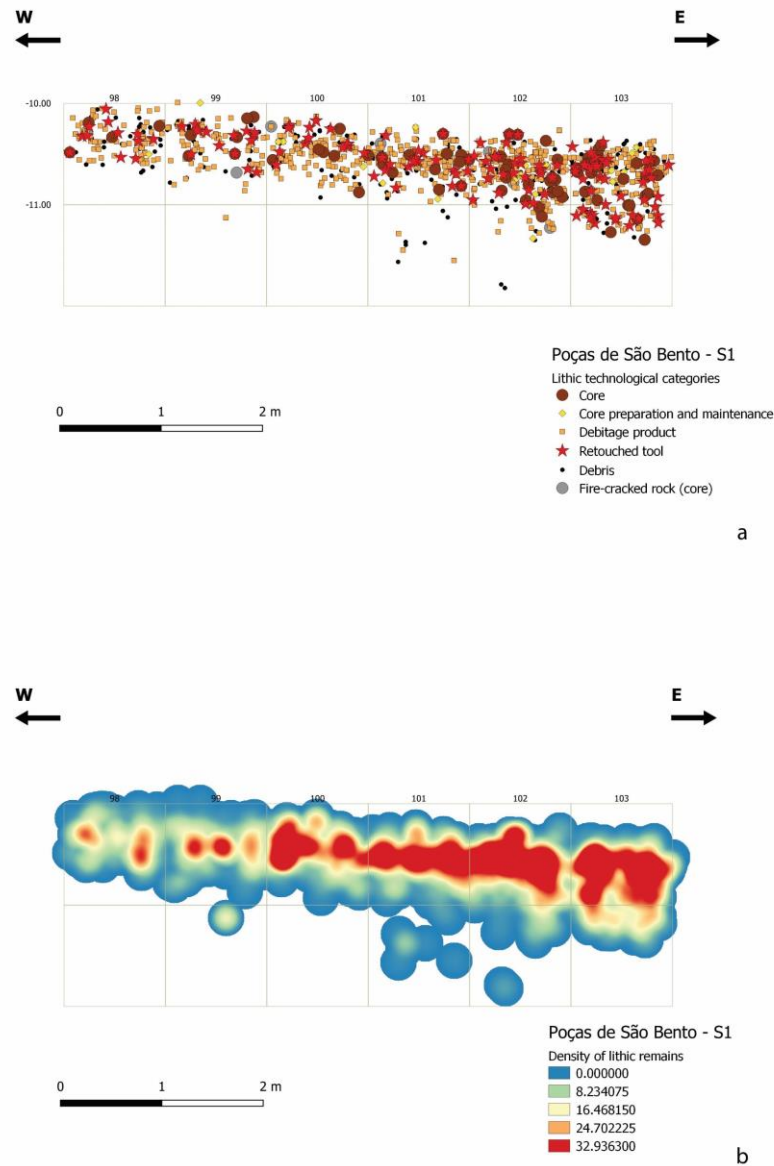


Figure 104: Poças de São Bento, area S1 – vertical distribution of the lithic material and Kernel Density Estimation showing the material densities (image by author).

Lithic distribution in area S6

Despite the high lithic density found in area S6, the analysis of the spatial distribution of the lithic remains is limited, due to the small dimensions of the excavated area. The lithic remains had a higher density in the western part of the area and the uppermost layers (Figure 105, Figure 106). A small lithic concentration on the eastern extreme of the area is also noticeable. These concentrations were mostly related to SU 602, 603 and 605.

In general, the lithic technological categories were represented over the entire area without substantial differences. However, and despite a general tendency of a higher lithic density to be observed in the western zone, cores and some material of core preparation and

maintenance were particularly concentrated in the west (mostly in SU 601, 602 and 603), whereas their presence on the eastern zone was low. Concerning the human burial that was found in this area, the infill of the grave pit (SU 613) does not reveal a particular composition in terms of lithic material. Significant differences in the distribution of lithic material by size, raw material or state of fragmentation are also not observed in the excavated area (*Appendices – Figure B20*).

Concerning the few geometric microliths, in general, triangles and trapezes were found in a higher position in the stratigraphy, while segments were located in a lower position (*Appendices – Figure B21*). Almost all geometric microliths were found in SU 602, 603 and 604, being nearly absent in the lowest layers. However, the small dimensions of the assemblage (n=10) pose strong limitations to chronological or cultural interpretations.

Lithic distribution in area S9

Concerning the general horizontal distribution of the lithic remains in area S9, a higher density in the eastern half is visible, which can be related to the higher stratigraphic depth and thickness of the shell midden in this part of the excavated area (Figure 107). With respect to the vertical distribution of the materials, the highest densities can be observed in the middle levels (mostly associated with SU 904), at the western zone (due to the lower stratigraphic depth) and central zone of the area (Figure 108). As mentioned before, in the case of area S9, the largest quantities of lithic remains were recovered from SU 904, and not from the surface layers as found in areas S1 and S6, a situation that generates a quite different picture. In addition, shell midden layers only provided about 6% of the lithic remains recovered in the area, which is a relatively lower value when compared to other analysed areas (*Appendices – Table B4*).

In general, specific distribution patterns are not observable concerning the technological categories and dimensions of the materials. For example, the largest unretouched flakes of the assemblage were found through the entire sequence (*Appendices – Figure B22*). However, with respect to lithic raw material, hyaline quartz had a limited distribution – it was concentrated in the eastern half of the excavated area and mostly associated with SU 904, the stratigraphic unit with the highest number of lithic remains (*Appendices – Figure B23*). The hyaline quartz assemblage was mostly composed of debris (76%), although debitage products and a core were also found. With respect to the materials found in the combustion-related feature (SU 916/928/930/931), a specific composition is not observable, but debitage products reveal a higher fragmentation rate when compared to the values for the whole stratigraphic sequence (*Appendices – Table B18*).

Concerning the geometric microliths, which were mostly recovered from SU 903, 904 and 902, specific spatial patterns are not observed, despite the relatively large area that was excavated. The main types were found over the entire area and stratigraphic sequence (*Appendices – Figure B24*).

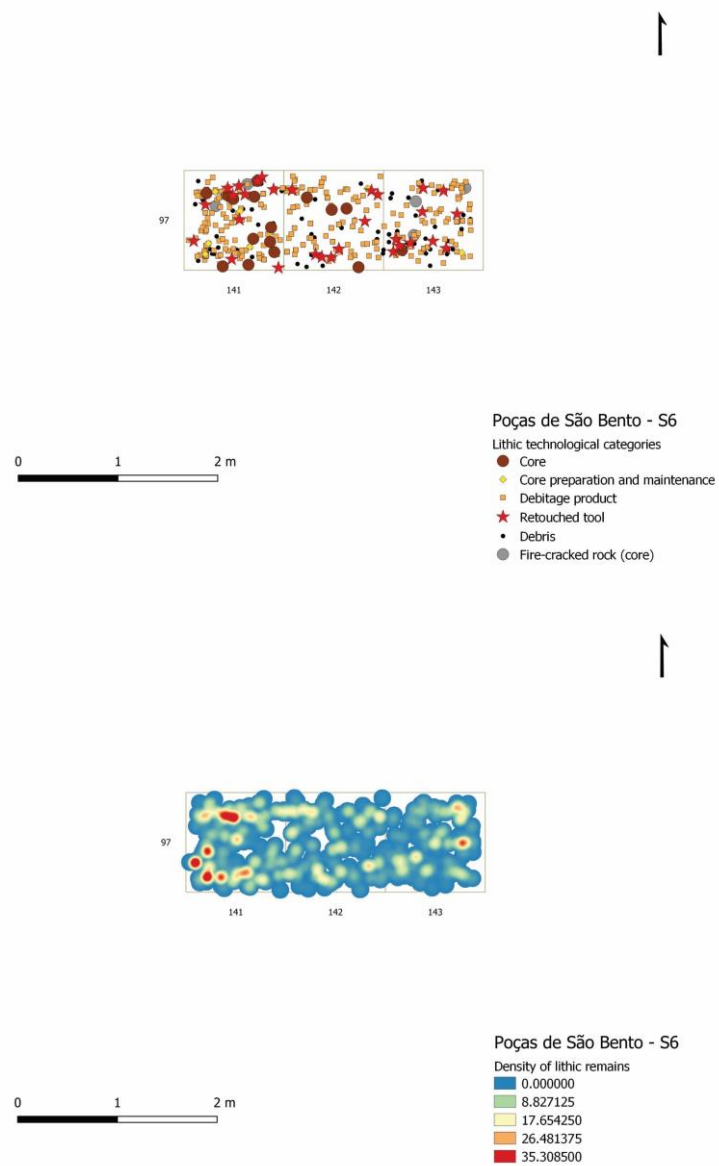


Figure 105: Poças de São Bento, area S6 – horizontal distribution of the lithic material and Kernel Density Estimation showing the material densities (image by author).

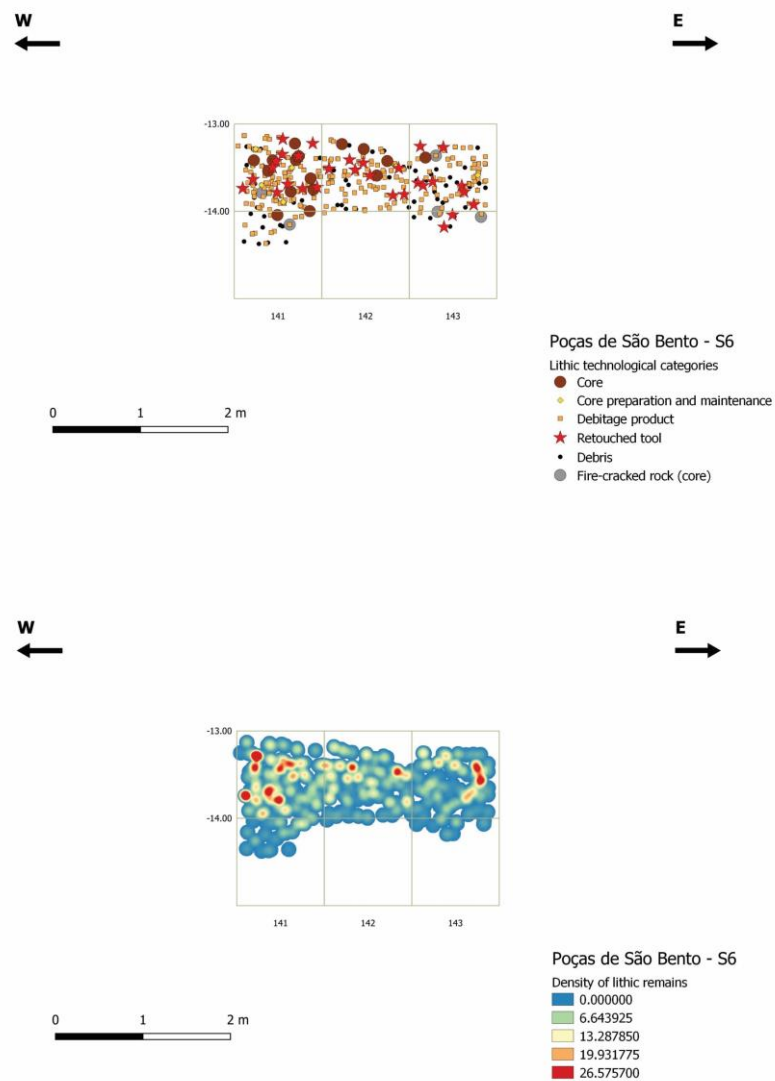


Figure 106: Poças de São Bento, area S6 – vertical distribution of the lithic material and Kernel Density Estimation showing the material densities (image by author).

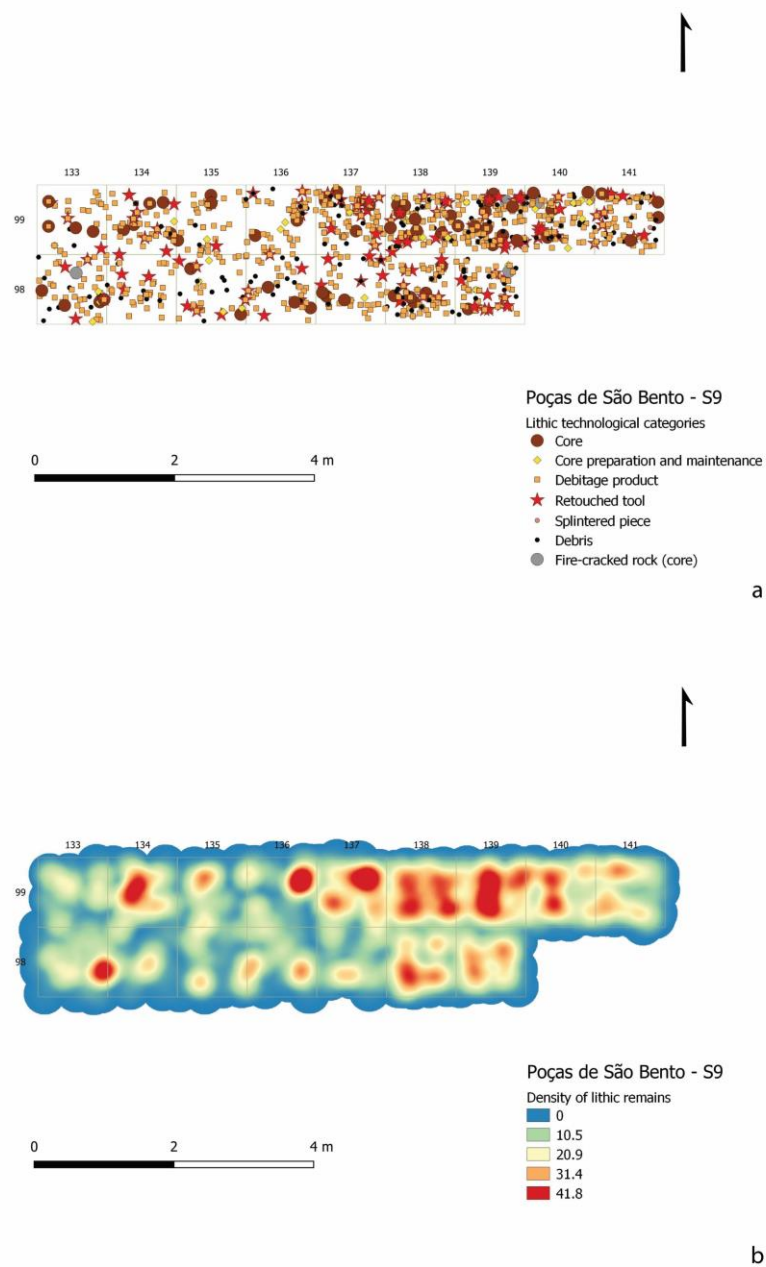


Figure 107: Poças de São Bento, area S9 – horizontal distribution of the lithic material and Kernel Density Estimation showing the material densities (image by author).

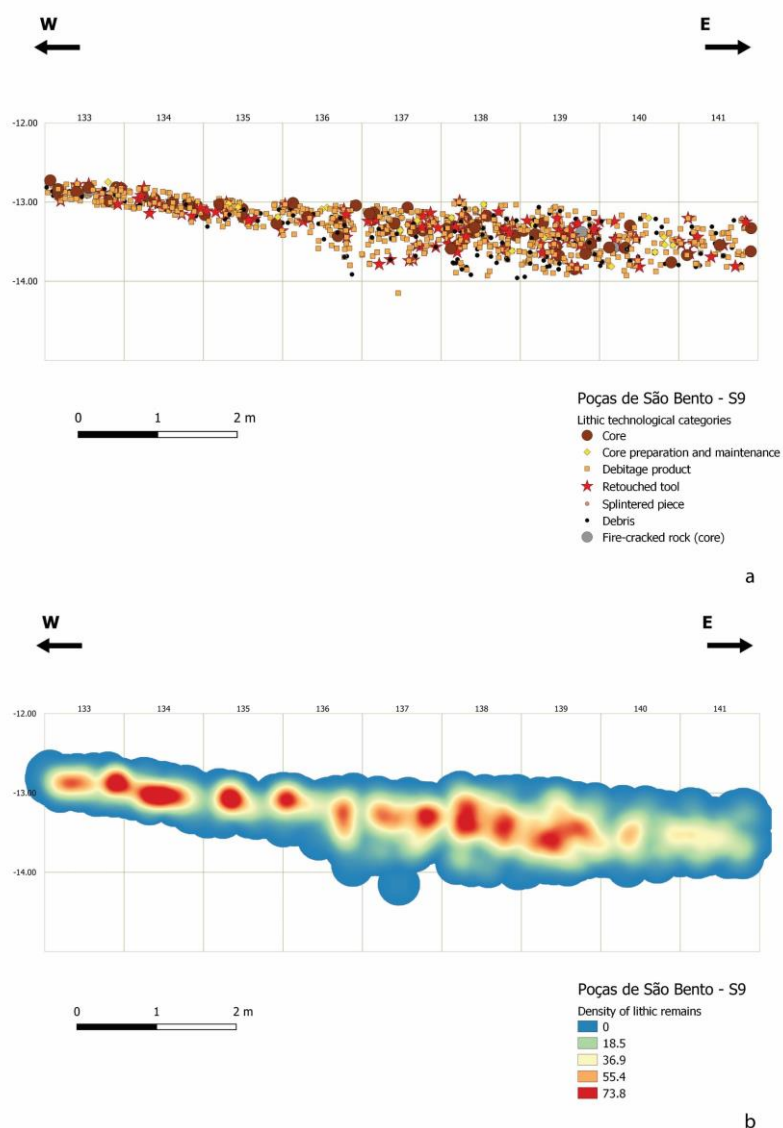


Figure 108: Poças de São Bento, area S9 – vertical distribution of the lithic material and Kernel Density Estimation showing the material densities (image by author).

Intra-site variation of lithic remains

In areas S1 and S6, there was a clear tendency for the majority of lithic remains to concentrate in the uppermost layers (without shells). A similar tendency was also previously observed in area ARN-LS, excavated in the 1980s (Araújo, 1995–1997). However, an absence of the largest lithic remains (such as cores and large flakes) from the uppermost layers is not observable in areas S1, S6 and S9, contrary to what was reported for the area ARN-LS (Araújo, 1995–1997, p. 123). Therefore, the available data do not suggest a vertical migration of lithic material centred on small-sized remains in the most recently excavated areas, although post-depositional movements of lithic remains in general would have occurred with

some intensity, considering the sandy contexts⁶, the nature of the shell midden and the impact of agriculture works on the site. In general, however, shell midden layers contained a significant quantity of lithic material in the analysed areas so far (12–13% in S1 and S6 and 9% in ARN-LS), although the value is somewhat lower in area S9 (6%). Some lithic concentrations of specific raw materials and technological categories are also identifiable in area S1 and S9, under the uppermost stratigraphic units, suggesting some consistency in the deposits and the practice of local knapping locally or nearby.

All technological categories of the lithic *chaîne opératoire* were represented in the analysed areas of excavation, indicating the practice of local knapping at the site in general. The proportions of the lithic categories are quite similar when the analysed areas are compared, notably the values from tools and cores. In this sense, the present analysis partially contradicts the hypothesis suggested in the preliminary study of SU 7 and SU 12 of area S1 that indicated a lower presence of cores, bladelets and microliths in that specific area of the site (Araújo et al., 2015). In fact, the proportion of cores in the lithic assemblage of area S1 (2%) is equivalent to area S9, and also the area excavated by Arnaud/Larsson (Araújo, 1995–1997, p. 110). However, some differences in terms of lithic composition between the excavated areas can be highlighted. In area S9, for example, a slightly higher frequency of debitage products (47%) in relation to debris (45%) can be observed, while in areas S1 and S6, debris is clearly predominant in the assemblages (54% and 63%, respectively).

Flakes were predominant among the debitage products in the most recently excavated areas (67%–77%). The higher proportion of bladelets among the debitage products in area ARN-LS (57%) compared with the recently excavated areas (22%–31%) can be, at least in part, related to the differences in the classification criteria applied to flakes and chips – flakes less than 2 cm in length/width were classified as chips in the former study, while this study used the limit of 1 cm. However, it should be noted that, even if the material less than 2 cm in length is excluded from the analysis, flakes still represent about 70% of the debitage products in areas S1, S6 and S9. In addition, although the existence of an important non-intentional production of small flakes on siliceous rocks, as found in area ARN-LS, can be suggested for areas S1, S6 and S9, it seems clear that some intentional production also occurred, as indicated by the relatively large dimensions of some flakes and the substantial quantity of retouched tools obtained on flakes of different dimensions. Tools on bladelet were more frequent in general, but the use of flakes for tool production was also relevant, especially in areas S1 and S9. A preferential use of siliceous rocks for bladelet production is observable, but contrary to the situation reported for area ARN-LS, a preferential use of non-siliceous rocks for flakes in areas S1, S6 and S9 is not found. Instead, it seems evident that flakes were obtained either on siliceous rocks or other raw materials.

Concerning the retouched tools, the presence of geometric microliths in the most recently excavated areas had a much lower prevalence (28%–35%) when compared to area ARN-LS (68%). Also with respect to the typology of the geometric microliths, the absence of a single dominant type in areas S1, S6 and S9 should be noted, which contrasts with the clear

⁶ The concentration of lithic remains in the uppermost layers is a phenomenon also observed in other archaeological sites in sandy contexts with microlithic lithic industries, such as the Neolithic site of Valada do Mato (Évora, Southern Portugal) (Diniz, 2007).

dominance of trapezes in area ARN-LS (53% of the total of geometric microliths, $n=293$) (Araújo, 1995–1997, p. 131). Despite this, it can be noted that areas S6 and S9, located on the eastern part of the site, presented a higher proportion of trapezes in the assemblages (30%–39%) when compared to area S1, on the western part of the site, where the proportion of trapezes was much lower (23%) and other geometric types were more frequent.

Compared to areas S6 and S9, area S1 revealed higher fragmentation rates of bladelets and flakes among the lithic material associated with shell midden stratigraphic units, including the infill of the pit that was found. This difference can be possibly related to the impact of intense trampling and secondary deposition indicated by the microstratigraphic analysis of the shell layer of this area (Duarte, 2019, p. 267). In contrast, the lower fragmentation rates of lithic material found in the shell midden units of S6 and S9 can be related to the low degree of trampling and rapid burial identified through the microstratigraphic analyses of the shell midden in area S9, and also to the proximity to the main funerary area.

Despite the overall image of homogeneity of the lithic distribution throughout the site, generally, the presence of flakes among the debitage products and retouched tools seems to have been more prominent in areas S1 and S9, while bladelet debitage and associated tool production was more prominent in areas ARN-LS and S6, which were closer to the central part of the shell midden and the main funerary area. Compared to area S9, however, area S1 presented a higher proportion of debris, and also higher lithic fragmentation rates in the shell midden units. On the opposite side, area ARN-LS was characterised by a higher proportion of geometric microliths among the retouched tools. The presence of trapezes among the microliths was also more prominent on the eastern side of the site, especially in areas ARN-LS and S9. These general differences in the lithic remains at the intra-site level are difficult to interpret (Figure 109). The abundance of lithic debris and higher lithic fragmentation in the shell layers in area S1 can possibly reflect a differentiation in the activities carried out in the space, notably more intense trampling, occupation and secondary deposition of shell deposits in area S1 compared to the eastern zone, as evidenced by the results of the microstratigraphic analysis (Duarte et al., 2017b; Duarte, 2019). The lower proportion of trapezes in area S1 in comparison with the areas excavated on the eastern side is more difficult to explain, but it can be linked to possible chronological and/or functional differences between the areas. The human burial activity was concentrated in the eastern part of the site (closer to areas S6 and ARN-LS) and seems to have started during an early phase of the Late Mesolithic occupation (end of the 9th millennium cal BP–beginning of the 8th millennium cal BP), as suggested by the stratigraphic information and the radiocarbon date obtained on a bone sample from the human skeleton found in S6 (OxA-29113: 7238 ± 35 BP) (Duarte et al., 2017b; López-Dóriga et al., 2019). The western side did not provide any human remains during the excavations and the earliest radiocarbon dates are from the first half of the 8th millennium cal BP (López-Dóriga et al., 2019), which might indicate some chronological differences between the western and eastern areas of the site regarding their first use.

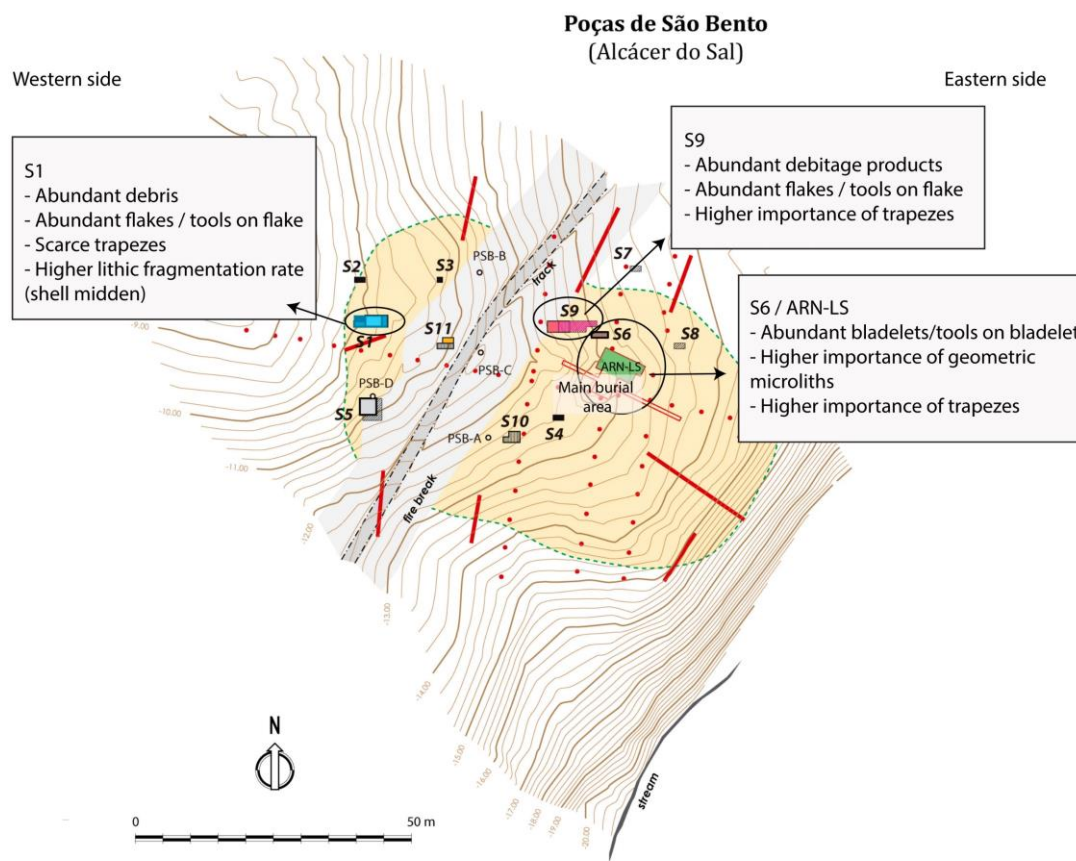


Figure 109: Poças de São Bento – summary of the main intra-site differences in the lithic distribution (modified from original plan by Sado-Meso Project).

5.2.1.2.3. Discussion and conclusions

Despite the limitations of the available data from Poças de São Bento, notably the absence of a continuous, large-scale excavation undertaken recently, the lack of a finer chronology of occupation or the impacts of the post-depositional movements at the site, the present technological, typological and spatial analysis of lithic remains allows us to distinguish some intra-site differences in the lithic distribution. These differences contradict the general idea of homogeneity of the site and shell midden accumulation that can be suggested by the ‘visible’ characteristics of the stratigraphy or the microlithic character of the lithic industry in general. Instead, the obtained results support the idea of some spatial differentiation of the activities which took place at the site, which has also been suggested by other archaeological evidence (i.e., features) and the results of the microstratigraphic analyses. Further advances on the microstratigraphic analyses, but also in other domains, such as the study of the abundant malacological remains that were recovered, would be important to provide additional comparisons between different types of data and to better understand the functioning of the site.

5.2.2. Document analysis of other sites

5.2.2.1. Cabeço do Pez

According to a report (APMH/2/1/32/4) and a letter from Roldão available in the Personal Archive of Manuel Heleno (PT/MNA/APMH/5/1/654/12/3/7, Quinta de Baixo, 14/04/1955), the first field work undertaken by Heleno's workers at Cabeço do Pez (also mentioned in the old documentation as Quinta de D. Rodrigo and Quinta de Baixo) started in 1955, although it is not clear if there were formal excavations at that time. It was noted in this early research that, despite the large dimensions of the site, it had a short stratigraphy. In addition, a feature with ash ('cinzeiro') was easily identified. The undertaking of excavations in 1956 at the site is recorded in a list of geometric microliths recovered from each excavated area (called A, B and C) and also available in the archive of the National Museum of Archaeology (APMH/2/3/7/1), but detailed information from these works is also unavailable. A site plan by Paiva conserved at the museum (tube 4) can be attributed to 1956 and contains a relatively simplistic representation of the elements discovered in the excavated areas (A, B and C), notably two main concentrations of human burials, several stone concentrations with a circular form and shell deposits (*Appendices – Figure B25*). The stratigraphic sections that are represented indicate that some of the skeletons were found on the basal sands, which were covered by a dark brown sediment layer of about 0,65–0,70 m with shells, hearths and ash, that was under the topsoil. The plan and an additional detailed drawing in the museum (MNA, Archive A, A.11) also contains the representation of a stone-structured negative feature with bone remains inside. The feature was described as a 'well or funerary urn' and apparently cut into the second layer and the basal sands. The nature and chronology of this feature is unknown, possibly corresponding to a relatively recent construction after the formation of the shell midden.

About 310 photos from the Personal Archive of Manuel Heleno can be attributed to the site of Cabeço do Pez and the excavations at the site undertaken between 1957 and 1959.⁷ However, despite the relatively high quantity of available photos (when compared to other shell middens of the Sado valley), a significant number are repetitions and detailed information is unavailable. Some of these photos do not include a specific mention of Cabeço do Pez, but they can be related to the site through the references to the names of the areas of excavation and years. In addition, concerning the excavations of 1958 and 1959, some reports and letters from Roldão are known and available in the archive, as well as two published site plans (Santos et al., 1974, fig. 3) (*Appendices – Figure B26*).

The exact dimensions of the excavated area during these works are unknown, but it is thought that most of the central part of the shell midden was reached, and the site was one of the most extensively excavated sites of the Sado complex. According to Arnaud, 19 trenches ('sonda') and seven main areas ('talhão') would have been excavated (Arnaud, 1984). In the campaign of 1958, three areas of 7 m² (D, E and F) were divided into squares ('secção') of 3 m, separated by corridors of 0.5 m, which reflects the application of Wheeler's excavation method (Santos et al., 1974; Arnaud, 2000). The use of this methodology is documented in the site plans and captions of the photos, which contain references to squares, layers and sub-layers. The profile sections in the 1958 plan show that the shell midden layer

⁷ At the National Museum of Archaeology, it was observed that some photos archived in the box 'APMH Ft Cx.1 – Arapouco' and attributed to the site of Arapouco were actually taken at the site of Cabeço do Pez. For example, photo APMH/2/11/8-46/154, which was in the box labelled Arapouco, has a specific mention of 'D. Rodrigo' (the other name of the site of Cabeço do Pez) and a date of 1958.

was composed of a grey sediment and shells and was about 0.60 m thick along the excavated areas. The shell layer was over the basal sands and, in some cases, under a dark layer below the topsoil. The drawings and descriptions also indicate that the shell midden layer at Cabeço do Pez had a relatively low density of shells.

In addition to the references to human skeletons, a significant number of descriptions from Cabeço do Pez is related to other aspects of the excavations. For example, the photos and reports of J. Roldão have numerous references to hearths ('lares') characterised as circular stone concentrations that frequently contain calcareous hard sediment, charcoal, shell concentrations, terrestrial faunal remains, fire-cracked rocks and lithic tools (APMH/2/3/7/2 and APMH/2/3/7/3). According to the descriptions (such as those in the photo APMH/2/11/8-6/154), these features were mostly associated with layer 2 (a shell midden layer) (*Appendices – Figure B27*). This situation can be also confirmed through the section profiles in the site plan by Paiva, where the features are mostly represented in the shell midden layer. The plan also shows that these circular features were distributed over the excavated area (areas A, B and C). The captions of the photos also attest to their presence in areas E and F (APMH/2/11/8-46/154), indicating a wide distribution over the site (Figure 110). In some cases, these features were near the skeletons (e.g., APMH/2/11/17-17/187). The frequency of associated concentrations of shells is highlighted in the photos and the plan by Paiva, and, in some cases, the presence of whole shells was observed (e.g., APMH/2/11/17-119/187). The discovery of deer remains was also recorded in the photos (e.g., APMH/2/11/17-126/187) and reports (APMH/2/3/7/3-20/32) (*Appendices – Figure B28*). In some photos, however, only concentrations of non-structured small stones can be observed, which suggests that situations with distinct characteristics (and reliability) were categorised as hearths ('lares'). There are also photos of a circular feature classified as an 'oven' that are attributable to Cabeço do Pez (Figure 111). The feature was apparently formed by a hard sediment and some fire-cracked rocks, revealing similar characteristics to some of the features classified as 'hearth' (APMH/2/11/17-54/187, 55/187). Overall, the available records suggest that some of these features effectively corresponded to stone-structured hearths, while others seem more dubious.



Figure 110: Cabeço do Pez – feature found in the second layer of area F ('Talhão F'). It is described as a part of a hearth from which the central stones were removed (Personal Archive of Manuel Heleno/National Museum of Archaeology - APMH/2/11/8-1/154).



Figure 111: Cabeço do Pez (probably) – feature classified as an ‘oven’ by the excavators (Personal Archive of Manuel Heleno/National Museum of Archaeology - APMH/2/11/17-55/187).

In addition to the high quantity of lithic material (APMH/2/3/7/1) and terrestrial faunal remains that were found (Arnaud, 1989), the reports from Roldão also contain a number of mentions to the presence of pottery fragments in the upper level (APMH/2/3/7/3). Some of these materials are characterised in a later publication by other researchers about the site (Santos et al., 1974), through which it is possible to understand that pottery remains were found in several layers of the site, and not only in the top layer. A similar situation also occurred at the nearby Amoreiras shell midden, and was related to post-depositional movements of the material through the stratigraphy (Diniz, 2010).

The 1983 excavations, under the direction of Arnaud (Arnaud, 1984; 2000), were undertaken on a small area of 2 m², probably close to Area E excavated by Heleno’s team. According to the available information, a complex stratigraphy was observed, in which the shell layers had substantial variations in terms of shell density. Remains of combustion activities were also found in these excavations. A hearth was identified through the presence of a dense concentration of shells, some of which were still closed, and charcoal layers. Another combustion feature was found over the basal sands, and characterised by a stone concentration and charcoal, but few shells. Overall, the discovery of these features in such a small area of excavation confirms the particular importance of combustion features at this site. Some Neolithic pottery remains were found, as occurred in the previous excavations, as well as a grinding stone and mortar on the top of the shell layer, suggesting that there had been Neolithic occupations at the site.

The small test pits carried out by the Sado-Meso project in 2010 did not result in the identification of new features, although confirmed the strong effect of erosional processes (Arias et al., 2015a).

5.2.2.2. Vale de Romeiras

The available documentation (site plans, photos, reports and letters) indicates that the excavations carried out at Vale de Romeiras by the staff from the National Museum of Archaeology occurred in 1959 and 1960. The site plan from 1959 available in the museum (MNA, Archive A, A120) (*Appendices – Figure B29*) includes several stratigraphic sections through which it is possible to understand that in general, topsoil covered the shell midden

deposits (grey sediment with shells) or, instead, a layer with dark sediment, which was over the yellowish clay-like soil or the brown basal sands, deposited over the bedrock (*Appendices – Figure B30*). Despite the small dimensions of the site, some variations in the stratigraphy can be observed in the sections, being also clear that the shell deposit was quite limited in area and thickness (less than 40 cm).

The letters from Roldão (Personal Archive of Manuel Heleno) highlight the discovery of a large quantity of human burials concentrated in a small area, in the beginning of the field work (PT/MNA/APMH/5/1/654/32, Torrão, 26/08/1959). Most skeletons were found in the bedrock or basal sands, in some cases with some lithic material nearby, although the details of the association between material and burials are unknown. The location of 23 skeletons was also recorded in the site plan and stratigraphic sections from 1959 (MNA, Archive A, A120), as well as some badly preserved photos (for example, APMH/2/11/83-1/58, 13/58, 14/58). It is possible to understand through these graphic records that few skeletons were identified in the shell layer. The existence of pit graves was not described, although this can be assumed through the anthropological evidence (Peyroteo Stjerna, 2016). The site plan also shows that the area of distribution of shells almost corresponded with the location of the burials. Despite being discussed in more recent times (Arnaud, 1989; 2000; Cunha and Umbelino, 2001), the placement of the burials in a semicircle was not mentioned in the old written documentation of the excavations.

In addition to the human skeletons, the presence of lithic and terrestrial fauna remains was highlighted, notably the discovery of a deer antler in the dark layer with few shells, which was not associated with any skeleton, as described in the letters (PT/MNA/APMH/5/1/654/37, Torrão, 10/09/1959) and recorded in some photos (APMH/2/11/83-38/58, 40/58) (*Figure 112*). An individual drawing of a concentration of faunal remains (called 'd') is known (MNA, Archive B, B37) (*Appendices – Figure B31*) and several other concentrations are represented in the site plan, in some cases close to the skeletons. However, the nature of these deposits is unknown, notably if the animals were deposited in an articulated state. The presence of some pottery remains on the surface and in the dark layer was also noted, as well as the identification of a perforated stone adornment (PT/MNA/APMH/5/1/654/37, Torrão, 10/09/1959; PT/MNA/APMH/5/1/654/53, Torrão, 02/09/1960).

Contrary to other sites, such as the nearby shell midden of Cabeço do Pez, there are no descriptions of structured features other than human burials, such as hearths. Only a stone concentration with a circular form and another smaller one with an irregular form (called 'b') are represented in the site plan of 1959, in the shell layer. However, the nature of these features is unclear.



Figure 112: Vale de Romeiras – photo dated to 1959 of a deer antler found in a layer with dark sediment (Personal Archive of Manuel Heleno/National Museum of Archaeology - APMH/2/11/83-40/58).

5.2.2.3. Arapouco

This site was excavated by Heleno's team in 1961, and possibly in 1962, but little information is known from these excavations. Only one site plan is known, dated to 1961 (MNA, Archive A, A120(a)), which indicates that five long trenches in the borders of the shell midden and a main area in the north-east zone were excavated (*Appendices – Figure B32*). The majority of the photos (from an assemblage of more than 116 photos archived in the MNA) is dated to 1961 and provide evidence of several parts of the excavations. However, it was observed that some photos catalogued in the archive as belonging to Arapouco (APMH/2/11/8) were, in fact, taken at Cabeço do Pez, in 1958, as indicated by the references to 'D. Rodrigo', 'Talhão E' or 'Talhão F' (such as APMH/2/11/8-46/154 or 1/154).

Several human burials were found at Arapouco, comprising at least 32 individuals (Cunha and Umbelino, 2001), some of which were recorded in the photos. In addition to the skeletons, there are references to hearths ('lares'), as found in Cabeço do Pez (such as APMH/2/11/8-38/154, 55/154 or 70/154). These features were characterised by a circular form and the presence of concentrations of shells and charcoal. In the case of the photo with the reference APMH/2/11/8-69/154 (Figure 113), a high concentration of shells found in the second layer strongly contrasts with the surrounding sediment, but a stone structure was visibly absent. There are also records of features described as circular concentrations of stones associated with shells and/or ash, in some cases containing references to hearths ('cinzeiro') (such as APMH/2/11/8-40/154). A letter from Roldão with the reference 'Vale de Guizo?' and dated to 1961 probably describes the excavations at Arapouco, notably the discovery of some skeletons and a feature characterised by a circular concentration of unburnt stones (PT/MNA/APMH/5/1/654/71, Vale de Guizo?, 21/11/1961). While, in some cases, these features seem to have corresponded to simple concentrations of shells, in others, there is clearer evidence that can be related to combustion activities (such as the situation observable on APMH/2/11/8-42/154) (Figure 114). It is interesting to note that one of the most recent test pits carried out in 2016 by the Sado-Meso project (area S1) also revealed the presence of a strong concentration of shells of *Scrobicularia plana*, many with the complete shells, filling a small depression in the basal sands (Diniz et al., 2017).



Figure 113: Arapouco – photo dated to 1961 of a dense concentration of shells found in the layer 2, section 4, called 'lar' (hearth) (Personal Archive of Manuel Heleno/National Museum of Archaeology - APMH/2/11/8-69/154).



Figure 114: Arapouco – photo dated to 1961 of a stone concentration after the removal of ash and shells, according to the notes on the backside. It possibly corresponds to a hearth (Personal Archive of Manuel Heleno/National Museum of Archaeology - APMH/2/11/8-42/154).

5.2.2.4. Discussion and conclusions

The written and graphic documents from the past excavations in the shell middens of Cabeço do Pez, Vale de Romeiras and Arapouco are generally limited in information on site structure and function.

The analysis of the documentation from Cabeço do Pez allows us to understand that, despite the relatively large dimensions of the site when compared to other shell middens of the Sado valley, the shell density of the midden was relatively low. Despite that, the presence of some spatially limited dense concentrations of shells was reported. The combustion activity seems to have had a high prominence at the site, considering the abundant record of features. Some of these features were structured with stones, while others were not, indicating some diversity in the types. These features seem to have been also frequently associated with contexts characterised by high densities of shells, which might indicate some relation between combustion and shell disposal activity. Apparently, some combustion features were also close to the burials. The presence of combustion features (some structured

by stones and others not) and concentrations of shells was also observed and recorded at Arapouco.

Despite the proximity to Cabeço do Pez, Vale de Romeiras is a considerably different site. The high quantity of burials contrasting with the small dimensions of the site and the visible organisation in semicircle can be highlighted. In addition, there is an absence of references to structured features other than burials, such as hearths, in the available documents, although abundant combustion features were recorded at Cabeço do Pez. The presence of some faunal remains was recorded, but the nature of these deposits (structured or not, domestic or ritual) is not possible to clarify through the available information.

5.3. Shell middens of Brittany, north-west France

5.3.1. Beg-er-Vil

5.3.1.1. Document analysis

The site of Beg-er-Vil was discovered and excavated in relatively recent times, a circumstance that enabled the acquisition of much information.

The excavations in 1985–1988

The first formal excavations at the site were conducted between 1985 and 1988, by the team of Olivier Kayser, over a total area of 22 m² (Figure 115), being described in some reports (Kayser, 1985c; 1987b; 1988b). The area corresponded to the thickest zone of the shell deposit (Marchand and Dupont, 2015). The excavations were undertaken using artificial levels of 5 cm, systematic sieving of sediments and three-dimensional recording of most of the lithic and bone remains.

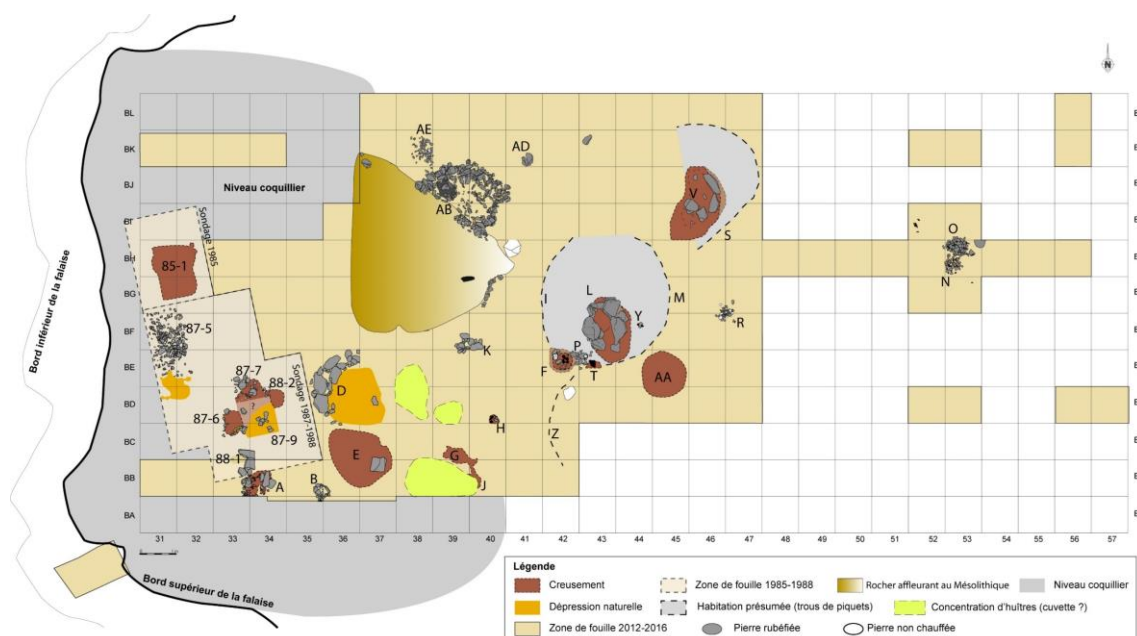


Figure 115: Beg-er-Vil – plan of the excavated area in 1985–1988 and 2012–2018, with the main identified features and indication of the extent of the shell midden zone in grey (adapted from original image by Grégor Marchand).

Despite the difficulties to define the stratigraphic units in detail, three main stratigraphic layers were identified, from top to bottom – layer 1 (top/vegetal layer), layer 2 (dune) and layer 3 (shell midden). It was observed that the shell midden layer was between 0.50 m and 0.60 m thick at the time, comprising a large quantity of shells, faunal remains and lithics, and lying over the rocky substrate and the Pleistocene beach (Kayser, 1987b). Despite the homogeneity of the shell midden layer, significant internal differences in the density of shells (notably oysters), flint remains and burnt stones were noted. A level of burnt stones was identified inside, being observed that it tended to become thinner towards east (Kayser, 1988b).

A significant number of features with different degrees of definition were identified, notably stone concentrations (eight), pits (five) and an area characterised by burnt sediment at the bottom of the shell midden (Kayser, 1985c; 1987b; 1988b). Many of the identified stone concentrations contained fire-cracked rocks and were interpreted as remains of dismantled hearths. The pits were mostly found at the bottom of the stratigraphy, cutting the fossil beach, and presenting a low depth in general (0.10–0.20 m). Some of them contained material remains inside. However, the limits of most features were difficult to understand by the excavators (Kayser, 1987b). It can be considered that only two pits were well-defined.

Pit 85-1 is one of the most interesting features that was found in the north-west zone (Figure 116). It was a rectangular pit, 1.5 m in length and 1 m in width, but only 0.15 m in depth, which was cutting into the fossil beach and bedrock. Three red deer antlers whose tines had been removed were found on the top of the structure. In addition, several other materials were placed inside, notably two small bone tools (one was decorated), a decorated bone dagger, a shell with incisions and some lithics and bone fragments (mostly burnt). The feature was interpreted by Kayser as a refuse pit with a possible ritual function, due to the specific infill (Kayser, 1985c; Poissonnier and Kayser, 1988). The ritual or ‘special’ character of the feature was also more recently highlighted by other researchers, considering that the other pits discovered at the site did not have a similar infill (Marchand et al., 2018).

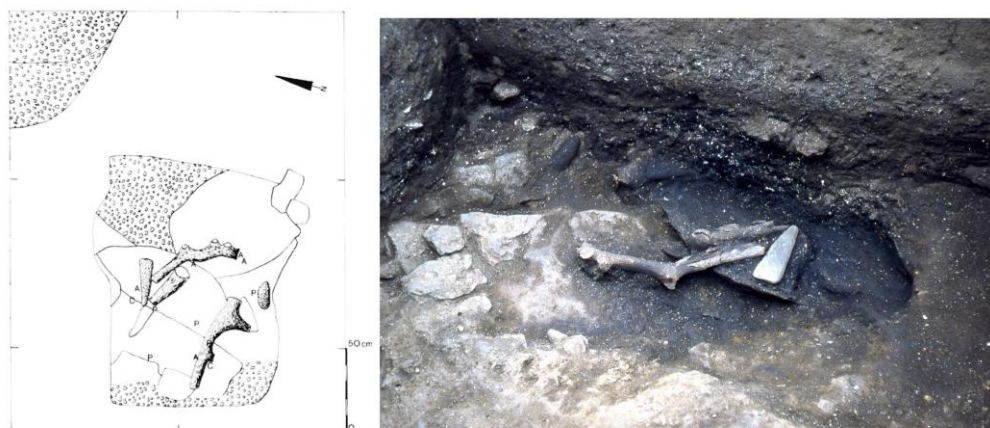


Figure 116: Beg-er-Vil – plan of pit 85-1 with antler remains found during the excavations in 1985 (Poissonnier and Kayser, 1988, fig. 2) and photo of the same feature (photo credits: Olivier Kayser, courtesy of Grégor Marchand).

Pit 87-6 (possibly connected to 87-7) was discovered in the south-west part of the excavated area, but it displayed a more irregular, oval-shaped form, measuring 0.65 m in length, 0.50 m in width and only 0.10 m in depth. It was cut into the shell midden and had some blocks defining the feature and some material inside, notably flint remains, an antler and a bone tool. It was interpreted that the feature was initially used for storage and then reused for discard (Kayser, 1987b). However, considering the low depth of the feature, a storage function seems quite improbable. It was possibly connected to pit 87-7, which contained a bone tool and other similar infill, but the definition of the feature in the field was not clear.

Numerous material remains were recovered in these excavations, notably lithics (flaked stone tools and some percussive tools), faunal remains (marine and terrestrial fauna, including fish and bird remains), bone/antler tools and some macrobotanical remains. A human mandible was also found, but the details are unknown (Kayser, 1987b). The existence of significant tendencies concerning the material distribution in the field was not reported, apart from the concentration of a high quantity of lithic material in the top levels (Kayser, 1988b).

Based on the results of these excavations, Kayser distinguished several phases of occupation at the site and accumulation of the shell midden (Kayser, 1988b). It was proposed that, during the first phase of occupation, several features related to residential/domestic activities (i.e., storage, cooking, lithic tool production) would have been constructed. Later, the site would have been used as a dumping area (shell midden accumulation). After another phase of dumping or reorganisation of the residential area (corresponding to the level of burnt pebbles, oyster and bone remains in the shell midden), a period of simple accumulation would have followed. The occupation would have ended with the abandonment of the site, when a large quantity of lithic material would have been rejected.

The excavations in 2012–2018

Between 2012 and 2018, new archaeological excavations were carried out at Beg-er-Vil under the direction of Marchand and Dupont (Marchand, 2012; Marchand and Dupont, 2013; 2014a; 2015; 2016a; 2017; 2018; 2019; Dupont and Marchand, 2021) (*Appendices – Figure B34*). The formerly excavated area was extended to the east, reaching a relatively marginal zone of the shell midden, and also the surrounding sandy zone. Each square meter of the excavation was divided into quarters and the sediment was wet sieved with 4 and 2 mm meshes. The sediment samples were then sorted. Lithic and bone remains over 2 cm long and smaller significant tools were three-dimensionally recorded in the field using a total station. As a result of the field seasons of 1985–1988 and 2012–2018, a total area of 170 m² of the site was excavated, using a meticulous recovering system (Marchand et al., 2019).

In general, the researchers distinguished two zones in the excavated area – the shell level in the west, lying on a slight slope towards the south-west, and a sandy peripheral area in the east, which was mostly horizontal (Figure 115). The stratigraphy at the shell midden zone comprised, from top to bottom: a dune (SU 3); a brown sandy layer with silty aggregates with archaeological remains, but no shells (SU 4.1, 4.2); a series of rich, black-coloured, organic sandy-silty layers with a large quantity of shells, lithics and bones (SU 5.1 to 5.7), including a

level of numerous reddened granitic blocks (5.3 and 5.4), which contained or was cut by several features (such as E, B, G) and was also characterised by an accumulation of oysters; a dark sandy layer with silty aggregates, abundant shells and tools (SU 6); a clayey-silty layer with numerous pebbles (from the fossil beach) and no archaeological objects (SU 7), which was placed on the Pleistocene beach (SU 8). The shell level was 0.30–0.40 m thick in the excavated area, and thinner than in the area excavated before in the 1980s (*Appendices – Figure B33*). The central and eastern part of the sandy zone was characterised by the succession of dune sediments (SU 103 to 105), followed by brown sandy and silty layers with abundant archaeological remains (SU 4, 100 and 101), some features (such as V, AA, T, L, AB) and several silty and clayey layers (SU 141, 142, 152, 120, 121) that were over the Pleistocene beach (SU 8) (Marchand and Dupont, 2018; Marchand et al., 2018) (Figure 117).

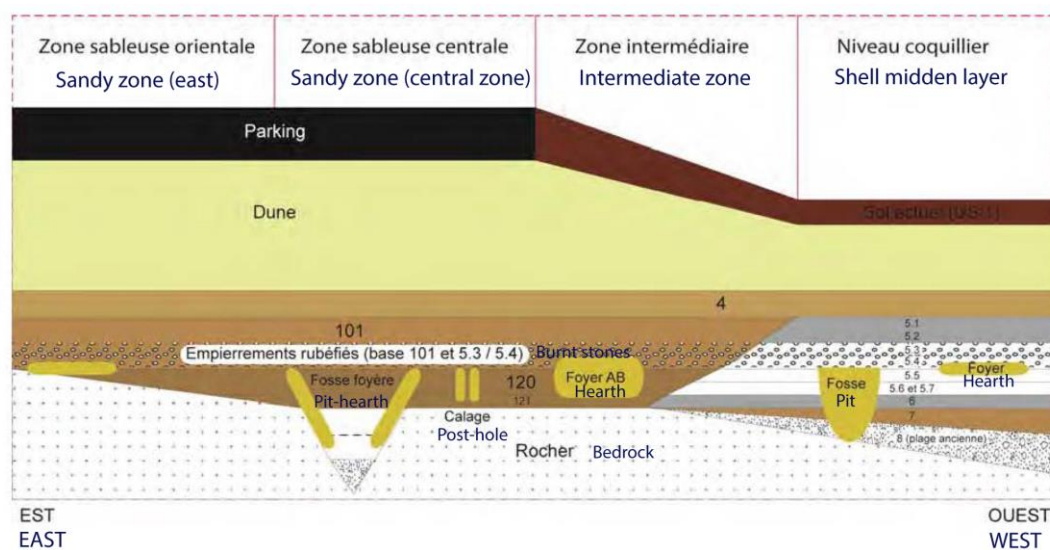


Figure 117: Beg-er-Vil – schematic representation of the east–west stratigraphic section (adapted from Marchand and Dupont, 2018, fig. 113).

The shell midden was characterised by the presence of abundant charcoal, fish, bones and shells, some of which were burnt. More than 30 mollusc species were identified, among which the most prominent were mussels (*Mytilus edulis*), limpets (*Patella sp.*), periwinkles (*Littorina littorea*), cockles (*Cerastoderma edule*), topshells (*Porcus lineatus*), European clams (*Ruditapes decussatus*), dog whelks (*Nucella lapillus*), peppery furrow shells (*Scobicularia plana*) and flat oysters (*Ostrea edulis*). Despite the thinness of the conserved shell layer, the researchers could distinguish the presence of different accumulations, each one characterised by the presence of one to three species only, instead of a homogeneous mass of shells from all mollusc species represented at the site (Marchand et al., 2018). One of the most interesting aspects is the accumulation of large oysters that was detected in association with the level of burnt stones (SU 5.3 and 5.4). The microstratigraphic study also allowed researchers to distinguish successive episodes of deposition. Signs of trampling were detected in the upper parts, indicating that the midden was not only a place for deposition, but also a place of circulation during a relatively long period. Abandonment episodes were not detected through the analysed sequences, but it is unclear whether the site was continuously occupied or

successively frequented in different and short periods (Marchand et al., 2018; Marchand and Dupont, 2019), although the chronometric data indicates a relatively short chronology of occupation of the site (possibly less than 100 years).

The excavated areas of the site provided numerous lithic remains, mainly on local flint and including all the categories of the lithic *chaîne opératoire* (from chips to retouched tools). Bone remains were also identified with some frequency, notably in the shell midden zone. The detailed methods of recovery allowed researchers to identify the presence of diverse fauna at the site, notably numerous marine mollusc species, but also marine fish, crabs, marine and terrestrial birds and mammals. According to the most recent analyses (Marchand and Dupont, 2019; Dupont and Marchand, 2021), these resources could be found in diverse biotopes, which were probably located within a radius of 5 km from the site. Some of these identified species are also considered to be indicators of an occupation of the site on an annual basis.

In addition, a large number of features was detected during these campaigns, comprising stone concentrations (at least six), hearths (at least eight, including hearth-pits), pits (five) and a number of isolated and grouped postholes. Two of the mentioned hearth-pits and alignments of postholes and vertical stones defined two circular features that were interpreted as dwellings (Marchand and Dupont, 2018; 2019). Despite the abundance of features and the large dimensions of the excavated area, graves were not identified at the site.

Abundant combustion features were found in both areas of the site and were characterised by a high variability, occurring either as hearth-pits or as surface hearths formed by circular stone concentrations. Hearth-pits were also diverse: some were shallow, ‘cuvette’ type pits (such as feature B and E), while others were deeper, reaching about 0.50 m in depth (such as feature L and V). Some features were delimited by stones or slabs, while others not. The use of natural depressions and fractures of the bedrock for the construction of hearths was also confirmed in several cases, such feature AB. Together with features L and V, feature E (hearth-pit) was one of the largest features found in these excavations, 1.5 m x 1.4 m and 0.25 m in depth. It was delimited by a large stone block and cut into the shell midden and the layers below. In addition, it was filled with a dense concentration of shells with low fragmentation, while the bottom of the feature was reddened. A small shell fragment decorated with incisions was also found inside (Marchand and Dupont, 2014a), which was similar to the shell fragment found in the previous excavations, in pit 85-1. It should be also underlined that several stone concentrations at the site contained burnt elements, as found in the previous excavations, suggesting that these features also corresponded to remains of dismantled hearths. The abundance of lithics and shells with marks of exposure to fire also gives evidence of the importance of firing activities at the site (Marchand et al., 2018). The variability of firing-related features at the site indicates that combustion activities possibly occurred for different functions, although being difficult to detail (Marchand and Dupont, 2018).

With respect to the other identified pits, some had a poor definition in the field, while others were irregular and shallow, with only a few centimetres in depth (such as features G and J). Their exact function is less clear, although their association with firing activities seems probable for most situations.

However, it was the discovery of two circular structures around large hearth-pits, interpreted as dwelling features, that became one of the most outstanding achievements of these excavations for their uniqueness. The first dwelling feature, 3.5 m in diameter, was identified 4 m from the shell midden zone, by the presence of aligned postholes and vertical stones defining a circular area, and a hearth-pit in the centre (structures L, I, M, F, P, T, Y). The hearth-pit with a diameter of 1.50 m and a depth of 0.50 m was carefully delimited by inclined slabs, while the postholes were defined by the presence of vertically implanted stones. 2 m from this structure, another similar feature was detected from the identification of a hearth-pit surrounded by postholes defining a more irregular, but circular shape (structures V, S, U). The two circular features were interpreted as huts by the excavators, but other possible functions were also suggested, such as their use as drying devices or wind screens (Marchand and Dupont, 2018; 2019).

Based on the results obtained in the excavations, the researchers distinguished two main areas of the site that would have been used for different functions/activities. According to this view (Dupont and Marchand, 2021), the shell midden zone would have been used for daily waste discard and several other activities, notably combustion. On the other hand, the sandy area would have been used for diverse activities, such as combustion, but also for habitation, as indicated by the presence of the two dwelling features. Therefore, the spatial organisation of the site could be evidenced by the differences in the nature of the deposits, as well as the presence and arrangement of the features.

The spatial arrangement of the features

The excavations at Beg-er-Vil undertaken so far have allowed researchers to understand that the shell midden and the surroundings were continuously occupied in the space, as reflected in the construction of features on both sides of the site and mostly at the bottom part of the stratigraphy. Some features were placed inside or cut into the shell layers, while others were completely outside the shell accumulations. The absence of significant cross-cutting relationships between different features is consistent with the chronological and microstratigraphic data of the site, which suggest a relatively short period of occupation with respect to the Mesolithic chronology (possibly less than 100 years), without visible or prolonged abandonment episodes or reoccupations (Marchand et al., 2018; Marchand and Dupont, 2019).

The construction of negative features was found throughout the entire excavated area. Many of these features were relatively shallow, between 0.03 and 0.30 m of depth, and quite irregular. However, some structures were delimited by one or multiple slabs or parts of the natural rock, revealing some effort in its construction, as well as an opportunistic use of the conditions of the ground. With regard to the two hearth-pits of the dwellings, which were carefully defined by inclined slabs, they have similarities with the structured combustion features found at the site of Téviec (Péquart et al., 1937). It seems clear through their characteristics and infill that the majority of the pits at Beg-er-Vil were related to combustion and dumping activities. The hypothesis of storage use is difficult to support, especially if these realities are compared with the storage pits with specific infill recorded in Jomon shell

middens, such as those found at the site of Higashimyo, in Saga prefecture (Sakaguchi, 2009; Matsui, 2013; Nishida et al., 2016b).

Combustion activities seem to have had a high importance throughout the site and were apparently related to domestic purposes, as indicated by the presence of numerous hearths and pits that can be associated with firing activities, the layer of burnt blocks in the shell midden, the distribution of burnt stones through the entire area, or the abundant charcoal remains, lithics and shell fragments with marks of exposure to fire. It should be stressed that despite the extent of the excavated area and the finding of some isolated human bones, it was not possible to attest to the practice of funerary activities at the site. However, it is probable that some ritual practices have occurred at the site, as suggested not only by the presence of human bones, but also by the evidence provided by pit 85-1 containing several antlers, bone tools and decorated remains. The location of that pit in the shell midden zone and the exceptional character of the infill suggest two hypotheses: it is possible that the shell midden zone had a particular ritual meaning at the site, or instead, the shell midden and the pit simply enabled a better preservation of the organic material that was found inside, including the exceptional items. Curiously, the only two shell fragments with incisions recovered at the site were found in the shell midden zone and no decorated tools have been identified in the sandy zone so far.

Contrary to the hearths, the two features interpreted as dwellings were both found in the sandy zone, at a close distance from each other, indicating the existence of a tendency for the clustering of similar features, as found in other Mesolithic shell middens of the Brittany region (Téviec, Höedic). In addition, it is possible to understand that, at Beg-er-Vil, the residential area of the site was not located on the shells (at least it seems so), but in the immediately contiguous, flat area. However, despite the differences between the two areas, their close proximity and continuity can be highlighted, which are also reflected in the wide distribution of the lithic material remains throughout the site.

5.3.1.2. Spatial analysis of material remains

5.3.1.2.1. Previous research and methods of material analysis

The excavations undertaken between 2012 and 2018 allowed the recovery of a large quantity of archaeological remains, namely flaked lithic remains, but also a substantial number of ground stone tools, mostly percussive tools (Marchand et al., 2019), as well as abundant faunal remains (Marchand and Dupont, 2019).

The present analysis is focused on the individually plotted lithic material recovered between 2012 and 2017. The technological and typological study of the lithic assemblages recovered in each year was undertaken by different researchers involved in the research project at Beg-er-Vil – Grégor Marchand (2012), Diana Nukushina (2013, 2015 and 2017), Gaëlle-Anne Denat (2014 and 2016) and Jorge Calvo Gomez (2016, 2017) – using the main classification scheme established for the project (Marchand and Dupont, 2013; 2016a; 2017; 2018). Despite the large amount of lithic remains that had already been studied from the site, there is still a large quantity of sediment from sieving that has not been sorted and contains a large quantity of small lithics (lithics recovered through sieving represent between 79% and 83% of the total recovered lithics in the field seasons of 2012, 2013 and 2016). As a

consequence, only a part of the lithic material from sieving, notably the assemblages of geometric microliths from the 2012–2016 field seasons, could be included in this analysis. The technological and typological data obtained through the lithic studies were adapted to this analysis and cross-examined with the available spatial information (three-dimensional data from the individually plotted material and contextual data). The spatial analysis and map rendering of the lithic distribution use GIS software (Quantum GIS).

With respect to the other material remains, such as bones and shells, the scant data concerning their distribution and characteristics that were available until 2022 were also integrated in this study as much as possible. The data concerning the analysis and distribution of oyster shells were provided by Catherine Dupont, being limited to the material recovered between 2012 and 2014. Concerning the human bones, the fragments recovered during the excavations were very few in number and analysed by Clémence Glas (Marchand and Dupont, 2018).

5.3.1.2.2. Analysis of the lithic remains and results

Lithic technology and typology

A total of 8912 lithic artefacts were individually plotted in the excavations of 2012–2017. Flaked lithic remains totalled 8849 remains, while 63 items were percussive tools (Table 8, Figure 118).

Categories from the whole lithic operative chain are represented in the assemblage of plotted material, indicating the practice of local knapping. Debitage products are the most abundant category (62%), notably flakes. However, it should be noted that most part of debris, bladelets and retouched tools (notably geometric microliths) were recovered through sediment sieving, being underrepresented in the present analysis.

In general, individually plotted lithic artefacts were slightly more abundant in the shell midden layers (57%), compared to other layers (43%) (*Appendices – Table B20*). Lithics were particularly abundant in SU 5.3 (15%), 5.2 (15%) and 5.1 (11%). Considering that a high number of small lithics from the shell midden layers is typically found in the sieved sediments, due to the difficulties of identifying them in the field, the real proportion of lithic remains in these units would have been much higher. However, comparing the stratigraphic units at an individual level, it can be highlighted that SU 101, a silty layer that was found under SU 4, in the central part of the sandy zone, provided the highest quantity of plotted lithic remains (16% of the total). A significant quantity of material was also recovered from SU 4 (12%), a silty and sandy layer identified under the dune layer in all of the excavated area. When the lithic categories in SU 4 and SU 5 are compared, it can be found that, although the proportion ofdebitage products and retouched tools are similar in those units, the proportion of cores is much higher in SU 5 (10%, compared to 5% in SU 4). Differences on the proportion of core preparation and maintenance material are also substantial (4% in SU 5 and 2% in SU 4) (*Appendices – Table B21*). With respect to SU 101, a high proportion of cores is also found (9%). In addition, 65% of the percussive tools found at the site came from the shell midden stratigraphic units (SU 5), with a particular incidence in SU 5.3 (19%) and 5.5 (21%), corresponding to the middle and bottom parts of the shell midden (*Appendices – Table B23*).

Table 8: Lithic technological categories from Beg-er-Vil (individually plotted flaked lithic material from the 2012–2017 excavations).

Technological category	Total N	Total %
Core	784	8.86%
Core preparation and maintenance	281	3.18%
Core maintenance flake	169	60.14%
Core maintenance blade	3	1.07%
Core maintenance bladelet	4	1.42%
Crested blade	7	2.49%
Crested bladelet	7	2.49%
Crested flake	11	3.91%
Core tablet	58	20.64%
Partial core tablet	16	5.69%
Other	6	2.14%
Debitage product	5521	62.39%
Flake	4688	84.91%
Bladelet	505	9.15%
Blade	292	5.29%
Split pebble	36	0.65%
Retouched tool	492	5.56%
Splintered piece	6	0.07%
Debris	1765	19.95%
Fragment	1569	88.90%
Chip	195	11.05%
Burin spall	1	0.06%
Total	8849	100.00%

Concerning the main features identified at the site (D, L, V, E), all contained some quantity of lithic remains, although with variations (*Appendices – Table B22*). Features L and V, which are the two hearth-pits of probable dwelling features, included the highest quantities of lithic remains (n=88 and n= 87, respectively), although the material represented less than 1% of the total recovered lithic remains in both cases. In addition, all lithic technological categories were represented in the infills, which do not reveal specific concentrations. It can be observed that structure V contained a higher proportion of debris (28%) and retouched tools (10%) when compared to structure L (in which debris was 15% and retouched tools were 5% of the recovered lithics), although both features shared identical characteristics and provided similar quantities of lithic remains in general.

Almost all lithic tools from the site were produced on flint (93%) (*Appendices – Table B24*). Flint pebbles would be locally available, but at some distance from the site (Marchand et al., 2016). Some use of quartz (4%) and quartzite (2%) is found, although it has a low presence. Despite this, it can be observed that quartz and quartzite, as well as other raw materials, such

as sandstone or granite, were abundantly used for macrolithic/pebble tools, notably choppers and percussive tools (*Appendices – Table B25, Figure B42 and 43*).



Figure 118: Some lithic material found at Beg-er-Vil – core maintenance flake (top), retouched flake (bottom left) and bladelets (bottom right) (adapted from original photos by François Eluard).

Generally, the lithic production at Beg-er-Vil is characterised by the exploitation of small pebbles, predominantly of flint, and the production of microlithic tools. A significant part of the materials shows signs of burning (49%), which reflects the importance of combustion activities, that are also evidenced by the abundance of hearths and burnt pebbles/blocks at the site.

Despite the limitations, it can be found that cores (9%, n=784) and material from core preparation and maintenance (3%, n=281) are relatively abundant in the analysed assemblage. Cores are small, with an average length of 25 mm, although remains of cortex are frequent, indicating the small dimension of the original pebbles (*Appendices – Figure B35, B37*). Flake scars are predominant in the cores, although the presence of flake and blade/bladelet scars on the same core is frequent. Prismatic cores are prevalent, but they reveal some morphological diversity. Unipolar cores are the most frequent type (16%), being immediately followed by bipolar cores (13%) (*Appendices – Table B26*). Multipolar cores are also somewhat significant in the site (7%), indicating a high frequency of reorientations of the debitage. The high frequency of core tablets and core-rejuvenation flakes in the assemblage also demonstrates the need for frequent core surface refreshing during the debitage procedures. The small size of the flint cobbles and high incidence of inclusions and overhanging accidents explain these tendencies and indicate the general low quality of the raw material. The presence of abundant flaked/tested pebbles (20%) in the assemblage also indicates the same problem.

The high number of cores and core maintenance material, the low quantity of crested products, as well as the high frequency of remaining cortical surfaces on cores, debitage

products and even some retouched tools, suggest the practice of relatively simple debitage procedures and a low intensity of core reduction.

Flakes are the main debitage products at Beg-er-Vil, representing 85% of the assemblage. They are morphologically diverse and tend to be short, with an average length of 25 mm and average width of 20 mm (*Appendices – Table B30*). In addition, a significant part (14%) presents cortex on more than 50% of the dorsal surface, whereas the presence of smaller areas of remaining cortex is frequent. These characteristics are indicative of the small dimension of the original cores and their low level of reduction (*Appendices – Figure B38, B39*).

Blades were recovered in some number at the site (5%), but they are small and short (average length of 34 mm and width of 15 mm) (*Appendices – Table B31*). They also present a quite irregular form, corresponding to ‘elongated’ small flakes. Bladelets represent only 9% of the recovered debitage products. They are clearly underrepresented among the individually plotted material, but relatively numerous among the material recovered through sieving.

Retouched tools are predominantly characterised by the presence of geometric microliths (14%), truncated pieces (15%), notches (13%) and backed pieces (11%) (Table 9). Denticulates (8%) and drills (4%) are also relatively important among the retouched tools (*Appendices – Figure B40, B41*). Most retouched tools were produced on flake blanks (63%), although the use of bladelets (16%) was surely also relevant but underrepresented in the analysis. Despite being rare, the use of short blades as blanks of retouched tools was found (12%), suggesting that, even with a lack of standardisation, blade production had some intentionality.

Table 9: Retouched tools from Beg-er-Vil (individually plotted material from the 2012-2017 excavations).

Retouched tool	N	%
Backed blade	5	1.02%
Backed bladelet	3	0.61%
Backed flake	32	6.50%
Backed knife	10	2.03%
Backed piece	6	1.22%
Burin	4	0.81%
Chopper	2	0.41%
Denticulate	37	7.52%
Drill	21	4.27%
Drill+truncation	1	0.20%
Endscraper	5	1.02%
Geometric microlith	71	14.43%
Notch	64	13.01%
Notch+other	1	0.20%
Truncated piece	74	15.04%
Various	156	31.71%
Total	492	100.00%

Few splintered pieces (n=6), as well as some split pebbles (n=36) have been identified. The low numbers indicate that the use of bipolar percussion on anvils was unusual at the site.

Lithic material from sieved sediments (2012–2016 excavations)

Concerning the lithic material recovered from sieved sediments, it is not possible to present a full analysis, due to the existence of large quantities of unprocessed sediment from several field seasons at the time of the present study. For the field seasons of 2012, 2013 and 2016, all the material was studied, making it possible to have a notion of the most abundant types of material that was recovered. Most of the material recovered through sieving was undetermined fragments, small flakes and chips, but numerous bladelets and geometric microliths were also found, mainly in 2012 and 2013, in the shell midden zone.

The large quantity of geometric microliths collected from the sieved sediments from 2012–2016 field seasons reveals the importance of the sieving procedures in Mesolithic shell midden contexts. From a total of 231 geometric microliths identified up until 2022, 160 pieces (69%) were recovered from sieved sediments (*Appendices – Table B27*). They were mostly found in the upper shell midden layers – SU 5.3 (21%), 5.2 (21%) and 5.1 (12%). Layers SU 4 (12%) and SU 101 (10%) provided some microliths, but in a much lower quantity (*Appendices – Table B28*). Although some rare triangles (3%) were detected in the shell midden units, trapeze-type geometric microliths were largely dominant at the site (86%). Trapezes are mostly short (65%), relatively large (average width of 9.6 mm) and symmetrical, with rectilinear truncations formed by abrupt retouch, revealing a high typological uniformity (*Appendices – Table B29; Figure B36 and B41*). Microburins are almost absent from the lithic assemblage (only one piece was recovered so far).

Intra-site distribution

In general, lithic materials were abundantly distributed through the shell midden and sandy zones (Figure 119). However, a higher concentration of materials was detected in the western part of the excavated area (Figure 120). The concentration in the west was mainly related to the higher abundance of lithic remains in the shell midden layers, notably in SU5. In the case of SU4, from which a significant quantity of lithic remains was also recovered, the distribution and concentrations were more dispersed over the entire area of excavation.

The distribution of the different lithic categories and raw material types occurred over all the excavated area and generally followed a tendency of concentration in the western zone, providing a quite homogeneous image. Despite that, some exceptions can be observed:

- 1) Percussive tools seem to have been particularly concentrated in the north-western zone (squares BH, BG, BF34, 35 and 36), notably in the shell midden stratigraphic units that corresponded to the middle and bottom parts of the shell accumulation (SU 5.3, 5.5 and 30) (*Appendices – Figure B45; Table B23*). Quartz was the most frequent raw material among percussive tools, followed by quartzite. However, the concentration in the north-western zone was clearly dominated by quartz tools, while quartzite tools were more distributed over the excavated area (*Appendices – Figure B46; Table B25*). On the other hand, the dimensions of percussive tools do not reveal a particular pattern of distribution.

- 2) Although the eastern zone (sandy zone) was characterised by a lower density of lithic material, some slight material concentrations (mainly retouched tools and debitage products) can be identified (*Appendices – Figure B44*). The presence of features in the western zone does not seem to have had a particular relation to the lithic distribution, but the lithic concentrations in the eastern zone tended to be located in the areas occupied by the largest negative features (dwelling features) (Figure 120).
- 3) Among the retouched tools, drills are one of the few categories that were more abundant in the eastern zone (mostly in SU 101 and 4) (*Appendices – Figure B47*).
- 4) The small group of splintered pieces was almost exclusively found in the eastern zone (mostly SU 101 and 4), contrary to other lithic categories (*Appendices – Figure B45*).

Individually plotted geometric microliths were mostly identified in the sandy zone (*Appendices – Figure B48*), a situation that clearly results from the difficulties in immediately detecting these small tools in the field during the excavation of shell midden sediments. When the assemblage of microliths recovered from the sieved sediments (from 2012–2016) are considered in the analysis, the largest concentrations can be observed in the western (shell midden) zone, particularly in the north-western part (*Appendices – Figure B49*). The area of features D and E also provided a high concentration of microliths. In the sandy zone, although the numbers are much lower, the highest quantities mainly corresponded to the areas with dwelling and combustion-related features.

The distribution of cores by type does not reveal a specific pattern. However, with respect to the dimension of the materials, it can be observed that the largest cores (more than 40 mm of length) were more frequent in the western zone, particularly in the north-western zone (*Appendices – Figure B50*). The same tendency is not found concerning the distribution of debitage products according to the dimensions, which seem to not present significant differences (*Appendices – Figure B51*). The distribution of debitage products by type and state of fragmentation also does not reveal a specific pattern.

The recent use-wear analysis undertaken by Calvo-Gómez (2023), although identified traces of use related to different activities in some lithic materials (such as plant working, soft animal material processing and projectile use), also did not result in the identification of spatial patterns of lithic distribution at the site.

Although the general tendency of concentration of lithic material in the western zone can be partially related to the slight slope towards the south-west and a possible mobilisation of the remains through erosive processes, a reorganisation of the lithic distributions at the site could have more likely happened through human circulation between the areas, as suggested by the results of microstratigraphic analyses (Marchand et al., 2018; Marchand and Dupont, 2019), and redeposition of sediments into the slope. Despite that, the significant concentration of heavier items in the south-west zone, such as larger cores and percussive tools, is more difficult to interpret only as a result of post-depositional processes. It is more likely to be related to differences on the substrata, notably the presence of the Pleistocene beach and, consequently, a high quantity of natural pebbles that were available in the western zone.

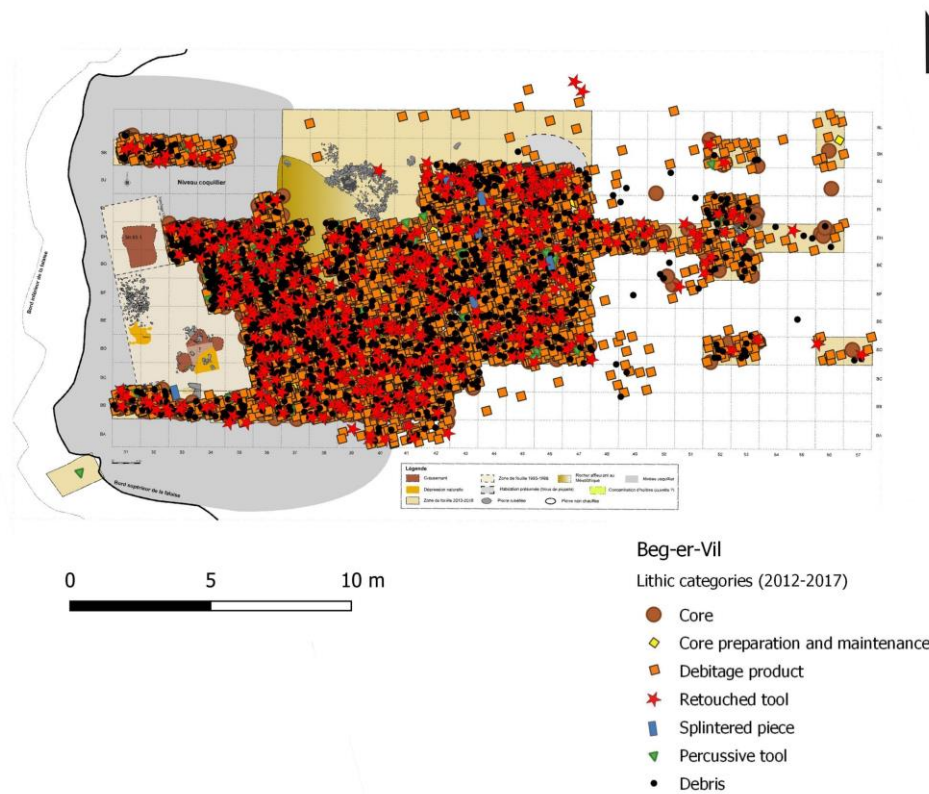


Figure 119: Beg-er-Vil – horizontal distribution of the individually plotted lithic material in the excavated area (2012–2017 excavations) (image by author).

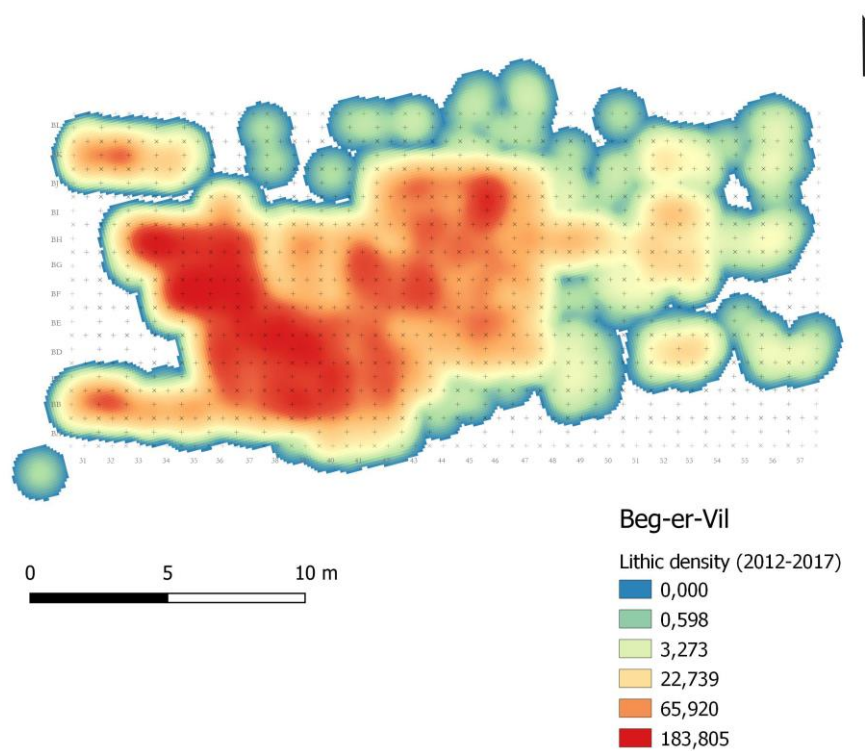


Figure 120: Beg-er-Vil – Kernel Density Estimation showing the lithic material densities of the items that were individually plotted at the site (2012–2017 excavations) (image by author).

5.3.1.2.3. Analysis of other material items

Although the study of other material items from Beg-er-Vil by several researchers is still ongoing, some aspects can be highlighted through the analysis of the currently available data.

With respect to the distribution of shells, a concentration in the western zone and a progressive decrease of their density towards the east was observed in the field. Also, significant differences between shell accumulations were identified through the malacological and microstratigraphic analyses (Marchand et al., 2018), revealing that the shell layer was not a homogeneous, single deposit. Despite the limitations, the available data concerning the distribution of oysters recovered between 2012 and 2014 indicates the existence of concentrations in specific parts of the shell midden area, notably in the south-west zone, in squares BB35 and BF35 (*Appendices – Figure B52*). Some oyster concentrations were also detected in the excavations from 2015, in squares BB38-39 and BD38-39 and BE38, which were possibly filling small depressions, although the limits of these features were not clear in the field (Marchand and Dupont, 2015).

Concerning the rare, isolated human bones (a total of three) (Marchand and Dupont, 2018), they were found dispersed over the shell midden zone, without being associated with negative features or specific items. Two of them (a mandible and a parietal bone) were identified in the area excavated in the 1980s by Kayser (squares AG20 and AG22), while the other fragment (a clavicle) revealed the presence of cut marks and was found during the most recent works, in the south-west zone, through the excavation of a test pit (Z) near the cliff (Marchand and Dupont, 2014a). While these remains are too rare and scattered to argue for burial activity at the site, their presence seems to indicate that some type of ritual practice (with funerary or other character) was undertaken in association with the deposition of shells.

5.3.1.2.4. Discussion and conclusions

Due to the extensive area that was excavated with careful methodologies, the archaeological record of Beg-er-Vil provides several important pieces of information concerning site structure and function.

Firstly, a continuous occupation of the shell midden and sandy zones was observed, with the deposition of material remains and construction of well-defined features in both sides of the site. It is thus clear that the occupation of the site was not limited to shell deposits or to dumping activity. Instead, there is evidence of multiple types of activities carried out in a typical settlement site, such as food/resource collection and consumption, processing, tool production and, probably, habitation and ritual activities.

Secondly, although many identified features were related to combustion activities, their formal differences suggest the existence of distinct functions of the fires that could have ranged from food processing to ritual functions. On the other hand, the infill of the negative features (mostly composed of shell, charcoal, lithic and animal bone remains) do not suggest a deposition of specific objects for storage. Instead, these deposits appear to have mainly resulted from the accumulation of remains of debris from the settlement. Only some exceptional elements in the site seem to have been special items suggesting a possible ritual purpose. These elements (i.e., antlers, decorated bone tools and shell fragments, human

bones) were all composed of organic material and found in the shell midden zone. However, the significance of the location of these items is difficult to interpret, notably if there was some symbolic meaning associated with their presence in the shell midden. Antlers and decorated tools seem to have been specifically deposited inside negative features – the case of pit 85-1 is unique at the site, with a clear concentration of these special items in the feature suggesting a symbolic/ritual deposition. Contrary to this, the human bones were not associated with any visible feature, specific deposit, or primary burial context.

Thirdly, the position of the features suggests some clustering of structures of similar types (particularly, the dwelling features that are close to each other), a tendency also observed in other Mesolithic shell middens of the region. The concentrations of oyster shells detected in the south-west zone were also close to each other and suggestive of a clustering pattern, but further advances in the analyses of the sieved materials are needed. At the same time, the absence of significant cross-cutting relationships between features shows an extensive use of the available space. These aspects indicate the existence of some degree of spatial organisation of the features that was kept with little disturbance. This view is also in accordance with the relatively short chronology of occupation of the site.

Finally, the lithic remains reveal the relevance of local tool production at the site. However, the distribution of the main categories of lithic production over all the site, in a quite homogenous way, does not allow the identification of specific debitage zones. The higher lithic density found in the shell midden zone can be attributed to several causes, which include secondary deposition through dumping activity and natural movement from the east. Despite that, the high concentration of percussive tools, especially on quartz, in the north-west zone, can be distinguished among the lithic density in the shell midden zone, indicating the possibility that some specific activity requiring percussion was undertaken in the zone – lithic knapping or other work on hard material that could include the breakage of mammal bones and crab shells (Marchand et al., 2019).

5.3.2. Document analysis of other sites

5.3.2.1. Beg-an-Dorchenn

The first excavations

The site of Beg-an-Dorchenn was identified and excavated for the first time at the end of the nineteenth century by Du Châtellier (Du Châtellier, 1881; 1882–1883; 1889), who discovered a probable proto-historic human burial. The site was later excavated by Bénard Le Pontois, between 1920 and 1926 (Bénard Le Pontois et al., 1919; Bénard Le Pontois, 1929) and by Giot, between 1946 and 1950 (Giot, 1947; Giot and Guilcher, 1947), whose works provided several pieces of evidence of Mesolithic, Neolithic, Bronze and Iron Age occupations. The past descriptions indicate that the shell accumulation was 80–100 m² and 1–1.60 m thick (Du Châtellier, 1881; 1882–1883; 1907; Bénard Le Pontois, 1929; Giot and Guilcher, 1947). However, more recently, it was found that the shell level presented a thickness of 0.30–0.40 m (Kayser, 1984; Dupont et al., 2010). It thus seems likely that the site corresponded to an actual mound in the past, but it was severely affected by erosion.

During early field work, some combustion features were identified through the area of the shell midden (Du Châtellier, 1881; 1907; Bénard Le Pontois, 1929). The presence of ash

and charcoal was also noticed (Du Châtellier, 1881). In addition, Bénard Le Pontois noted that several cores were recovered near a large hearth (Bénard Le Pontois, 1929, p. 44). However, details about the characteristics and chronology of the combustion features are unknown, despite their clear importance at the site. The finding of two features classified as dwellings was also mentioned, but only one was described with more precision – according to the researcher, it was a circular dwelling of more than 2.5 m in diameter, being defined by a stone wall and a pavement of flat stones over a layer of yellow clay (Figure 121). Fire-cracked rocks from possible hearths were on the pavement, but few other materials were found (Bénard Le Pontois et al., 1919, p. 175; Bénard Le Pontois, 1929, p. 45). Unfortunately, contextual information and clear graphic documentation of these features were not published (*Appendices – Figure B53 and B54*), limiting the analysis.

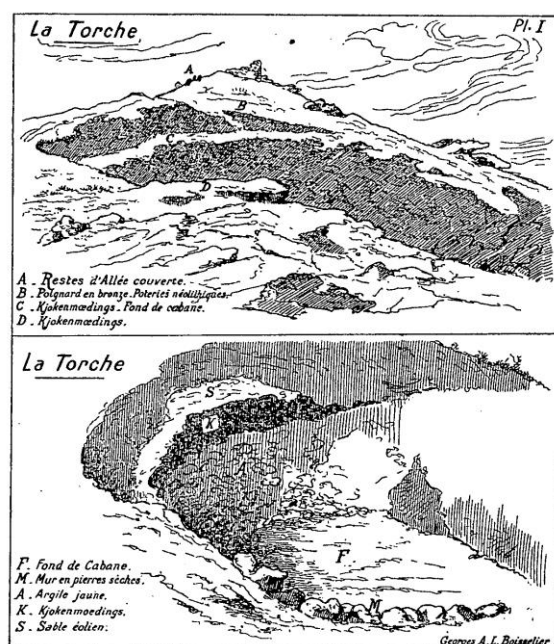


Figure 121: Beg-an-Dorchenn – drawing of the site from 1919 with indication of the megalithic monument on the top of the outcrop (A), the shell midden (C, D, K) and a dwelling floor (F and M) (reproduced from Bénard Le Pontois et al., 1919, p. 174).

The excavations in 1984–1988

The excavations undertaken by Kayser's team between 1984 and 1988 were centred on the Mesolithic occupation of the site, and are documented in several reports and articles (Kayser, 1984; 1985b; 1985a; 1986b; 1987a; 1988a). An area of 53 m² was excavated on the current footpath. The excavation was performed through squares of 1 m, which were further divided into quarters and excavated through artificial levels of 5 cm. Wet sieving and sorting were used with the sediment that was recovered and the main lithic and bone remains were three-dimensionally recorded.

Overall, the following stratigraphy was observed, from top to the bottom (Kayser, 1988a): a level of sand and gravel (C1, medieval occupation), a level of sand/dune, where several tombs were cutting the bottom levels (C2, protohistoric occupation), a level of sand/dune with some Neolithic materials on the top (C3), a shell midden layer (C4, Mesolithic) and a

silty/clayey layer with Palaeolithic artefacts. The shell midden layer was about 0.35 m thick and was further divided into four sublayers: a sandy layer with abundant lithics, an organic layer with a high quantity of shells, a sandy layer (C4) and a silty/clayey layer probably from an early phase of the Mesolithic (C5). The stratigraphy of the Mesolithic occupation was partially affected by the subsequent occupations, notably some of the features that were found.

Concerning the Mesolithic occupation, the most prominent find was a large oval stone feature, measuring at least 3.5 m in length and 3 m in width, located in the north-west part of the excavated area (*Appendices – Figure B55*). The stone structure was formed by large, reddened blocks. A flat and circular surface hearth was found inside, measuring 1 m of diameter and being covered by fire-cracked quartzite rocks. Some lithic and shell remains were found in association. This structure (formed by a stone concentration and a hearth) was interpreted by Kayser as a dwelling floor, which, according to the author, could have been related to the other two supposed dwelling structures found by Bénard Le Pontois (Kayser, 1985b). Stratigraphically, the structure was covered by 0.10–0.15 m of shell layer and cut into by a German trench and two protohistoric burials. Despite the strong disturbance, according to the researcher, the Mesolithic chronology of this structure was evidenced by its stratigraphic position, the reddened state of the blocks (which were clearly different from the stones of the protohistoric level), and the lithic material found over the stone concentration and between the blocks of the feature (Kayser, 1984).

In addition, a circular hearth-pit about 0.80 m in diameter and delimited by inclined reddened blocks was found in the eastern zone. The presence of a flat hearth in the stratigraphic section of the southern cliff was also mentioned. At 3 m from the hearth-pit, an ‘isolated block’ was found over a stone concentration, which was interpreted as a seat (Kayser, 1987a). This stone concentration was located over a large and shallow pit, which did not contain specific materials (some fragments of shells and flint), but included a negative feature characterised as a possible posthole (Kayser, 1988a). The presence of structuring stones defining the possible posthole was not described and questions concerning the reliability of this feature can be raised. In general, little information was provided about these features, whose function remains unclear.

Numerous lithic and faunal remains, some adornments, rare bone tools and macrobotanical remains were found. The study of the lithic materials from these excavations undertaken by Olivier Rault (1992) included 13928 pieces. According to the analysis, lithic production mainly used local flint pebbles, through two main operational sequences – the production of bladelets and the production of split pebbles and splintered pieces (through bipolar percussion). The latter seems to have been specific to this site, being practically absent in other Mesolithic sites of the region (such as Beg-er-Vil). It was observed that cores were mostly unipolar, and retouched tools (mostly notched or denticulated pieces) were mainly made on flakes and bladelets. Microlithic armatures were frequent among the retouched tools (about 18%) and dominated by symmetrical trapezes with concave truncation (so-called ‘Téviec-style’). In addition, pebble tools had some presence in the assemblage (i.e., choppers, percussive and abrasive tools). The results of a spatial analysis of the lithic remains that was carried out led the author to suggest that the squares of the excavation richer in split pebbles

and splintered pieces contained the lowest quantities of cores, and vice versa. The researcher defined five zones according to the distribution of split pebbles and splintered pieces (Rault, 1992, p. 137): the stone structure (1), where little material was found; the south-west zone (2), characterised by a large quantity of material; the south-east zone (3), where an ‘isolated’ block and a large quantity of material was found; the eastern zone (4), where most part of hearth 2 was found and the northern zone (5) (Figure 122, Table 10). Based on the large quantity of materials, the author suggested the presence of a particular operational sequence of split pebbles/splintered pieces and knapping activity area in the south-east zone (3), which could be associated with the ‘isolated’ block (Rault, 1992, p. 151). The presence of other lithic concentrations near the limits of the excavation was also noted and attributed to the development of specific activities, although they were not specified.

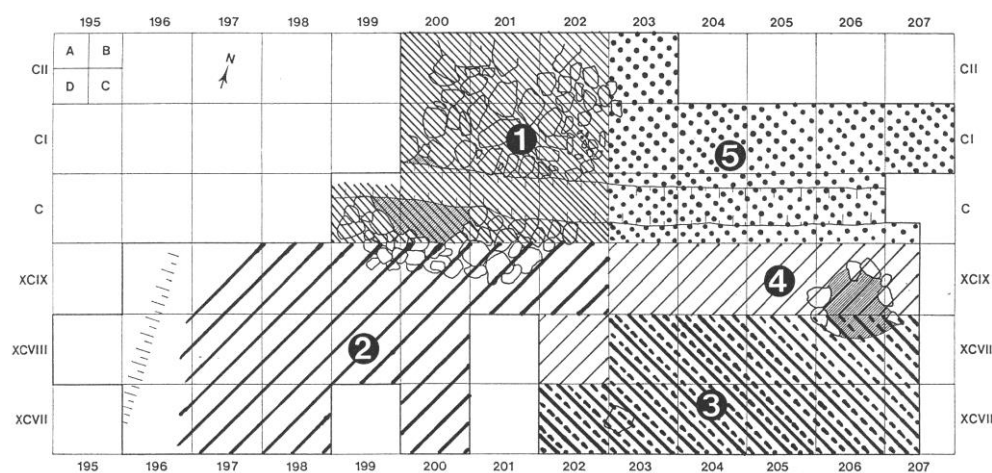


Figure 122: Beg-an-Dorchenn – excavated area in the 1980s divided into five zones according to the distribution of split pebbles/splintered pieces, as proposed by Rault (1992, fig. 74).

Table 10: Beg-an-Dorchenn – characteristics of the main zones of the excavated area in the 1980s according to the quantity of split pebbles and splintered pieces, as defined by Rault (1992, pp. 137–140).

Zone	Location	Number of squares	Quantity of split pebbles/splintered pieces
1	Stone structure	10	Low
2	South-west	13	High (predominance of split pebbles)
3	South-east (south of Hearth 2/isolated block and pit)	11	High (abundant splintered pieces and debris)
4	East (northern part of Hearth 2)	6	Low
5	North	11	Middle

However, the reanalysis of the data from all lithic categories included in Rault’s study and the comparison of the material density between the zones defined by the researcher (instead

of counting by squares) allowed a broader and different view of the material distribution (Figure 123) (*Appendices – Table B32*). It is thus possible to conclude that:

- 1) The zones with the highest quantities of split pebbles and splintered pieces at the site also contained the highest quantities of cores (zones 2, 3 and 5), a perspective that contradicts the idea of the author of a dichotomous relation between these two categories of lithic material, which was based on the material distribution by individual squares;
- 2) Zones 2 (south-west) and 3 (south-east) contained the largest quantities of lithic remains in general;
- 3) Despite its relatively large dimensions, zone 1 (stone structure) presented few lithic remains;
- 4) Microlithic armatures were widely distributed through the five zones, but they were more frequent in zones 3 (south-east) and 5 (north); in zone 5 (north), a large proportion of bladelets among the total lithic remains was recorded.

This picture also stresses the possibility that a knapping area was located in zone 3 (south-east), but, contrary to the perspective of Rault, it seems likely that it was not limited to the operational sequence of split pebbles/splintered pieces. In fact, zone 3 was one of the densest zones in lithic remains in general, with an important presence of bladelets and armatures. It should be noted, however, that detailed stratigraphic information concerning the distribution of lithic remains is not available, limiting the analysis to a global view of the Mesolithic level.

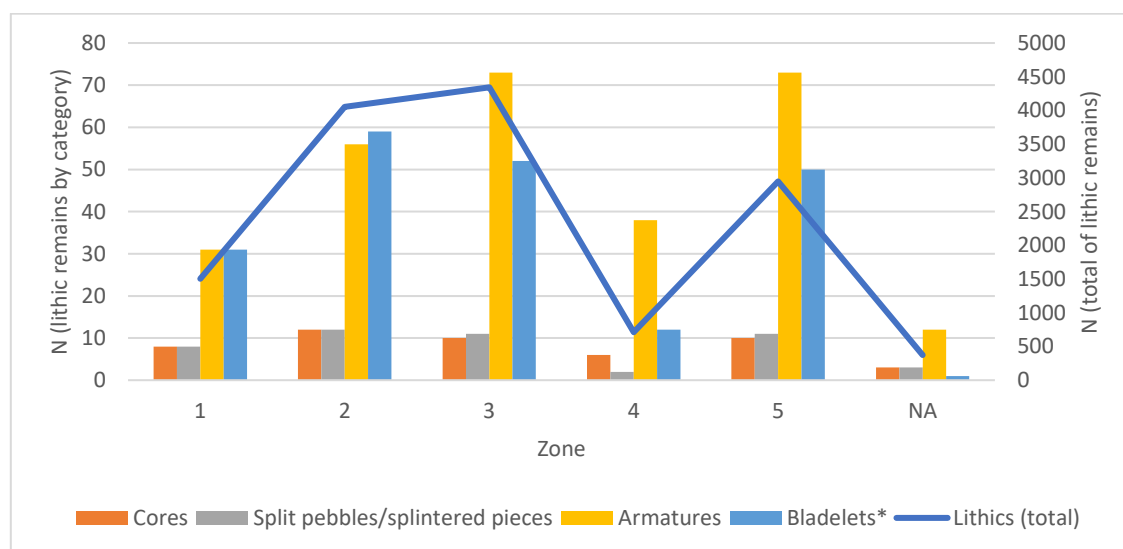


Figure 123: Beg-an-Dorchenn – lithic distribution by zone of excavation and category of lithic artefacts (calculations based on the frequency counts by square from Rault, 1992).

5.3.2.2. Tévéc

The main excavations at the shell midden of Tévéc were carried out between 1928 and 1930 by Marthe and Saint-Just Péquart (Péquart and Péquart, 1928; 1929; Péquart et al., 1937). These works started at the zone near the cliff and continued inland. The excavations were undertaken in levels, but the use of sieving was not reported. At that time, it was observed that the shells were distributed over an area of 200 m², but the site was already partially destroyed by marine erosion (Péquart et al., 1937, p. 5). The shell deposit appeared as a

uniform layer 0.60–1 m thick without visible internal variations (Péquart et al., 1937, p. 18). Most of the attention was given to the funerary component of the site. As a result, the available information about the stratigraphy and other aspects of the site is limited.

Chipped and ground stone tools, bone and antler tools, personal ornaments and faunal remains were the main recovered materials. Only a hundred chipped lithic artefacts are known in the literature. Despite the presence of several categories of material, the assemblage was mostly composed of retouched tools (Péquart et al., 1937, p. 18), probably as a result of selective recovery in the field.

However, numerous structures were identified and recorded during these excavations, which included hearths, human graves and an isolated stone structure (Figure 124). The discovery of a high number of hearths was highlighted – at least 29, from which 23 features⁸ were represented in the original plan of the site (Péquart et al., 1937, fig. 3) and six features were reported as being part of the graves and classified as ritual hearths. The morphology was diverse and included hearth-pits (bordered in some cases by large, inclined blocks), natural depressions in the rock, flat hearths formed by circles of stones and ritual hearths with a coffer form placed over the graves. The hearths were divided into three types by the excavators according to their supposed function – ‘domestic’, ‘feasting/cooking’ and ‘ritual’ hearths (Péquart et al., 1937, p. 19). The ‘feasting’ and ‘ritual’ hearths, which were presumably associated with funerary activity, were described in detail, while there is little information provided about the ‘domestic hearths’:

- 1) The ‘domestic hearths’ were formed by stone concentrations with a modest dimension, irregular form, lack of complex construction, evidence of high-temperature fires and use for immediate and daily activities. It was also observed that many of these hearths were not located at the same level, being stratigraphically separated by 0.15–0.20 m in the shell layer, which suggested that the features were not all contemporaneous (Péquart et al., 1937, p. 20).
- 2) The ‘feasting/cooking hearths’ were characterised by their location near or adjacent to the graves, large dimensions, regular and circular form, relatively complex structure with large stones and large quantity of charcoal and burnt bone remains, suggesting the practice of high-temperature fires. It was assumed that the features would have allowed the cooking of large volumes, such as deer meat (Péquart et al., 1937, p. 21) (Figure 125).
- 3) The ‘ritual hearths’ were described as small coffers usually formed between the stone structure (‘cairn’) and the covering slab of the graves, as part of a funerary monument. Remains of ash, charcoal and shells were found inside, suggesting to the authors the practice of occasional, low-temperature fires. Deer and wild boar jaws were found in some cases in these features, which were interpreted as deposits/offerings that were made after the fires (Péquart et al., 1937, p. 23).

⁸ In fact, 24 combustion features were represented in the original plan of the site, but the location of feature no.19 matches with the descriptions of the ‘false grave’ or ‘cenotaph’ discovered in 1929 (Péquart et al., 1937, p. 59). For this reason, it was not considered to be a combustion feature in this analysis.

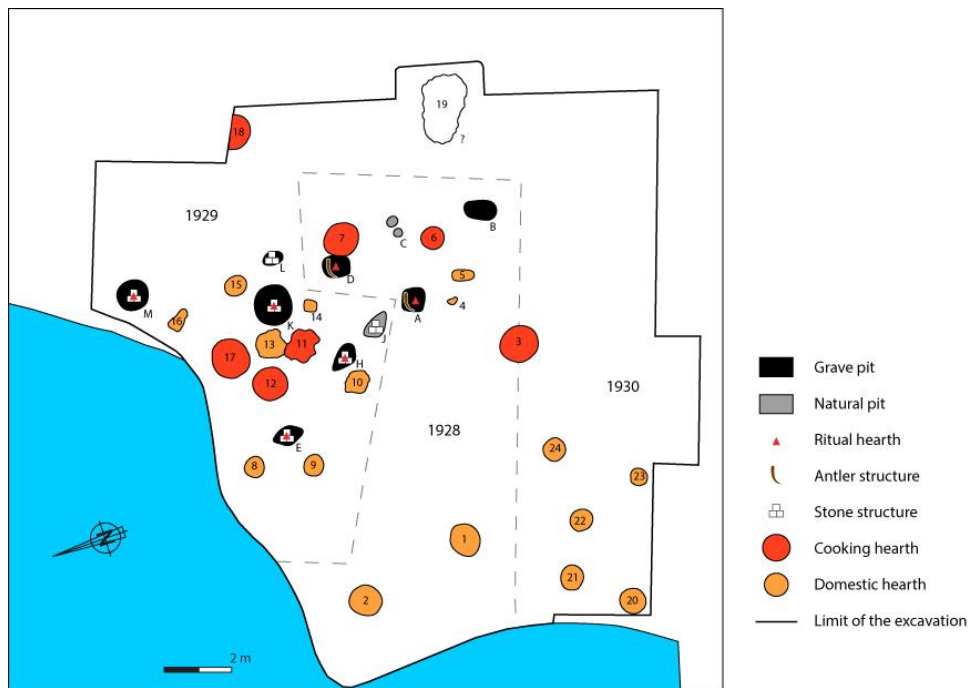


Figure 124: Tévéc – site plan with the location of the different types of features identified in the excavations (modified from Péquart et al., 1937, fig. 3, based on the descriptive information).

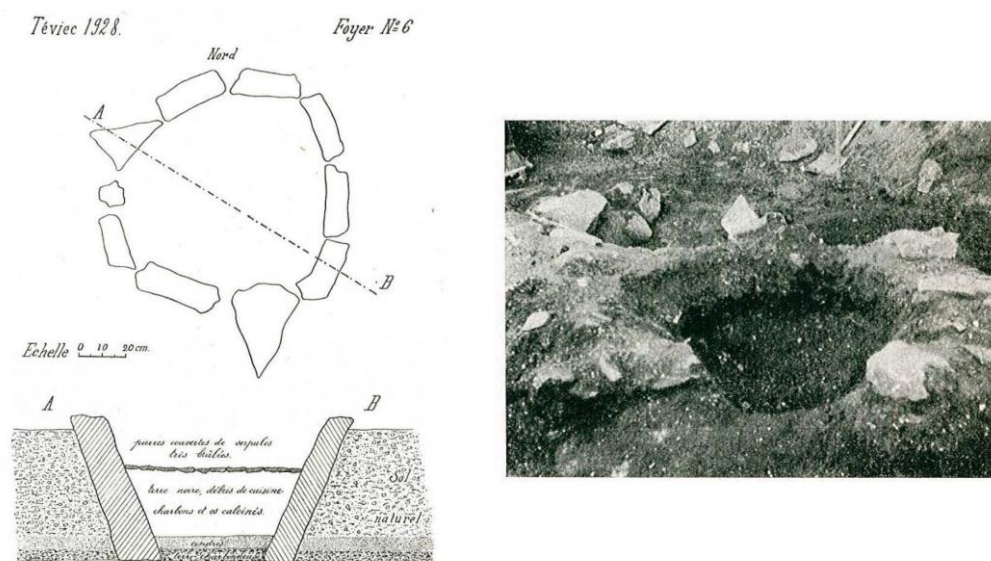


Figure 125: Tévéc – examples of hearth-pits classified as ‘feasting’ or ‘cooking’ hearths (hearth-pit no. 6 on the left and no. 17 on the right) (reproduced from Péquart et al., 1937, figs. 10 and 7).

Ten human graves containing one or multiple individuals were found and described in detail (Péquart et al., 1937). In total, 33 buried individuals were identified (adults and children). Eight features corresponded to grave pits that were mostly open in the sterile beach deposits, while two features were natural depressions in the rock. Despite having some diversity, most features had a circular or oval plan and were small (less than 1 m long) and shallow (between 0.12–0.20 m deep). The graves were concentrated in a specific area of the site, without overlapping each other. They were complex features, mostly including associated features,

notably ritual hearths, stone covering structures or both (Figure 126, Figure 127). Four graves had remains of ‘ritual hearths’ and stone structures that were described as massive concentrations of blocks (‘mausoleums’) (Péquart et al., 1937, p. 28). In addition, two skeletons had antler covering structures, while others had antler depositions near them. Several grave goods were also found, notably adornments. Despite the richness of the burial features and associated materials, non-burial pits and dwelling-related structures were not identified at the site. Only one isolated stone concentration, similar to those found on the graves but without an associated burial or pit, was identified at the eastern limit of the excavation. It was characterised as a ‘cenotaph’ (Péquart et al., 1937, p. 59), but the exact function is unclear.

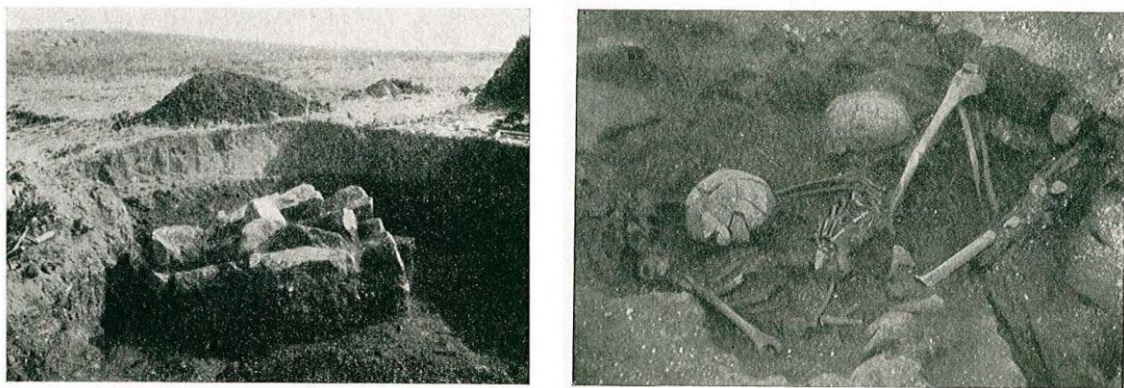


Figure 126: Téviec – examples of graves found at the site (Grave M with a ‘mausoleum’ on the left and Grave H with skeletons on the right) (reproduced from Péquart et al., 1937, figs. 25 and 19).

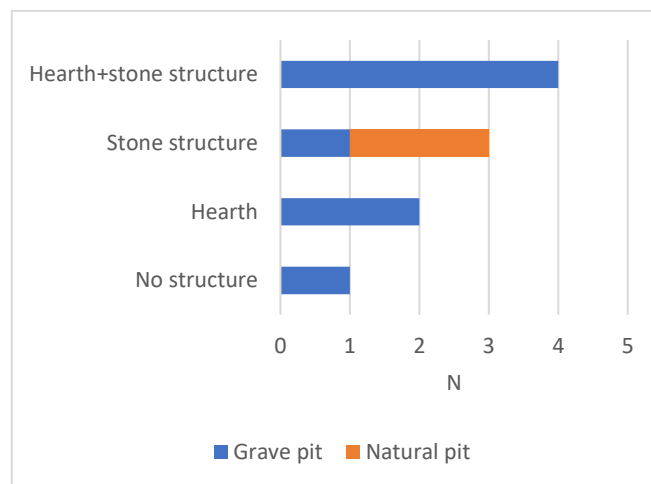


Figure 127: Téviec – graph displaying the types of structures associated with the grave pits found in the excavations of Péquart and Péquart (based on the data from Péquart et al., 1937).

Although the available stratigraphic and chronological data are too few to accept or reject the contemporaneity of the structures, the observation of the site plan published in 1937 and the analysis of the available descriptions (Péquart and Péquart, 1929; Péquart et al., 1937) allow the identification of some spatial patterns:

- 1) The funerary-related structures (graves, 'feasting/cooking hearths' and 'ritual hearths') were concentrated in the north-east zone of the site, while the western zone was characterised by a concentration of so-called 'domestic hearths' and the absence of burials;
- 2) The most complex grave pits (specifically, those with massive stone coverings) were the closest to the sea. On the one hand, this might indicate that the site was larger, extending to the direction of the sea; on the other hand, it could also suggest a preferential disposal of the dead near the sea.
- 3) The 'domestic hearths', which apparently presented different forms and dimensions, were distributed over the entire excavated area, with the exception of the eastern and south-east zones, in which a decrease in size of the archaeological level was observed by the excavators (Péquart and Péquart, 1929, p. 34).

In summary, it seems likely that there was some spatial arrangement of features and activities, with the concentration of burial and ritual activities on one side of the site. However, it is highly probable that the so-called 'domestic hearths' included features with different characteristics and purposes that could be other than 'domestic'. The importance of combustion activities throughout the site seems clear, although some descriptions indicate that the features were found in different archaeological contexts, suggesting some chronological differentiation. Also, the evidence of residential activity at the site is scant, being limited to some elements, such as the presence of lithic artefacts (with little information), combustion features without a visible funerary or ritual function, faunal remains from diverse animals or the shell midden itself. The function of these elements, however, can all be discussed in terms of a ritual–domestic dichotomy.

5.3.2.3. Höedic

The shell midden of Höedic was excavated between 1931 and 1934 by Marthe and Saint-Just Péquart (Péquart and Péquart, 1934; 1954), after the works at Tévéc. According to them (1954), at that time the site extended over an area of 200 m², as found at Tévéc. However, the shell deposit was thinner, approximately 0.25–0.50 m thick. In addition, a level of sands with Neolithic or more recent remains was identified, which was absent at Tévéc. This layer was over a sterile level of pebbles and sand deposited on the shell midden layer, revealing some discontinuity in the sequence (Figure 128). In addition, it was found that any Neolithic element was found in the shell midden layer, which was deposited directly on the bedrock (Péquart and Péquart, 1954, p. 11). However, in general, the available information about the excavations at Höedic is much less numerous when compared to Tévéc.

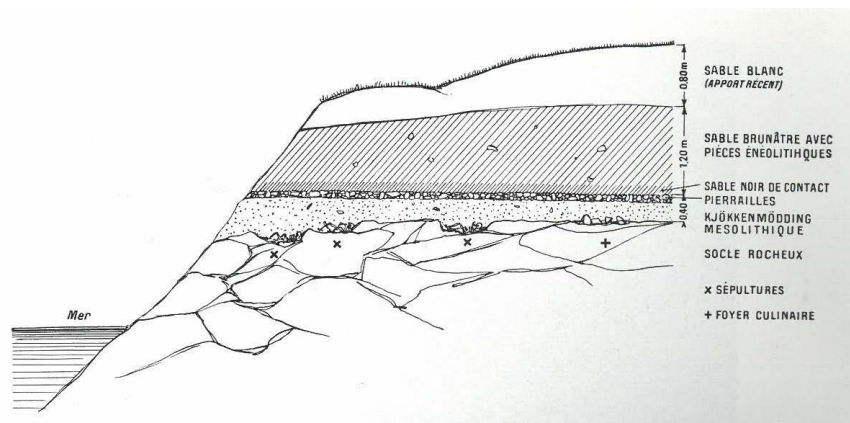


Figure 128: Höedic – scheme of the stratigraphy of the site, in which the Mesolithic shell layer lies on the bottom, and hearths and graves lie in the bedrock (reproduced from Péquart and Péquart, 1954, fig. 5).

Some lithic material was found, but the exact numbers and other pieces of detailed information are unknown, apart from abundant retouched tools. It was reported that an assemblage of about 50 narrow and thin blades was found near a hearth, which was interpreted as a probable deposit for stock of lithic material that would be used for microlithic tool production (Péquart and Péquart, 1934; 1954, p. 17), although other hypotheses can also be considered. Bone/antler tools and faunal remains from diverse animals were also recovered. In general, the number of obtained materials seems to have been lower compared to Tévéc (Péquart and Péquart, 1954). Contrary to this, abundant personal ornaments were found at Höedic, especially shell adornments.

In respect to the features, the excavators reported that, in general, the structures from Höedic were less solid and complex than those from Tévéc (Péquart and Péquart, 1954, p. 62) (Figure 129). Some hearths of different types (surface hearths and ones inside natural depressions of the bedrock) were identified through the presence of some blocks, fire-cracked rocks and charcoal (Péquart and Péquart, 1934; 1954). According to Péquart and Péquart, these features were less structured than those from Tévéc, which would indicate their use for immediate purposes (Figure 130). Only one combustion feature was graphically represented in the publications, showing a circular and flat hearth no more than 2.10 m long (Péquart and Péquart, 1954, p. 15), that reveals a relative simplicity of the construction. However, the combustion features were not represented in the site plan and few spatial references were provided. According to the descriptions of the excavations, at least some hearths would have been found near the graves (Péquart and Péquart, 1954, p. 30) and remains of a supposed ritual hearth were detected on the covering slab of a grave (grave K) (Péquart and Péquart, 1954, p. 52). It was also observed that the shell deposits were denser in the zones where the hearths were located (Péquart and Péquart, 1934, p. 4), a situation that might indicate that the combustion activity was related in some way to the deposition of the shell midden. The little stratigraphic information that is available indicates that most combustion features were under the shell layer (Péquart and Péquart, 1954, fig. 5).

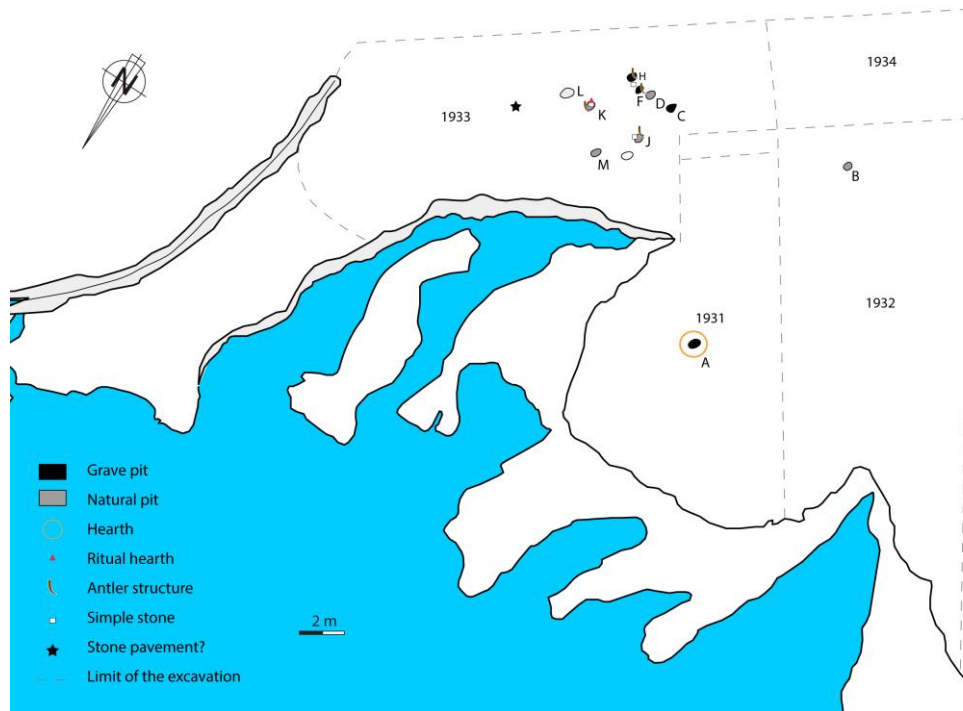


Figure 129: Höedic – site plan with the location of the different types of features identified in the excavations (modified from Péquart and Péquart, 1954, fig. 42 based on the descriptive information).

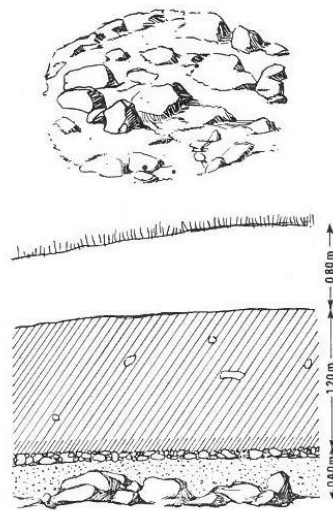


Figure 130: Höedic – drawing of a hearth (reproduced from Péquart and Péquart, 1954, p. 15).

A total of 10 graves with different typologies (grave pits, natural depressions, simple depositions) were found from which nine contained human remains of a total of 14 individuals (Figure 131). The features were detected at the bottom of the stratigraphy (cutting into the shell layer or in the bedrock). Most graves (eight) were concentrated in the eastern part of the excavated area, as a single cluster. The most complex graves (with associated structures, such as hearths or antler structures) were found close to each other, but, in general, the features occupied a larger area of the site when compared to Téviec. The absence of stone structures such as those identified at Téviec ('mausoleums') was highlighted by the excavators (Péquart and Péquart, 1954, p. 62). At Höedic, although most graves were

delimited by small pebbles, the bodies were usually protected with small slabs and the shell midden deposit, instead of large stone structures. Ritual hearths were also rarely reported (two cases), being assumed that most fires were sporadic. In addition, it can be stated that, in the case of Höedic, the effort of digging a pit was lower, considering that the use of ‘natural pits’ (natural depressions in the rock) was recorded in half of the graves (five cases). A case of simple deposition on the flat bedrock was also reported. Grave pits were only found in four cases, cutting into the shell layer or the bedrock. Despite the relative simplicity of the features at Höedic, antler structures were found in four graves, being more frequent than at Téviec (Péquart and Péquart, 1954, p. 72) (Figure 132). Grave goods were also relatively numerous, notably adornments, antlers and bone tools. Finally, a circular and large stone concentration (characterised as a pavement/floor), without associated materials, was identified to the east of the necropolis, at some distance from the main concentration of graves. It was interpreted as a structure for flattening the terrain surface, with a possible social or ritual function (Péquart and Péquart, 1954, p. 64). However, the nature of this feature and its association with the funerary and ritual activity are unclear (Figure 133).

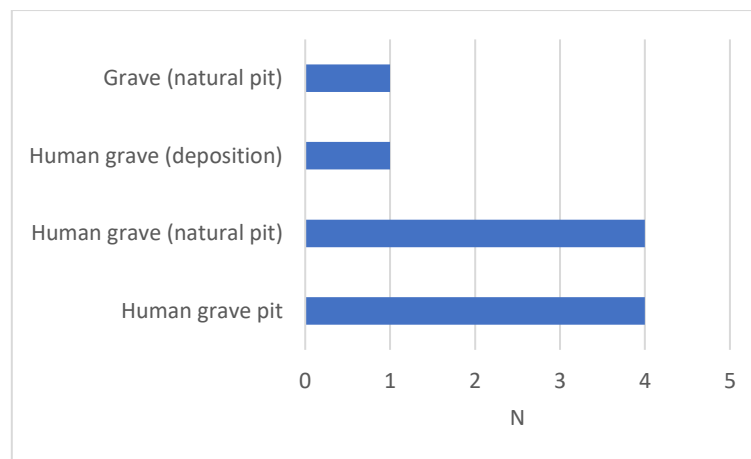


Figure 131: Höedic – graph displaying the types of graves found at the site: ‘human grave pit’ (grave pit with human remains), ‘human grave (natural pit)’ (natural depressions in the rock with human remains), ‘human grave (deposition)’ (deposition of human remains on the bedrock), ‘grave (natural pit)’ (natural depression in the rock with typical grave goods inside but no skeletal remains) (based on the data from Péquart and Péquart, 1954).

The funerary and ritual use of this site is clear, considering the graves and other material evidence that were found, despite the apparent lower complexity of the features and intensity of combustion activities when compared with Téviec. The difference in the effort made in construction is noticeable through the typology of the graves, but also of the hearths, notably the absence of identified hearth-pits and the simple structure of the features in general. As found at Téviec, there is little evidence of a residential use of the site, apart from the presence of lithic and faunal remains, some hearths and the relatively isolated stone concentration. However, the details of the features are little known, and the exact functions (domestic or ritual) are up for discussion.



Figure 132: Höedic – (left) grave J with remains of an antler structure (reproduced from Péquart and Péquart, 1954, fig. 31); (right) grave L, lying on the bedrock (reproduced from Péquart and Péquart, 1954, fig. Pl. III, 5).

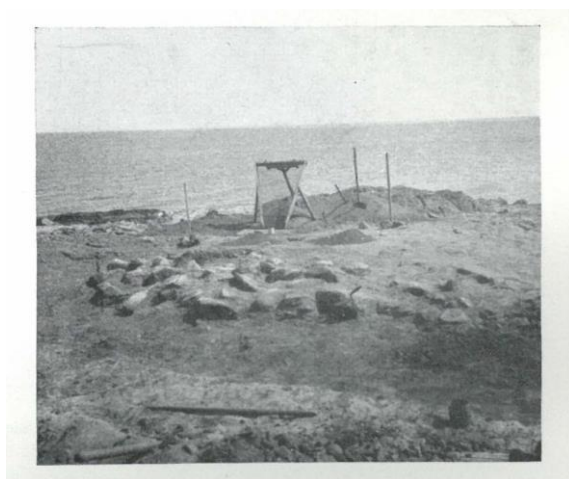


Figure 133: Höedic – photo of the isolated stone structure found to the east of the main cluster of graves, whose function is unknown (reproduced from Péquart and Péquart, 1954, fig. Pl.III, 6).

5.3.2.4. Discussion and conclusions

The characteristics of the available information from the sites of Beg-an-Dorchenn, Téviec and Höedic are considerably different. At Téviec and Höedic, the excavations occurred a longer time ago and most of the obtained data are related to the burial structures. Contrary to this, although the first field work at the site was dated to the end of the nineteenth century, Beg-an-Dorchenn was excavated more recently and provided more diverse datasets. The absence of funerary features from the Mesolithic chronology at the site contributed to a less focused approach, although the total excavated area was relatively small and the number of identified structures was lower.

In the three shell middens, the frequency of hearths indicates that combustion activities were an important component, both in funerary and non-funerary sites. Several types of combustion features were documented, from simple surface hearths to hearth-pits delimited by inclined slabs. The frequency of the latter type of hearth was probably associated with the need for protection of the fires from the coastal winds (Marchand, 2017).

The identification of several stone structured features at these sites (mostly hearths, graves) reveals some effort in its construction and maintenance, although being variable. For example, despite being two funerary sites with numerous similarities, the features (hearths and graves) at Tévéc and Höedic revealed significant differences, being generally more structured and complex at Tévéc. However, the presence of antler structures was more frequent at Höedic. It is thus difficult to evaluate the meaning of these differences between sites, notably if they result from adaptations to local conditions/resources or cultural differences.

At Tévéc and Höedic, the identified features were concentrated in certain areas of the sites. In addition, it can be noted that, to some extent, the features were grouped according to their types, such as evidenced at Tévéc by the location of the most complex features on a specific side of the site. Considering this, and despite the lack of data about other components, it can be understood that the location of the features through these sites was not random, but instead, followed rules of organisation that were kept during the period of occupation. Due to the limited area of excavation and the lower number of identified and well-defined features, spatial organisation is more difficult to evaluate in the case of Beg-an-Dorchenn. The practice of local lithic production is well-attested, but the hypothesis of the existence of a specific knapping area associated with an isolated block should be seen with caution, considering the possibility of sediment redeposition in shell midden contexts.

5.4. Shell middens in Okayama prefecture, western Japan

5.4.1. Hikozaki

5.4.1.1. Document analysis

The excavations in 1948–1949

Archaeological research at the Hikozaki shell midden begun in 1921. Successive field work (material collecting and excavation) took place before the Second World War, mainly under the framework of the activities of the Kibi Archaeological Association. However, little information is known about the details of these works (Tajima et al., 2007; 2008). In 1947, the eastern part of the site was partially destroyed as a consequence of construction works that were carried out for the expansion of the neighbouring brewery. Formal excavations were carried out in that area between 1948–1949 by the teams of the University of Tokyo directed by Nakao Sakazume and Hisashi Suzuki, and then by the researchers of the Hiroshima University directed by Jirō Ikeda (Tajima et al., 2013). A total area of about 200 m² would have been excavated by Sakazume and Suzuki (Yamasaki and Takahashi, 2007), while the excavations of Ikeda were limited to a small area of about 4 m² (Tajima et al., 2013). It is known that artificial levels were used in these excavations, but the use of sieving procedures was not described. In addition, during the most recent excavations, it was observed that some areas approached by the early researchers were not fully excavated, since some parts of the shell layers were still preserved (Tajima et al., 2013, p. 110). Despite this, the first works at the site resulted in the discovery of more than 20 human skeletons, mostly attributed to the Early Jomon, as well as a large quantity of pottery from the Early to the Final Jomon period, lithics, bone/antler tools and faunal remains (Ikehasu, 1971; Yamasaki and Takahashi, 2007). These discoveries attracted the attention of the scientific and local

communities at that time. The site became well-known at a national level, due to the large quantity of human skeletons that were found, but also the identification of pottery types (called Hikozaki Z1, Z2, K1 and K2 style) which became a chronological reference in the Seto Inland Sea region (Tajima et al., 2013).

The short report from Tōju Ikehasu (1971), which was published much later, describes a few aspects concerning the stratigraphy and structures that were found at the excavations (Figure 134). Two shell layers were identified, which were separated by an intermediate sandy layer. The lower shell layer (no. 1) was deposited over the basal sands and revealed a high density of shells and the presence of Hikozaki Z1 type pottery (Early Jomon), while the upper shell layer (no. 2) contained a high number of pebbles and pottery of Hikozaki Z2 type (Early Jomon) and from later periods. The skeletons were found in grave pits, which were cut into the deepest shell layer and the intermediate layer that separated the two shell layers, showing that the deposition of skeletons occurred after the formation of the first shell layer attributed to the Early Jomon phase (Ikehasu, 1971, p. 6). The presence of areas with ash, burnt soil (possible remains of surface hearths) and stone concentrations was frequent around the burials, notably between the second shell layer and the intermediate layer. It thus seems likely that these apparently simple features were related to burial activity.

Information about the distribution of materials other than pottery is absent. However, the presence of lithic remains from all the categories of the operational sequence and unfinished fragments of shell bracelets has been pointed out (Yamasaki and Takahashi, 2007), indicating the occurrence of production of flaked lithic artefacts and bracelets at the site.

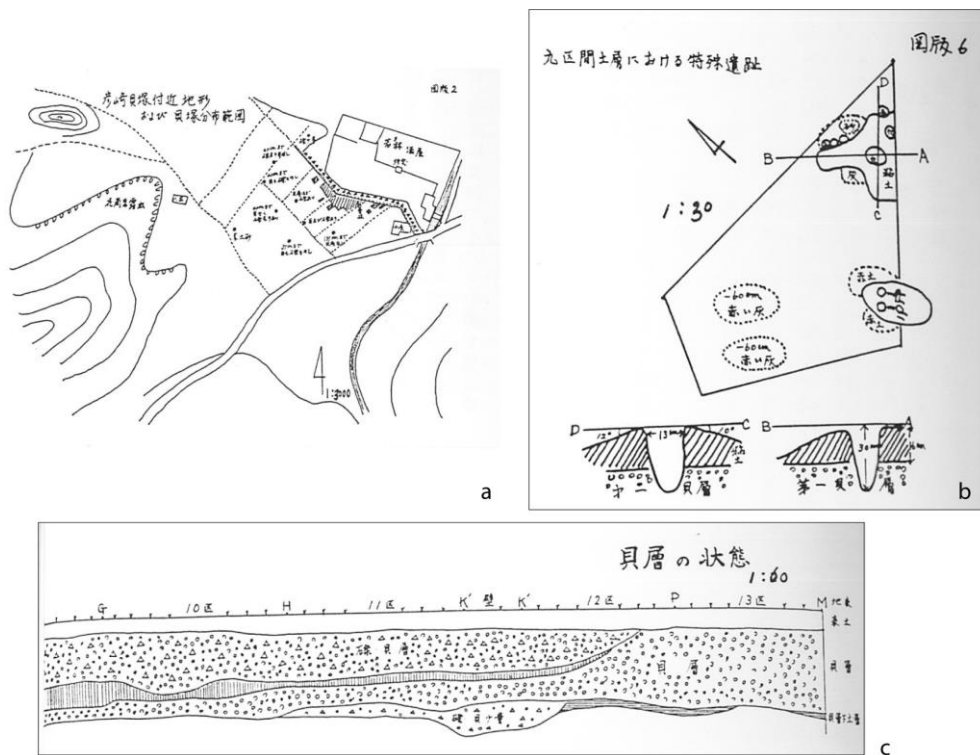


Figure 134: Hikozaiki – a) plan of the excavations in the 1940s (reproduced from Ikehasu, 1971, fig. 4); b) concentrations of ash near the identified graves (reproduced from Ikehasu, 1971, fig. 6); c) representation of part of the stratigraphic section, in which the two shell layers are separated by an intermediate layer (reproduced from Ikehasu, 1971, p. 6).

The excavations in 2003–2011

The most recent excavations at Hikozaki were undertaken in 2003–2004, 2006 and 2008–2011 by the former Nadasaki City Board of Education and current Okayama City Board of Education, in the context of the new measures for delimitation, protection and classification of the shell midden as a national designated site (Tajima et al., 2006; 2007; 2008; 2013). 47 trenches of different dimensions and distributed over three tablelands were excavated. The excavated area totalled more than 704 m². However, and following the objectives that were established for the field work, the excavation in most trenches was stopped when the shell layer was detected. Sieving, flotation and sediment screening procedures were applied to all the sediment from the Jomon layers and features as much as possible (Tajima et al., 2006, p. 162). In addition, three-dimensional recording of artefacts was used, although in a non-systematic way and limited to some trenches.

Overall, these works allowed researchers to estimate that the shell distribution occurred over an area of more than 10000 m² (Tajima et al. 2008). The site would have been mainly occupied from the Initial to the Final Jomon period, with the formation of the shell midden taking more than 5000 years. Evidence of occupation from the Jomon period was identified on two tablelands (A and B) (Tajima et al., 2008; 2013). The main tableland of the site (tableland B), which had been partially excavated in the previous works, revealed a sequence of shell layers from the Early to the Final Jomon and the presence of most of the features detected at the site. At tableland A, located on the western side and at a slightly higher altitude, it was observed that layers from the Yayoi period were above a Final Jomon layer without shells. Shell layers were not detected in the zone, but some features from the Final Jomon period were identified. Despite the limitations of the excavation by trenches, several features were identified, which were mostly located on tableland B, where the shell midden was detected.

According to the reports (Tajima et al., 2006; 2008; 2013), the excavations allowed researchers to show that, after a brief occupation of the site at the end of the Initial Jomon, the shell midden started to develop in the Early Jomon period (Figure 135). During this phase, the first features were constructed (notably pits, hearths and grave pits) and the shell midden would have reached its highest level of accumulation (1.7 m thick) and extension (8000 m²), indicating that the site would have acquired a central importance in the regional settlement. Evidence of occupation, shell midden formation and funerary use in the Middle Jomon period was also detected, although the shell midden area apparently decreased. In the later phase of the Late Jomon, the number of artefacts and features would have increased. In addition, some storage pits, symbolic artefacts and ritual features were identified, suggesting a renewal of the regional importance of the site and the control of the territory and food sources in this phase. Remains of occupation in the Final Jomon phase were also detected in the two tablelands of the site (A and B). However, it was observed that the shell midden area became smaller, and the number of identified features was more limited in this last phase of shell midden accumulation, marking the end of the role of Hikozaki as a settlement site.

from the Early Jomon and L17 from the end of the Initial Jomon until the beginning of the Early Jomon), which contained some pottery remains.

The shell midden was thus generally characterised as a continuous sequence of shell layers from the Early to the Final Jomon period. These layers were mostly described as ‘sediment with shells’, with some variations in shell density, malacological species (generally dominated by oysters and, in a smaller quantity, blood clam) and frequency of inclusions (notably pebbles). Some layers and occasional small deposits with a high density of shells were identified. For example, a dense deposit of closed oysters was found inside a grave pit, and was interpreted as an intentional covering (Tajima et al., 2006, p. 99). The sequence of shell layers had a visible interruption during the Early Jomon period, as evidenced by layer 12 (L12), a thin, sandy and almost sterile layer, which possibly corresponded to a short period of abandonment of the site (Tajima et al., 2006, p. 180), or to an intentional deposit to clean or control the smell of the accumulated debris (Tajima et al., 2008, p. 30). In addition, important changes were detected in the Final Jomon phase, notably a shift in the dominant malacological species from oyster to blood cockle, which was interpreted as a consequence of sea regression in the area. It was also found that in some phases of formation, notably during the first phase of the Early Jomon and the Final Jomon period, the shell midden was actually divided into two main areas of deposition (Tajima et al., 2013, fig. 81).

In summary, a large quantity of archaeological material was found in these excavations, which included pottery (from the Initial Jomon to the Final Jomon types), lithic tools (flaked stone tools, mostly on sanukite, but also some ground and polished stone tools), bone/antler and shell tools (including fishing tools and adornments) and some clay artefacts. Lithic and bone/antler and shell tool production also occurred at the site. The use of red pigment to paint some pottery vessels was also observed. A high quantity of faunal remains from diverse animals (molluscs from several species, terrestrial and marine mammals, fish, reptiles, amphibians and birds) and some macrobotanical remains were also found, evidencing the exploitation of a wide range of food sources.

Despite the limitations of the trench excavation method, a large number of structures from the Early to the Final Jomon was identified, which included: 21 hearths, two storage pits, 16 other pits, 16 posthole-like features, two pottery concentrations, five human skeletons (some in grave pits) and four ritual features (vessel deposits with animal remains) (Tajima et al., 2006; 2008) (Figure 136).

The hearths were mostly found in Early Jomon contexts, inside and outside the shell layers, presenting diverse forms and dimensions (although being roughly circular). These features were mostly surface hearths characterised by a red-coloured burnt sediment (*Appendices – Figure B56*). Some hearths contained stones and fire-cracked rocks. Also, in some cases, the hearths were in slight depressions. At least one circular hearth structured by some stones was identified. It was considered that most of the simple fireplaces were mainly used for mollusc processing (mostly oysters) through boiling in pottery vessels, although an increase of stone hearths in the Final Jomon was suggested, which was possibly associated with *haigai* cockle steaming (Tajima et al., 2006, pp. 190–194).

In addition, several pits with circular and oval forms for unknown purposes were recorded in contexts ranging from the Early to the Final Jomon phase. However, clear storage pits

were only identified in the Late Jomon phase. These two features were wet storage pits and were detected on the edge of the plateau. They had a clay cover and one of them still contained some acorns and woven remains (Tajima et al., 2006, pp. 38–39). Contrary to this, the posthole-like features were mostly detected in Early Jomon contexts. These features were not structured and their distribution did not reveal a particular configuration, being difficult to interpret or attribute to a dwelling feature. Clear remains of dwellings were not identified at the site, but it was suggested that the residential features were probably constructed on the shell midden or on the flat areas behind (Tajima et al., 2006, p. 180).



Figure 136: Examples of features found at Hikozaki in 2003–2004 – a) hearths (trench 14); b) storage pit (bottom with acorns and woven remains); c) grave pit with human skeletons no.3 and 4 (photos courtesy of Okayama City Board of Education).

Concerning the vessel deposits with animal remains, the identified features occurred in the Early and Late Jomon phases in relatively small areas and revealed some diversity of the contexts. The deposition of animal remains – limited to red deer and wild boar – took place inside a vessel (usually red-painted), which in some cases was put in a negative feature. In some cases, associated evidence of combustion was also detected, including a case of re-use of a hearth (Tajima et al., 2006, p. 106).

The identified burials were mostly single inhumations ascribed to the Middle and Late Jomon phases and their number was low when compared to those found in the preceding excavations. However, it should be noted that the recent excavations were only undertaken until the detection of the shell layer. Grave pits were identified in most cases. One of the

graves was under a fireplace and filled with a dense deposit of shells. In addition, a secondary burial was detected, revealing some variability in the funerary behaviour at the site.

Overall, the obtained archaeological evidence indicates an exploitation of diverse food sources at the site throughout the Jomon period. In addition, it was observed that different types of activities related to discard, food processing, tool production, burial and ritual were undertaken in close proximity (Tajima et al., 2013, fig. 81), although it seems that there was a certain spatial arrangement of the features. The importance of combustion activities was particularly highlighted, being related to food processing, but also ritual practices. The continuity of funerary and other ritual activities throughout the stratigraphy was also found, demonstrating the relevance of these activities throughout the entire period of occupation of the site, and not only during the first phase of the shell midden formation, to which most of the identified skeletons were attributed.

The spatial arrangement of the features

Numerous materials and features of different types have been found at the site of Hikozaki so far. According to the most recent research, the obtained evidence indicates that the features and associated activities were spatially organised at the site, although with significant changes through time (Tajima et al., 2013, fig. 81). In most cases, features of the same type were found in groups (notably graves, hearths and pits). The extension and layout of the shell midden seem to have changed considerably through time. The accumulations were larger in the Early Jomon phases, when funerary activity would have been more significant. Contrary to the large circular shell middens of the Kanto region, the layout of the shell midden does not reveal maintenance of a particular form, although a tendency of shell discard towards the north can be understood.

At least 34 human skeletons were identified during the excavations at the site. Burials were detected in Early, Middle and Late Jomon contexts, although the majority of the skeletons were attributed to the Early Jomon phase, cutting into the earliest shell layers. The limits of the grave pits were not always clear, but it was possible to understand that the single inhumation in relatively small pits was the most frequent procedure. Some cases of grave pits with multiple individuals were also identified. The burials were apparently organised in small groups, suggesting to the authors that the distribution reflected familiar relationships (Tajima et al., 2007, p. 76). In addition, the burials were found in specific areas of the site, notably in the north-eastern zone. The absence of cross-cutting relationships between the Early and Middle Jomon graves and the rarity of other features near the graves were considered as evidence of intentional maintenance of the preceding funerary spaces (Tajima et al., 2008, p. 69). However, it can be highlighted that combustion remains were detected over a Middle Jomon grave pit, indicating the practice of ritual fires or, at least, a spatial overlap (intentional or not) between combustion and burial activities (Tajima et al., 2006, p. 99; 2007, p. 74). It should be also noted that the presence of ash and burnt sediment near the skeletons was mentioned in the oldest documents about the site (Ikehasu, 1971), which also suggests a certain proximity between (at least some) combustion activities and burials.

According to the proposal of the excavators, food processing areas (defined by the presence of hearths and pits) would have tended to be located behind or between the areas

for shell deposition, although some overlaps would have occurred (Tajima et al., 2008; 2013). The researchers mentioned that during the Early and Middle Jomon phases, features other than graves were relatively rare in the areas with shell accumulation; contrary to this, several features (pits, hearths) were found in the flat areas without shells. It is thought that the residential (dwelling) area would have also been developed nearby, to the west of the shell midden (Tajima et al., 2008, p. 69).

Observing the published site plans and the location of the identified features (Tajima et al., 2006, pp. 178–195), a tendency for separation between burial and non-burial features seems clear in the Early Jomon phase, but it can also be found that some hearths, pits and ritual deposits were recorded in the shell midden area, indicating that the shell midden area was not limited to the placement of graves. In addition, the rarity of cross-cutting relationships in the Early Jomon period seems to be extendable to the majority of features and not limited to graves. Contrary to this, during the Middle Jomon phase, some features were cutting into others (including graves and pits), suggesting a different logic of spatial organisation.

Cross-cutting relationships between features were not identified for the Late Jomon phase. The diversity of features seems to have increased in this period, with the identification of ritual deposits and storage pits. In particular, the appearance of storage pits in a specific area, at the eastern edge of the plateau, can be considered as evidence of complexification of the intra-site spatial arrangement during this period. Concerning the ritual deposits with animal remains from the Late Jomon phase, symbolic items (a reused stone rod and clay objects) were found nearby and a reuse of a combustion feature was observed in one case, leading the researchers to suggest that significant changes could have occurred in ritual behaviour (Tajima et al., 2006, p. 190). It can also be found that all the ritual deposits of animal remains at the site occurred in shell midden contexts, indicating the existence of a relationship between the shell deposits and ritual activity.

During the Final Jomon phase, the dimension of the shell midden decreased, as well as the number and diversity of identified features (mostly limited to some pits), although the use of the two tablelands of the site was observed. Some human bones were collected, but clear funerary features from this period were not found. Formal hearths were also absent from the Final Jomon archaeological record, despite the identification of a high number of fire-cracked rocks, indicating the practice of combustion activities (Tajima et al., 2006, pp. 190–194).

5.4.1.2. Spatial analysis of material remains

5.4.1.2.1. Previous research and methods of lithic analysis

In the excavations of 2003–2004, 2006 and 2008–2011, a total of 2287 lithic remains (flaked, ground and polished stone tools) were recovered (Tajima et al., 2008; 2013). Previous studies (Tajima et al., 2006; 2007; 2008; 2013; Yamasaki and Takahashi, 2007) highlighted the presence of a sanukite-based flaked lithic industry dominated by flakes, as well as retouched flakes, scrapers and arrowheads among the tools, with frequent use of bifacial pressure flaking. According to the published raw-material provenance analyses (Tajima et al., 2007, pp. 123–124), the sanukite used in the materials from Hikozaiki would have been mostly

brought from Kanayama-Higashi (Sakaide city, Kagawa prefecture) located less than 30 km south from the site, on the island of Shikoku.

A re-analysis of the flaked lithic remains was undertaken at the History and Culture Centre of Nadasaki Town and the Centre for Archaeological Operations of Okayama City, which was focused on the material recovered from a set of trenches excavated at the main tableland of the site (T14, T8, T27, T9, T15, T23, T11, and T6). The purpose of this work was to obtain additional data on technological and typological aspects of the lithic production, and its spatial and diachronic variation at the site. The technological and typological characterisation was undertaken through the analysis of qualitative and metrical attributes proposed by several authors (Araújo, 1995–1997; Forenbaher, 1998; Inizian et al., 1999; Carvalho, 2008b; Uemine, 2012; 2018), which were adapted to the specific assemblage. Spatial analysis was undertaken on the materials from trench T14, the central and largest trench of the site (2 m x 20 m), where the highest number of materials and structures was identified. This trench was divided into ten squares/rectangular areas of approximately 2 m² (from A to J) and excavated until the Early Jomon features (Tajima et al., 2006). For the analysis, the available data of three-dimensional piece plotting⁹, as well as the published information about the lithic provenance by squares (excluding sections), chronological phases and stratigraphic layers were used (Tajima et al., 2006; 2007; 2008). The map rendering of the lithic distribution used GIS software (Quantum GIS). However, several aspects related to the methodology of excavation and the nature of the lithic assemblage conditioned the study and should be taken into consideration for the interpretation of the results, notably:

- 1) Limits of trench and partial excavation – shell layers were only dug at trench T14 and at small test pits undertaken in other trenches; coordinates were taken for materials from trenches T14, T8 and T27, but not systematically.
- 2) Some areas of excavation were affected by previous field work – the areas A, B and C partially corresponded with the formerly excavated area by the Tokyo University team.
- 3) Discrepancy of the available quantitative data, which were mostly obtained from the trench T14.
- 4) Existence of unprocessed sediment from the site, which means that a significant number of small artefacts that can only be recovered through wet sieving could not be included in the analysis.
- 5) High degree of fragmentation of the lithic remains.

5.4.1.2.2. Analysis and results

Lithic technology and typology

The analysis was undertaken on a total of 1165 flaked lithic remains¹⁰ recovered during the excavation of trenches T14, T8, T27, T9, T15, T23, T11, and T6 (Figure 137). The majority of the material was recovered from trench T14 (77%, n=900). Trench T9 also yielded a large quantity of remains, although less numerous (n=117) (*Appendices – Table B33*).

⁹ Databases provided by Mr. Masanori Tajima, Centre for Archaeological Operations of Okayama City/Okayama City Board of Education.

¹⁰ Pebble tools, notably net sinkers, could not be included in this analysis.

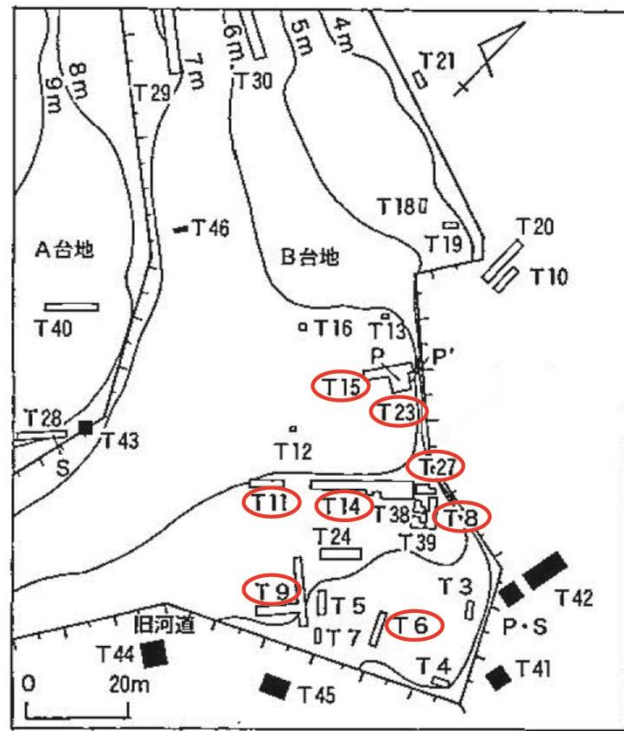


Figure 137: Hikozaki – map of the site with indication of the trenches (marked by circles) where the analysed lithic material was collected (modified from Tajima et al., 2013, fig. 81).

The analysed assemblage of lithic remains, made almost completely on sanukite (at least 95%), is dominated by debitage products (46%; $n=536$), namely flakes, followed by retouched tools (33%; $n=388$) (Table 11, Figure 138). Cores ($n=13$), core preparation and maintenance material ($n=3$) and splintered pieces ($n=18$) are few. The examined remains in general are predominantly ascribed through the archaeological context to the Late Jomon period (50%; $n=584$), and secondly to the Early Jomon (29%; $n=339$) (*Appendices – Table B34*). However, there are significant differences between trenches. With respect to the material from trench T14, it is mostly ascribed to the Late Jomon period (62%; $n=555$) (*Appendices – Table B35*), while almost all material from trench T9 (98%) and all material from trenches T23, T15, T8 and T27 is attributed to the Early Jomon period.

The technological categories that were identified in the assemblage indicate that flakes were the main blanks supporting the lithic production at Hikozaki. Cores were produced on flakes and also exhibit scars of flake removals. They do not display a standardised form or pattern of extraction, having quite variable dimensions. Platform preparation is only observable in one core, the predominant method being the use of cortical surfaces or natural fracture planes for striking. Most of the cores are attributed to the Middle ($n=5$) and Late Jomon period ($n=5$).

Table 11: Lithic technological categories from the Hikozaki site (flaked lithic material from T14, T8, T27, T9, T15, T23, T11, T6)

Technological category	Total N	Total %
Core	13	1.12%
Core preparation and maintenance	3	0.26%
Debitage product	536	46.01%
Retouched tool	388	33.30%
Arrowhead	75	
Scraper tools	59	
Retouched flake	42	
Notch/Denticulate	17	
Chipped stone axe	4	
Spearhead	1	
Irregular tool	1	
Diverse	189	
Splintered piece	18	1.55%
Debris	207	17.77%
Total	1165	100.00%

Debitage products are almost all flakes (98%, n=527). The absence of surface cortex for the most part (90%, n=472) suggests that the decortication was mainly performed off site. A high degree of fragmentation is visible, with only 12% (n=65) of the classified flakes remaining intact. The forms are not standardised, with frequent irregular (n=41) or divergent edges (n=20), and quite distributed lengths and widths (*Appendices – Table B38; Figure B63*). Despite the general small dimensions (less than 40 mm in length and 30 mm in width for the most part), the flakes are considerably wide. The orientation of the dorsal scars is variable, revealing a higher frequency of parallel (n=18), irregular (n=14) and crossed removals (n=12). Butts are mainly linear (n=94), flat (n=69) or cortical (n=49) (*Appendices – Table B40*), and bulbs are often diffuse (n=106) or absent (n=95) (*Appendices – Table B41*). In addition, some flakes present traces of crushing on the proximal end (n=23).

Flakes are the main blanks for tool production, which show a recurrent application of bifacial retouch. Arrowheads (n=75; 19%) and scraper tools (n=59; 15%) are the main classifiable tool types, although retouched flakes (n=42; 11%) and flakes with notches/denticulates (n=17; 4%) are also present in the analysed assemblage (*Appendices – Table B42*).

Arrowheads in various stages of production can be identified, indicating their local production at the site (*Appendices – Figure B59*). 40% of the analysed arrowheads are classifiable as final products (pieces with a fully defined regular shape, often obtained through invasive retouch), while 36% of the arrowheads can be characterised as belonging to an initial phase of production (blanks with a very irregular arrow form obtained through slight or any retouch) and 21% to an intermediate phase of production (pieces with a general, more regular outline and usually a more extensive retouch). Despite the existence of some formal diversity, concave bases (n=20), plain tips (n=24) and straight lateral edges (n=22) are the dominant characteristics of the arrowheads at the final stage of production (*Appendices – Table B43*). The use of invasive (n=16) or long retouch (n=8) is observable (*Appendices – Table B44*). Covering

retouch is absent, which indicates that it was probably not needed due to the thinness of the blanks. Diachronic differences on the arrowhead types seem not to be significant. However, it can be observed that the mean thickness values are slightly higher for the arrowheads from the Late Jomon, while the measurement values in general are lower for the Final Jomon (*Appendices – Table B44, Figure B64*). The overall values, especially those from the arrowheads from the Late Jomon phase, are very close to the dimensions of the assemblage of Asanebana shell midden,¹¹ as well as the materials recovered from the fifth excavation season at Tsushima Okadai, Okayama city. The latter presented an average length between 20 and 40 mm, average width between 10 and 20 mm and average thickness of 4.4 mm¹² (Okayama Daigaku Maizo Bunkazai Chosa Kenkyu Senta, 1994).

With respect to the scraper tools (the group that included side scrapers, tanged scrapers, endscrapers and fragments), the presence of cortical surfaces is rare (*Appendices – Figure B58*). The application of long (n=28) or short retouch (n=21) is prevalent, but tanged scrapers reveal a higher incidence of retouch, being frequent the use of long (n=9) and invasive retouch (n=4) in these tools. In general, it can be noted that the tools attributed to the Late Jomon present larger dimensions, especially in the case of side scrapers (*Appendices – Table B46*). It is probable that some of the scraper tools were used as cores before being retouched.

Among the retouched flakes and flakes with notches/denticulates, short retouch is predominant (n=25). The dimensions of the retouched flakes are generally higher than those of the unretouched flakes, suggesting a selection of larger flakes for tool production (*Appendices – Figure B58, B61 and B65*).

Some splintered pieces can be identified in the assemblage (n=18), being mainly attributed to Late Jomon contexts (n=11). Their forms tend to be rectangular and elongated. The dimensions are variable, but most of these artefacts present less than 60 mm in length and 50 mm in width, being relatively thick (*Appendices – Figure B58, B62 and B66, Table B47*). The mean thickness value of 12.44 ± 4.32 mm is close to the value of 13.6 mm registered for the thickest pieces of the Late Jomon assemblage recovered from the fifth excavation season at Tsushima Okadai (Okayama Daigaku Maizo Bunkazai Chosa Kenkyu Senta, 1994, p. 321). Previous analyses considered the splintered pieces to be working tools (Tajima et al., 2006, p. 217), following the traditional classification of Jomon lithic tools. Nevertheless, some of these artefacts could have resulted from the use of bipolar technique for lithic reduction at the site. The use of bipolar technique is well-identified at Tsushima Okadai, where it was associated with the production of arrowheads, due to the presence of small and thin flakes, and some small splintered pieces (Abe and Togashi, 1996). It can be suggested that, at Hikozaiki, some splintered pieces functioned as cores that were used until their exhaustion. The dimensions are suggestive of this function, since in general the analysed splintered pieces are thinner than cores, but thicker than unretouched flakes (*Appendices – Table B47*). Other elements of this industry also points towards the use of bipolar technique, such as: 1) the scarcity of identified cores; 2) some characteristics of the flakes, such as the high frequency

¹¹ Based on a preliminary observation of the available material deposited at the Okayama University of Science.

¹² The average values published in the report concern all arrowheads recovered in the fifth excavation season, including those that are not in the final stage of production (Okayama Daigaku Maizo Bunkazai Chosa Kenkyu Senta, 1994).

of small and thin pieces, linear butts and irregular edges, and the occurrence of traces of crushing on the proximal end, lateral fractures and accidents (Uemine, 2012; Gilabert et al., 2015); 3) the high frequency of fragments (Gilabert et al., 2015); 4) the presence of some chipped stone axes, probably produced through this technique (Kubota, 2007). However, to what extent this procedure could have been applied is a difficult question to address. Considering a context of importing large flakes into the site, it is possible to suggest that the bipolar technique could have facilitated the production of small flakes and some large tools, allowing a maximized use of sanukite, as this source was not immediately available.



Figure 138: Sample of flaked lithic materials from the Hikozaiki shell midden (excavations of 2003–2004 by the Okayama City Board of Education) – 1) core; 2) denticulated flake; 3) and 4) unretouched flakes; 5) tanged scraper; 6) side scraper; 7) splintered piece; 8) to 12) arrowheads (material deposited at the Centre for Archaeological Operations of Okayama City, photos by author).

In general, the observed typological and technological characteristics of the analysed lithic assemblage from Hikozaiki site are in accordance with those broadly described for the Jomon lithic production in the Okayama-Hiroshima Seto Inland sea region (Takehiro, 2003). Nevertheless, the restricted availability of the main raw material (sanukite) and the need for

a diversified toolkit for the variety of activities performed by the groups would have influenced the manufacture procedures at Hikozaki. Therefore, the use of strategies of maximization of sanukite are expectable, being evidenced in the lithic assemblage by a general small artefact size, the production and use of thin blanks, the frequency of short retouch, and the presence of splintered pieces suggesting an intensive use of flakes until their breakage or exhaustion.

Lithic chronological variation

Although the shell midden achieved its largest dimensions during the late Early Jomon phase (Tajima et al., 2008, p. 68), the highest quantity of lithic material recovered from the tablelands at Hikozaki with occupation evidence from the Jomon period was found in Late Jomon stratigraphic contexts (Tajima et al., 2008, p. 75). However, it should be taken into consideration that the material from the same chronology and preceding the shell midden formation is underrepresented in the collection due to the methodology of excavation that was adopted. In addition, the degree of fragmentation of the lithic remains also poses limitations to the classification procedure and diachronic interpretation of the material. Despite these constraints, the analysed assemblage of materials reveals that lithic production was quite uniform across the subperiods of occupation. The main technological and typological characteristics show a continuity of the use of sanukite and production objectives (a flake-based industry with scraper tools, retouched flakes and arrowheads). It can be understood that the stability of the groups occupying the site would have been crucial for the continuity of the acquisition of sanukite and other exogenous materials, the traditions of artefact production and the activities associated with these tools over several centuries. The maintenance of the main morphological characteristics of the arrowheads is particularly notable, since projectiles have been broadly considered to be dynamic elements of prehistoric material culture, since their morphological and technical features are often sensitive to changes in time and space (Pétillon et al., 2009).

Still, some diachronic differences can be distinguished. Cores were almost completely found in Middle or Late Jomon contexts, and splintered pieces in those from the Late Jomon. With respect to the Final Jomon period, flakes and tools seem to present smaller dimensions compared to other subperiods (*Appendices – Figure B63*), whereas some Late Jomon tools (scrapers) present the highest measurement values of the assemblage (*Appendices – Table B46*). An intensification of lithic production in the Late Jomon is suggested by the highest quantities of recovered material. Additionally, the presence of some large tools, such as chipped stone axes and scraper tools with higher dimensions, could have resulted from larger flakes being brought into the site in this period. Despite the possibility of an increased raw-material availability, sanukite was intensively used, as indicated by the frequency of small and highly exploited cores made from flakes, small debitage products and tools and splintered pieces (indicating the use of bipolar reduction). This visible increase in lithic production at Hikozaki can be associated with the increment of site density and population in the Okayama region in this period (Yamamoto, 2004; Tajima et al., 2008), as well as the growth of the circulation of sanukite (in quantity and dimension of blanks) in the Seto Inland Sea (Takehiro, 2003). On the contrary, although the number of analysed materials in this study is limited, it

is possible that lithic production at Hikozaki suffered a decrease in the Final Jomon, considering the smaller quantity of recovered lithics from the occupied tablelands and the lower dimensions of the products from some categories. Other archaeological indicators suggest a global decline in the activities at Hikozaki in the Final Jomon, notably the thinness of the shell layers and the absence of identified combustion structures from this phase (Tajima et al., 2006).

Lithic distribution at the site and in trench T14

Despite the discrepancies on the dimension of the assemblages, some differences in lithic composition can be observed between the analysed trenches (Figure 139). Cores were rarely found, but the majority was recovered in trench T14 (77%; n=10), particularly in areas F and G. Most splintered pieces were also found in trench T14 (89%; n=16). Core preparation and maintenance materials and chipped stone axes were exclusively found in this trench. With respect to the most frequent tool types, it can be highlighted that in trench T9 (mainly characterised by the presence of Early Jomon materials), a slightly higher percentage of scraper tools was found (23% of the total of tools in T9, compared to 14% in T14), although tanged scrapers were mostly found in trench T14 (13 of a total of 15) (*Appendices – Table B42*).

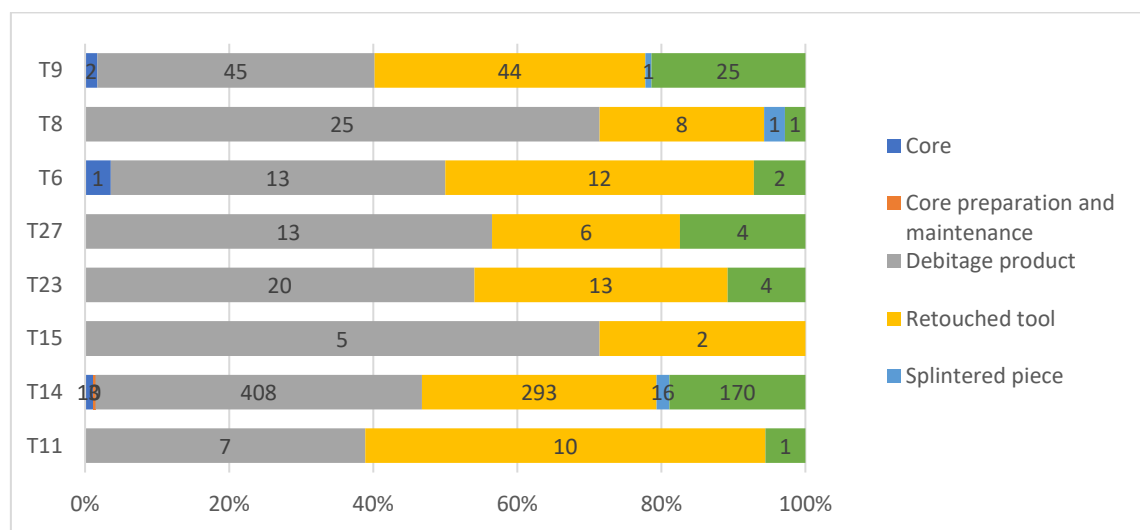


Figure 139: Hikozaki – lithic technological categories by trench.

According to the previous spatial analysis undertaken on the materials from trench T14, which was limited to the assemblage of individually plotted remains, the lowest artefact densities (pottery, lithic and other remains) coincided with the areas in which structures were identified (Tajima et al. 2006, p. 154–56). However, the present re-analysis of lithic remains included the data concerning the location of both individually plotted and non-plotted items (notably small lithic remains and flakes), providing a quite different perspective. The obtained results indicate that the main lithic concentrations were found in the areas with identified structures (e.g., hearths and pits), especially in the Early, Middle and Late Jomon phases (Figure 140, Figure 141):

- Early Jomon phase – the previous study indicated that the zones with a lower artefact density coincided with the zones where structures were located or found nearby

(Tajima et al., 2006, p. 154). However, the present analysis indicates that the highest densities of lithic remains were found in areas H, A, E and C, where several structures were detected.

- Middle Jomon phase – the previous analysis revealed that the artefact distribution was similar to the Early Jomon phase, although with a higher concentration around the pits, but not around the funerary pits (Tajima et al., 2006, p. 154). Contrary to this, the present analysis indicates that the densest concentrations were located in area E, where hearths, pits and graves were identified.
- Late Jomon phase – it was observed in the previous analysis that, in trench T14, the artefact density in general decreased in a south-west direction (area J), following the reduction in the thickness of the shell layer in the same direction (Tajima et al., 2006, p. 156). However, the present re-analysis of the lithic distribution by squares/areas reveals that areas F and J were the densest in lithic remains. Some differences in the distribution of certain categories of material can also be mentioned, with a higher presence of cores, splintered pieces and scraper tools inside and near area F, while the presence of debris and arrowheads seems more relevant in area J (Figure 142).
- Final Jomon phase – the identified structures and material remains were not abundant, but the highest concentrations of lithic material were found in areas I and J.

In addition, it can be noted that the infills of negative structures also contained a relatively abundant quantity of lithic remains, such as the case of Pit 2 and 3 (Middle Jomon), in which tools with larger dimensions, such as cores and ground stone tools, were found (*Appendices – Table B36 and B37*). The association of some cores and splintered pieces with pits from the Middle Jomon phase and ritual vessel deposits of animal remains from the Late Jomon phase also suggests the possibility that a symbolic value was attributed to these elements.

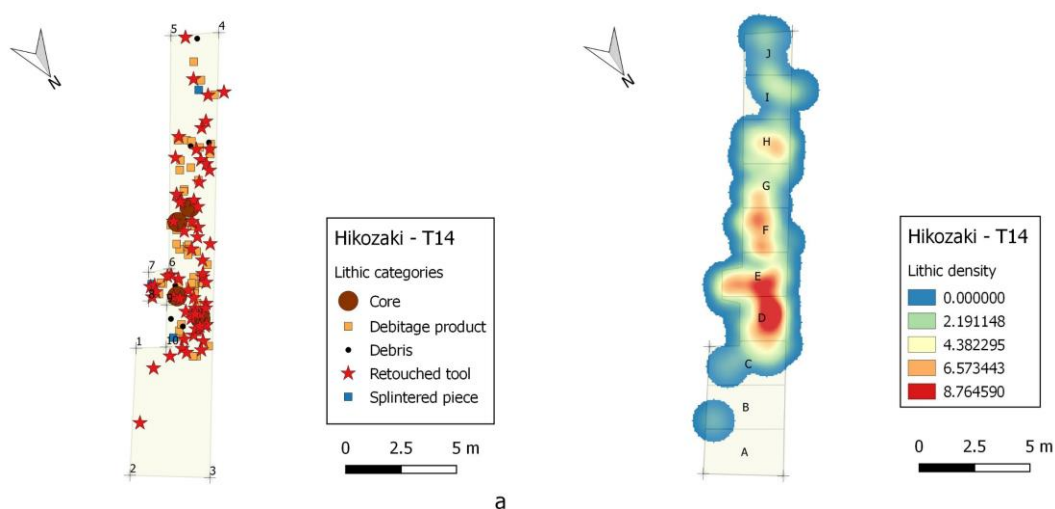


Figure 140: Hikozaiki, trench T14 – distribution of the individually plotted lithics (a) and Kernel Density Estimation (b) (image by author).

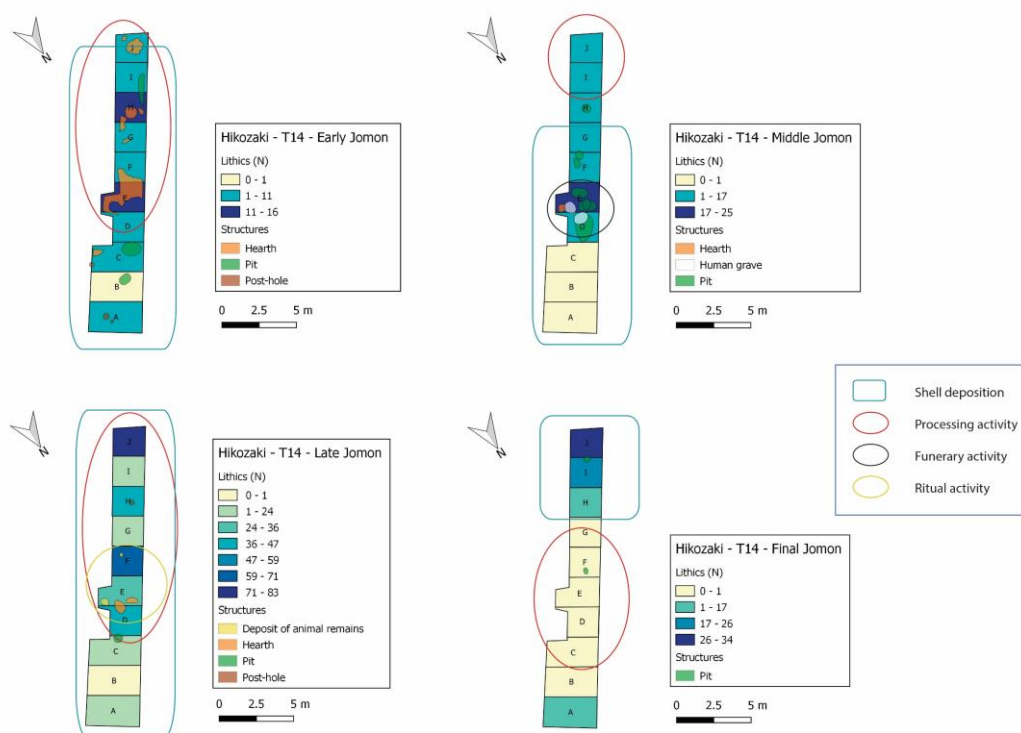


Figure 141: Hikozaiki, trench T14 – general distribution of lithic remains by squares/areas and Jomon subperiods (Early, Middle, Late and Final Jomon). The chronological attributions follow the published information in the reports (Tajima et al., 2006; 2007; 2008). The approximate location of the features and activity areas is based on the plans and the model of site evolution proposed by the excavators (Tajima et al., 2006, pp. 83–115; 2013, fig. 81) (image by author).

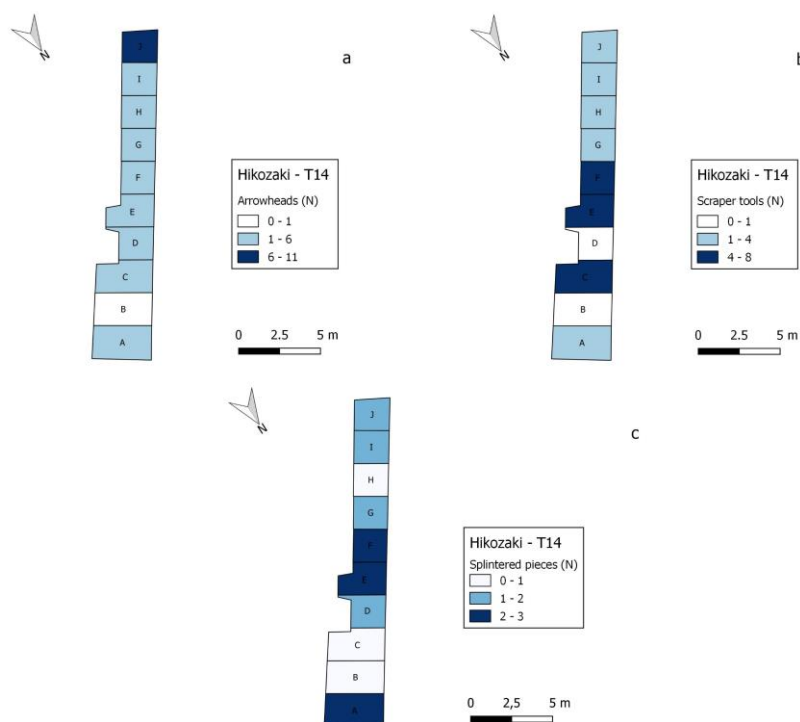


Figure 142: Hikozaiki, trench T14 – distribution of a) arrowheads, b) scraper tools and c) splintered pieces, by squares/areas (all Jomon subperiods included) (image by author).

The general lithic distribution in trench T14 seems to have progressively changed through time from the north-east to the south-west zone, following the development of the shell midden, which became denser in the western zone in the Late and Final Jomon phases. It should be taken into consideration that most of the analysed lithic remains were recovered from the shell layers (at least 65%, without counting the material associated with the structures). Therefore, the deposition of lithic remains seems to have been deeply linked with the deposition of shells, although the internal variation in the thickness of shell layers in trench T14 does not appear to be reflected in the quantity of recovered material in a simplistic way. It is yet possible that the variations in the type or size of the remains were somehow related to shell density, since larger artefacts were more frequently found in the middle zone of trench T14, where shell layers were thicker and structures more frequent.

The presence of all the technological categories of the operational sequences of lithic production (e.g., cores, splintered pieces, debitage products, tools, debris) and their characteristics indicate that lithic manufacture and discard were performed at the site throughout its occupation, with a higher intensity in the Early and Late Jomon periods. The available evidence also suggests that lithic manufacture at Hikozaki was mainly operated in proximity to shell discard, combustion, processing and ritual activities. At Tsushima Okadai, the 15th excavation season revealed a residential zone from the Late Jomon occupation, where lithic concentrations coincided with the major densities of structures (notably pits and combustion features) and indicated, according to the researchers, the presence of a debitage zone (Kutsuna, 2004). At Hikozaki, several factors pose difficulties to the interpretation of the lithic distribution, notably the restricted areas of excavation, the long time span of occupation and accumulation of refuse, the absence of microstratigraphic analyses and the need for deeper studies with the inclusion of all the lithic materials recovered through sieving. Despite these limitations, the presence of cores and splintered pieces, the high lithic density in general (with flakes, tools and debris, some large blanks) and the frequency of certain features (e.g., hearths) are suggestive of the presence of a debitage zone during the Late Jomon phase in the area of trench T14, possibly around squares D–F. It is also possible that some of these lithic materials were related to processing and ritual activities that took place in that area (Tajima et al., 2006, p. 190).

Overall, if the proximity between remains of different activities is evident at Hikozaki, notably at tableland B, the relationships between them are less clear. As mentioned before, burials appear that were organised in specific areas of the site and generally kept without significant disturbance. However, their association with shell deposits and closeness to other structures and material evidence (including lithic remains), which is particularly visible in the Middle Jomon phase, suggests that boundaries between ‘domestic’ and ‘ritual’ activities were not fixed, or, if existed, were not kept at the site for a long time.

5.4.1.2.3. Discussion and conclusions

The results of the analysis of the flaked lithic material from Hikozaki reveal that local lithic production was kept during the long time span of Jomon occupation, with few substantial changes. The maintenance of the main characteristics of lithic tool production

during such a long period can be interpreted as a result of high stability achieved by the Jomon groups in terms of raw-material acquisition, artefactual traditions and subsistence activities.

The integration of material that was not piece-plotted into the lithic analysis allows us to better understand the characteristics of artefact production and to obtain a considerably different view of the spatial distribution of the remains, in which the presence of features cannot be seen as an opposite occurrence in relation to the presence of lithic remains. The available evidence indicates that the production and discard of lithic tools were centred on a relatively limited area of the site, where other activities took place in proximity to each other, notably shell discard, combustion, food processing and ritual activities. In particular, shell midden formation occurred from the Early to the Final Jomon, revealing a long continuity of mollusc processing and discard at the same site and over the same tableland. The continuity of funerary and other ritual activities is also expressive of the symbolic importance of the Hikozaki shell midden for the Jomon groups. This concentration of activities of a different nature, which was also kept over a long period, can be related to the relevance of the site location in a territorially restricted area (the current Kojima peninsula was an island at the time), with a high productivity provided by the surrounding ecotone ecosystem and a strategic positioning in exchange networks between the seashore and more inland zones of the Seto Inland Sea region. Internally, the possible establishment of dwelling structures (residential zone) on the flat areas of the western part of the site, configuring a residential area outside the shell midden accumulations (Tajima et al., 2008, p. 69), can be seen as another explanation for the spatial circumscription of the other activities.

The general diachronic changes observed at Hikozaki and the strong association between shell deposition and lithic tool production/discard activities indicate that the access and consumption/use of aquatic food resources played a vital role in the duration and intensity of the occupations, even if a wide range of food sources were exploited and diverse activities were undertaken at the site.

5.4.2. Document analysis from other sites

5.4.2.1. Tsukumo

The discovery of the shell midden of Tsukumo goes back to 1870, but the first formal excavations only started in 1915 under the direction of Ryūzō Torii. The site was successively excavated by different researchers until 1921, in about 20 campaigns, with the main purpose of recovering human skeletons (Kamaki, 1986). The high number of identified burials – more than 170 individuals in total (Ando et al., 2020), many with a good state of preservation – strongly contributed to the development of numerous studies in the Jomon funerary world. However, detailed information about the archaeological context is scant, the available data being mostly limited to the reports from Kenji Kiyono, Sadahiko Shimada and collaborators about the excavation campaigns of 1919–1920 (Kiyono et al., 1920; Kyoto Teikoku Bungakubu Kokogaku Kenkyu Hokoku, 1920; Shimada et al., 1920) and some descriptions in a monograph about the works of 1921 (Kiyono, 1969). The most recent synthesis report of the Tsukumo shell midden (Ando et al., 2020) includes a publication and study of several

additional documents from the old excavations, but the available contextual information is still limited.

Excavations in 1919-1921

According to the above-mentioned old reports, the site did not reveal signs of shells on the surface at the time of the excavations of 1919–1920 (Kiyono et al., 1920, p. 2), which indicates that the shell midden was discrete, with a low visibility on the ground, as can also be observed today. It was characterised by the presence of a relatively thin layer of dark sediment with shells 0.30–0.60 m thick, which lied between two thin layers of black soil. A first layer of black soil was directly under the topsoil, while a second black soil layer was at the bottom of the stratigraphy, over the bedrock (clay and sands). The thickness of the shell layer was not constant and varied through the excavated area, being thicker at north-west and thinner towards south-west, a variation that is also visible in the schematic representation of the stratigraphy (Kyoto Teikoku Bungakubu Kokogaku Kenkyu Hokoku, 1920, fig. plate 3) (Figure 143). It was observed that the layer contained a relatively low density of shells, and in some areas, it was hardly distinguished from the soil. The mentioned stratigraphic scheme and the descriptions in the reports (Kiyono et al., 1920, p. 3) indicate that burials were mostly found in the deepest part of the shell layer, at a similar depth. Few skeletons were found in the upper part of the shell layer and in the upper black soil, including in the area without shell accumulation. Despite the predominant placement of the burials in the shell layer, their location was not limited to the areas with a higher density and thickness of shell accumulation, being also found in areas without shells, as also observable in the photos (*Appendices – Figure B67*).

According to the descriptions, cultural materials were mainly detected in the black soil and shell layer, and some in the disturbed top soil (Kiyono et al., 1920, p. 2). Pottery remains were abundant, but stone tools were rare (Kiyono, 1969, p. 39), although both types of material were more present in the black soil (Kiyono et al., 1920, p. 24). The upper black soil contained pottery from the Jomon period, but also some fragments from the Yayoi and more recent periods (Shimada et al., 1920, p. 24), a situation that indicates some disturbance. Contrary to this, those more recent remains were, according to the reports, almost absent in the shell layer. The presence of personal ornaments at the site was highlighted, notably earrings, shell bracelets and beads, which in several cases were found *in situ*, associated with the skeletons – in particular, many skeletal remains were found wearing shell bracelets on their wrists (Kiyono, 1969, p. 38) (*Appendices – Figure B67*). These situations attest to the good preservation of the burial contexts in general. Charcoal remains were identified near some skeletons, indicating possible combustion activities (Kiyono et al., 1920, p. 4) that could have been related to funerary rituals, but the presence of formal fireplaces was not reported. It was only noted that some stones were also found near a number of skeletons (Kiyono et al., 1920, p. 4). One photo shows the presence of a large and isolated block between skeleton 1 and 2 (Kyoto Teikoku Bungakubu Kokogaku Kenkyu Hokoku, 1920, fig. plate 4) (*Appendices – Figure B68*), but it seems to be a single documented case. The presence of stone structures was not recorded or noted at all in the texts.

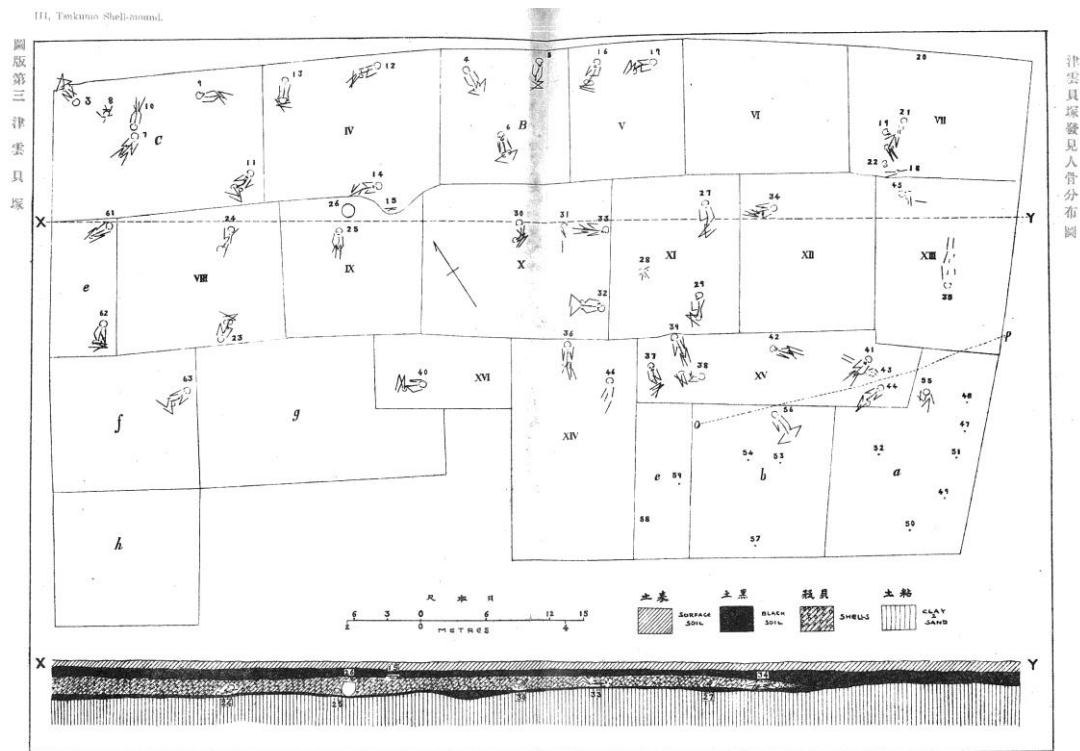


Figure 143: Tsukumo – plan and stratigraphic section of the excavated area in 1919–1920 with the identified burials (reproduced from Kyoto Teikoku Bungakubu Kokogaku Kenkyu Hokoku, 1920, fig. Plate 3).

In fact, and despite the high number of human burials that were found, the features identified during these excavations were limited to grave pits, which were distributed over most of the excavated area, and the deposition of a cinerary urn with an infant skeleton (Kiyono et al., 1920, p. 4). The majority of the burials were individual and occurred in pits that did not affect each other, revealing a general respect for previous inhumations. However, some intersections between features were mentioned (Kiyono et al., 1920, p. 3), which suggest the existence of chronological differences. The existence of significant chronological differences between burials was recently confirmed by several radiocarbon dates obtained from the human skeletons, which indicate a Final Jomon chronology for most of them and a main period of funerary activity of about 300 years, although some skeletons were dated to the Middle and Late Jomon (Ando et al., 2020). The position of the graves also indicates the existence of a spatial organisation by groups, since some configurations such as circles and rows can be observed. Some divisions by gender, type of adornments and type of tooth ablation can be identified, as previously commented on by other researchers (Kamaki, 1986; Kawase, 2006; Yamada, 2009; Ando et al., 2020). It was noted that skeletons with a higher number of bracelets were more frequently found in the north-western zone (Kiyono, 1969, p. 36), an observation that is in accordance with the higher frequency of females in the area and a major occurrence of skeletons wearing bracelets among females (Kiyono et al., 1920, p. 5). More recently, it was observed that waist ornaments were associated with the skeletons found in the western zone and earrings with those found in the south-eastern zone (Ando et al., 2020). It can be also noticed in the site plan published by Kamaki (1986, fig. 68) that

children tended to be grouped in specific locations (Figure 144). Overall, and despite the rarity of data and difficulties of interpretation, it seems likely that the location of burials was conditioned by certain rules of spatial organisation.

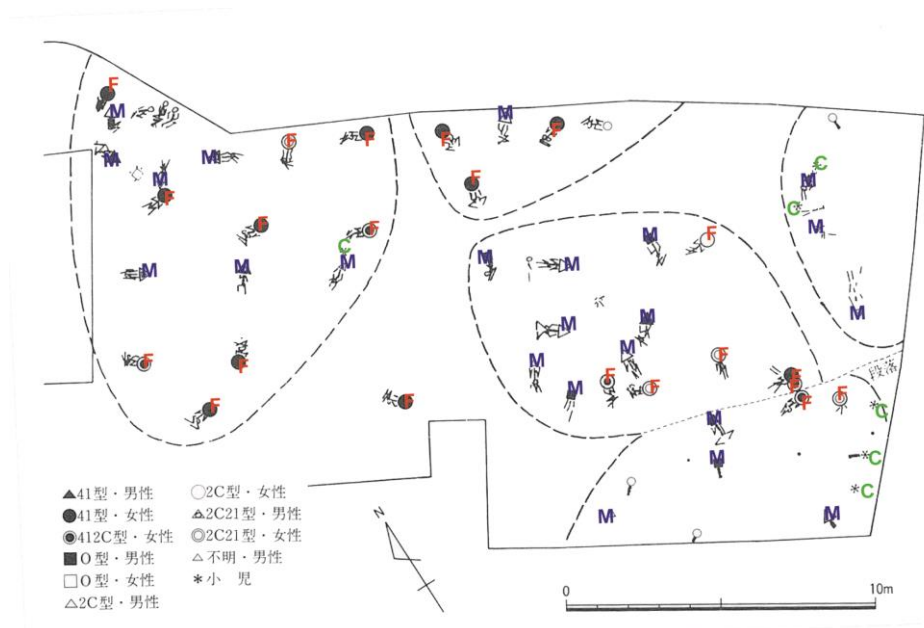


Figure 144: Tsukumo – plan of the excavated area in 1919–1920 with burials, highlighting the location of males (M), females (F) and children (C) (modified from Kamaki, 1986, fig. 68).

The records from the field work at Tsukumo in 1919–1921 suggest that the funerary activity was concentrated in the initial phases of the formation of the shell midden, although burials were found throughout the entire stratigraphy of the site. Considering the stratigraphic contexts of the burials (mostly located in the shell layer) and the absence of identified non-burial features, the accumulation of the shell midden seems to have been strongly related to the burial activity at the site. However, the identification of graves both in shell-rich and poor areas might indicate that this relation was not so linear from the spatial perspective, or there were substantial intra-site differences in the preservation of the shell midden. The rarity of detailed contextual data from the old excavations, however, limits a better understanding of this unique site in the Okayama region.

5.4.2.2. Discussion and conclusions

Due to the rarity of detailed information about the contexts of the discoveries at Tsukumo shell midden at the beginning of the twentieth century, possible inferences about site structure are very limited at the present stage of knowledge. It seems clear that the position of burials followed certain rules of intra-site spatial organisation, for which at least the sex and age of the individuals would have been influencing factors. However, it is crucial to obtain detailed chronological data for the burials in order to better understand this matter and the time span of occupation. The absence of features other than graves and the low density of the shell accumulations are quite peculiar characteristics, considering the high number of burials that were found and the dimensions of the site. However, this situation also poses additional difficulties for the interpretation.

In terms of site function, Tsukumo shell midden provided abundant evidence of the critical role of funerary and ritual activities at the site, despite the occurrence of significant remains of other activities, such as hunting and fishing. The little stratigraphic information indicates that the formation of the shell midden was strongly related to the funerary activity. At the same time, the importance of the exploitation of aquatic resources is evidenced not only by the presence of the shell midden itself, specific artefacts (e.g., fishing tools) and faunal remains, but also concerning some data from the anthropological remains (isotope and skeleton evidence). Therefore, it can be considered that the site was a place with a prolonged occupation where multiple types of activities occurred, although with a particularly strong funerary component.

5.5. Comparative reflections and conclusions

The shell middens from the Late Mesolithic of Portugal and France and the Jomon of the Okayama region in western Japan analysed in this chapter have a long history of research, in many cases going back to the nineteenth century or the first part of the twentieth century. In general, the sites that were not recently excavated provided limited datasets, because the focus of research at the time was placed on human skeletons (from an anthropological point of view) and the most interesting artefacts (from a culture-historical perspective). These research tendencies resulted in scant records about the archaeological contexts and biased material collections.

Despite these limitations, the analysis of documents from past excavations, such as photos, drawings, notes and reports, can bring some new details about situations that were not noticed or valued before by the researchers. This is a particularly relevant task concerning the old excavations of the nineteenth and beginning of the twentieth century, from which less information is known. In this work, aspects that have received less attention, such as non-burial features and deposits, could be highlighted. However, it was possible to find that the analysis of documents or records from the excavations can be also useful for a better understanding of more recent works, since published articles and books are always a result of processes of synthesis and interpretation that inevitably imply some loss of primary information from the field.

In fact, archaeological information about the past is always truncated or partial, even if modern and detailed methodologies of research are applied. The excavation and post-excavation of a shell midden, notably the sediment sorting, usually takes a long time. This means that data from field work may not be completely available for analysis even several years after the excavation has ended, as found with two of the three sites that were the subject of a spatial analysis in this work. Also, apart from Beg-er-Vil, France, the recent field work undertaken at these sites did not reach a large continuous extension, and the areas with shell accumulation tended to be prioritised, resulting in less information about the surroundings. Therefore, despite the advances that have been made and the higher amount of data that can be extracted from an excavation of a shell midden undertaken today, there are still various limitations, which can significantly affect the analysis of site structure and function.

Through this document analysis, it was possible to confirm that the Late Mesolithic and Jomon shell middens approached in this chapter were places of diverse activities that resulted

in concentrations of remains of a different nature. Often, shell midden deposits/layers were relatively rich in material culture remains, such as lithics, although the highest material densities were not always recorded in these contexts. The placement of features in general show concentrations in certain areas, clustering according to their typology and/or particular layouts. Funerary activity was important in the majority of these sites, which provided a significant number of human burials. However, some shell middens did not provide burial remains despite the abundant evidence of other activities. Also, combustion activities had a high relevance in almost all analysed cases, either in funerary and non-funerary sites. In addition, hearths often revealed intra-site diversity, suggesting differences in the purposes of the combustion activity and, in some cases, in the chronology. It was also interesting to observe that, in some shell middens with abundant evidence of funerary activity recovered in old excavations, such as Vale de Romeiras, in Portugal, and Tsukumo, in Japan, no combustion features were reported.

In recent excavations of shell middens, huge efforts have been made in the careful recovery to identify the materials and record their contexts. However, the intra-site distribution of materials, notably of lithic remains, has not been much discussed. In many cases, as found through the spatial analyses undertaken in this study, material densities can be identified, but the categories of lithic material reveal general homogenous distributions in the excavated areas, making the interpretation more difficult. The frequent presence of different types of anthropogenic deposits in shell middens (e.g., primary and secondary deposits, possible occupation surfaces), as found at Poças de São Bento, is another aspect that poses constraints to the interpretation of spatial data, in addition to the non-intentional post-depositional movements that often affect these sites and their material remains. Yet, some significant intra-site differences in the lithic distribution could be identified in the analysed sites regarding certain technological and typological aspects and using different scales of analysis (features, stratigraphic units, sub-areas and areas of excavation). These differences might reflect the existence of intra-site spatial differentiation in the nature and intensity of activities undertaken at the sites, including lithic production, use and discard.

The results of the spatial analyses undertaken in this study also indicated that, when a shell midden is excavated, the recording of the spatial position and stratigraphic context of units of sediment (and respective material assemblages) from delimited areas of excavation (buckets of soil, sub-squares or squares) can be more relevant and informative than the individual piece-plotting of certain material remains. The piece-plotting procedure allows researchers to record a precise location of each piece of material, but it is always limited to the materials that can be identified in the field with the naked eye – despite the careful rules of excavation that have been applied in shell middens, it is not possible to identify all relevant material remains during the excavation, especially when dealing with shell deposits and small lithics. On the contrary, the three-dimensional recording of units of sediment includes all the material remains that can be recovered through sieving and sorting of these units. It does not allow the location of each piece of material to the millimetre, but it definitely has a wider coverage, since the material remains that are recovered through sieving and sorting are often more numerous than those that are piece-plotted. Both techniques can be used at the same time and complete each other. Nevertheless, in the case of shell middens with small lithic

remains, it seems that the three-dimensional recording of units of sediment would be enough if it can be seen that the sieving and sorting processes will be concluded on time and allow the study of all the recovered material. In fact, as seen in this work, the integration of data from materials that were not piece-plotted into the spatial analyses can provide substantially different pictures of intra-site distribution from those that are only based on piece-plotted material.

PART III

Chapter 6 Shell middens and the last hunter-gatherer groups in Atlantic Europe and Japan: comparative discussion of the results

6.1. Analysing shell middens: methodological issues and perspectives from Atlantic Europe and Japan

The methodologies of excavation and laboratory analysis of shell middens and other archaeological sites are far from being homogenous across the world. Through the last chapters, it can be noticed that differences exist not only between Europe and Japan, or past and present approaches – researchers working today in the same country also use different methodologies. Several aspects affect how the investigation of a shell midden is conducted, such as research traditions, conditions of the site (history of investigation, state of conservation, classification), purposes of the study and available means (time, material sources, expertise and funding).

Numerous examples of Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan have demonstrated how meticulous and long the research of these sites can be, either in the excavation or in the post-excavation phases. It is widely recognised that shell middens contain a huge quantity of information in their matrix about different aspects of the environmental background and lifeways of the groups that left them. For that reason, it has been crucial to undertake a detailed record of the excavated contexts and specialised analyses of the deposits/contents in order to successfully extract the abundant data that these sites can provide.

Due to great concerns regarding the contextual information, the excavations of shell middens – especially in Europe – have been characterised by an intensive three-dimensional recording of material remains. In general, it could be observed through this study that features are less clear, and categories of material culture are less diverse in Late Mesolithic sites in comparison with many Jomon sites (due to the absence of pottery in the main occupation phases of the Late Mesolithic sites, the higher degrees of sedentism, technological development and social complexity of some Jomon cultures, among other aspects). As a consequence, the systematic recording of the spatial location of material remains has been a rule in the excavations, through the plotting of individual pieces (selected according to pre-established criteria), associated with the three-dimensional recording of buckets of soil from stratigraphic units or the excavation of artificially limited, small areas (squares and sub-squares). Naturally, these approaches take time in the field and generate a huge amount of data. At the same time, the interpretation of spatial data of material remains from open-air shell middens is often conditioned by the high dynamism that usually characterises these sites, notably the impact of post-depositional movements caused by natural and anthropic actions. Despite the constraints, registering spatial information of material remains can be seen as a necessary procedure to identify patterns and particular situations of distribution in the excavated areas. Given the limitations of the obtained data, however, it can be suggested that the recording of small remains could be more focused on the location of material assemblages in delimited areas/units of sediment (buckets of soil, sub-squares or squares), instead of being concentrated on the individual plotting of each piece of material with a high

precision. The use of more expedient strategies of three-dimensional recording of the materials, together with careful and detailed procedures of sieving and sediment sorting, could accelerate the excavation phases, without losing the small material remains that are often numerous and difficult to identify in shell midden deposits in the field, and their contextual information as well. On the other hand, it would be important to guarantee enough means to complete the sediment sieving and sorting procedures in all shell midden research projects, since these tasks tend to be partially postponed due to lack of time or funding.

Features are frequent in many shell middens and have also been subject of detailed recording in the most recent excavations in Europe and Japan. However, the limits of a negative feature dug in a shell midden deposit are often difficult to define when they are not structured by stones or other material. In many cases, a feature can only be detected through the identification of specific contents (such as a burial or a deposit that can be distinguished from the surrounding sediment). This problem often occurs in many Late Mesolithic and some Jomon shell middens, especially in western Japan where features in general are less numerous and structured (as exemplified by the lower frequency of pit-dwellings). The excavation of small areas, a strategy that is often adopted at these sites, poses additional difficulties for the identification of features. The present study confirmed that a careful digging of these sites is necessary, but an increase of excavations in larger areas would be desirable. The inclusion of areas that are adjacent to shell deposits in the excavations is undoubtedly important to identify features and obtain a better understanding of the site in general, as attested to by the example of Beg-er-Vil, in France, and several shell middens in Japan (such as the site of Higashimyo in western Japan, and many circular shell middens in the Kanto area).

Through the years, specialised analyses from a range of methodological perspectives (such as archaeozoology, archaeobotany, palaeoclimatology, coastal palaeogeography, anthropology, geochemistry or micromorphology) have assumed a particular relevant role in the study of shell middens in Atlantic Europe and Japan. The richness and complexity of shell deposits have provided a fruitful terrain for micro-scale analyses. It can be observed that archaeozoological and archaeobotanical analyses have been remarkably well-developed in the Jomon shell midden studies, while the approaches in Europe have been relatively more diverse, as exemplified by the frequent inclusion of geoarchaeological studies. However, it cannot be ignored that specialised analyses can take a long time to complete, in most cases being also dependent on the conclusion of sieving and sorting of large quantities of sediments. These analyses also need adequate funding and specialists. Consequently, specialised analyses have been frequently restricted to small samples, generating datasets that can be quite limited, and difficult to be interpreted or integrated into an overall view of the sites. Given this scenario, it can be highlighted that specialised and small-scale analyses in shell middens require well-defined sampling strategies and appropriate contextualisation of the data, in order to not lose the purpose of obtaining a wider understanding of the sites. Future research on the Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan should make further efforts for a better balance between different scales of analysis and a more effective interdisciplinarity.

6.2. Shell midden site function

6.2.1. Shell midden types *versus* variability

Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan are predominantly open-air sites associated with salty or/and brackish water environments, notably shallow bays, river estuaries and lagoons that support large quantities of molluscs. However, they are characterised by a large variability in terms of location, morphology, contents and duration of occupation, which can be even observed at an intra-regional level and within the same time-periods. This heterogeneity poses difficulties to the analysis of shell midden sites, notably their function (or multiple functions) and role in the settlement systems of the hunter-gatherer communities.

The construction of site typologies has been a valuable tool to try to answer to these problems through the systematisation of the available information. Several proposals of classification of Holocene shell middens have been made in Atlantic Europe and Japan, at a regional or national level, based on one or multiple variables, such as dimension, morphology and density of the shell accumulations, site location, associated water environments and human activities performed at the site (e.g., Dupont, 2003b; Okazaki, 2006; Abe, 2014a; Koizumi, 2016; Takanashi, 2018). In many situations, however, the characterisation and measurement of these variables are not uniform. For example, in Japan, it is common to distinguish shell layers according to the density of shells in the sediment, by dividing them into three types: *konkai dosō* (sediment layer with shells, when there is more sediment than shells), *kondo kaisō* (shell layer with sediment, when there are more shells than sediment) and *jun kaisō* (pure shell layer, when there is an extremely dense shell layer with very little sediment) (e.g., Okazaki, 2006). However, this kind of characterisation, usually made in the field with the naked eye, inevitably implies some degree of subjectivity. Therefore, it can be considered that shell midden typologies are naturally diverse, reflecting not only the heterogeneity of the sites and deposits, but also the multiplicity of possible ways of analysis of these realities. For this reason, shell midden site-types should not be assumed as universal, rigid, and unquestionable concepts but, instead, they should be regarded as a product of analyses and interpretations made by researchers, concerning a certain number of archaeological realities.

The classifications of shell middens according to their site function, in particular, require deeper debates. It becomes evident through the archaeological literature that the Late Mesolithic and Jomon shell middens have tended to be divided into two main groups – long-term residential sites and non-residential, logistical processing-specialised sites (e.g., Arnaud, 1989; 2002; Soares, 1996a; Abe, 2007). Larger sites with evidence of multiple types of activities (such as residential, funerary, food processing, tool production and ritual activities) and relatively long occupations have been often considered as residential sites. In contrast, sites with a low quantity and diversity of material remains and features have been often categorised as processing or specialised sites (mostly or exclusively dedicated to mollusc gathering and processing activities). The use of this dual division clearly reflects the dominance of Binford's forager-collector view of hunting and gathering societies (Binford, 1980) in both geographical extremes of Eurasia.

A significant problem regarding this division concerns the archaeological criteria used to classify a site as a processing-specialised site. In fact, the low quantity and diversity of material remains and features at a site can occur for reasons that are not related to site function. There are many examples of small Late Mesolithic and Jomon shell midden sites from which few data about their exact location, dimensions, stratigraphy, archaeological material and features are known, due to the poor state of preservation or the lack of detailed investigation of the sites. These examples include some Late Mesolithic shell middens of the Tejo valley, in Portugal, such as Vale da Fonte da Moça I and II, Cabeço dos Morros and Cova da Onça, which, despite the absence of extensive excavations and detailed records, were classified by Rolão as ‘shell middens for support’ with a temporary/specialised nature (Rolão, 1999b). It seems clear, however, that the lack of archaeological information from a site should be approached with more caution, without immediately assuming that it reflects a low diversity of activities in the past.

A second problem concerning the dual division of the shell middens into residential and processing/specialised sites is the concept of ‘residential shell middens’, considering that there is a low visibility of residential features and a lack of direct evidence of habitation activity at many sites. Dwellings are barely documented among the Late Mesolithic shell middens in Atlantic Europe. They are also relatively rare among the Jomon shell middens in western Japan, as found in Okayama prefecture and many other regions. Even at Higashimyo, in Kyushu, dwelling structures were not identified, despite the extent of the excavated area and the large quantity of other features identified at the site (Nishida et al., 2016b). Therefore, for many sites in these regions, the residential function can only be assumed through indirect evidence, such as remains of artefact production, food processing or consumption, storage or ritual activities. It can be considered that the existence of evidence of multiple types of activities at a site is a strong indicator of a residential function, although the details of the activity cannot be understood. Contrary to this, in many Jomon shell middens of eastern Japan, notably in the Kanto region, a large quantity of pit-dwellings have been found, providing a more direct record of the residential function of these sites. It should be noted, however, that in many cases, pit-dwellings were not identified in the shell layers, but in the layers below, or in areas that were not covered by shell deposits, evidencing a tendency for the separation of residential features from shell accumulations at the time of their construction and primary use (e.g., Nishino et al., 2017). At the same time, the identification of rare cases of pit-dwellings cutting into the shell layers suggests that some habitation activity also occurred in the shell deposits, but most traces could have been largely destroyed or not detected in the field work.

Contrary to the residential function – which can more likely be affected by clean-up operations, redeposition, re-use of materials and spaces, and more dependent on more perishable features that became invisible in the archaeological record – funerary activity is much more well documented in the Late Mesolithic and Jomon shell middens in general, in large part thanks to the extremely favourable conditions for bone preservation at these sites. Numerous burials have been identified, which in many cases were found clustered in particular areas within the sites and closely associated with shell deposits. Sites such as Vale de Romeiras, in Portugal, Tévéc and Höedic, in France, or Tsukumo, in western Japan, have

been considered examples of cemeteries or necropolises (e.g., Arnaud, 2000; Peyroteo Stjerna, 2016; Péquart et al., 1937; Kiyono et al., 1920). Some researchers even suggested that certain shell middens with abundant human burials would have been mainly dedicated to funerary and ritual activity, instead of ‘domestic’ or residential activities, at least in some phases of occupation (Peyroteo Stjerna, 2016; Gonçalves et al., 2018). However, it seems clear through the present study that many Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan with burial activity were multifunctional sites, instead of being exclusively dedicated to a funerary function. Shell middens with burial activity usually provide evidence of various types of activities, such as artefact production, food processing, storage, fishing or habitation. In addition, and although several sites reveal a tendency for concentration of the burials in the first phases of development of the shell middens, such as those in the Tejo and Sado valleys, in Portugal, or the Hikozaki shell midden, in western Japan, some burial activity in later phases of occupation is also frequently found. In general, it seems that the funerary function was not limited to a single or first phase of the formation of the sites; instead, the activity was often continued, with varying intensities or interruptions, over various centuries of occupation and multiple generations. Therefore, it can be understood that numerous Late Mesolithic and Jomon shell middens with funerary activity were a type of multifunctional sites with a particularly relevant social role for the communities – a role that was remembered by different generations, as attested by the continuity of burial activity and the rarity or absence of situations of body disturbance caused by new burials. In general, these sites are characterised by a strong physical proximity between funerary and other activities, or between dead and living things, even if dwelling evidence is not always found.

However, the extent of ritual activity (in general) in shell middens is an important aspect to further discuss regarding the functional classification of these sites. As mentioned in this work, burials in shell middens were not limited to humans. Dog burials are known at several sites, as exemplified by Poças de São Bento and Cabeço da Arruda, in Portugal (Detry and Cardoso, 2010; Arias et al., 2015a), or Kasori in Chiba prefecture (Nishino et al., 2017) and Higashimyo, in Saga prefecture (Nishida et al., 2016b), in Japan. Although rare, cases of inhumation of other animals are also known in Japan, as found at Saihiro shell midden, in Chiba prefecture, where a wild boar and racoon were inhumated in addition to dogs (Tsuruoka et al., 2007). Additionally, in Jomon sites, intentional depositions of pottery vessels with animal remains inside are known, such as those found at Hikozaki and Asanebana shell middens, in Okayama prefecture (Kake Gakuen Maizo Bunkazai Chosa-shitsu, 1998; Tajima et al., 2006), as well as concentrated depositions of certain parts of animals (such as skulls) (Ogawa, 2012). In Late Mesolithic shell middens in Europe, numerous concentrations of (articulated or non-articulated) animal bone remains (e.g., Gonçalves et al., 2018) and isolated findings of deer antlers (as seen in previous chapters) are known, although the characterisation as intentional depositions with ritual purposes has been a hypothesis among others. The ritual use of deer antlers, however, is well-known, notably as grave coverings at Tévéc and Höedic sites, in France (Schulting, 1996). Overall, animal-related ritual activity seems to have been largely developed in many shell middens in Atlantic Europe and Japan. In addition, in several Jomon shell middens, significant quantities of ritual/symbolic artefacts were also recovered, such as figurines (almost unknown in European Mesolithic) and stone

rods (e.g., Tsuruoka et al., 2007), which, again, confirm the relevance of ritual practices at these sites.

Since Hiromichi Kono (1935) proposed that Jomon shell middens with human burials could have been used as sacred places to ‘send spirits back’, based on the practice of *Iomante* rituals by Ainu people (sending of physical beings’ gods spirits back to a different religious plane), many authors in Japan have regarded Jomon shell middens as special places for the deposition of dead things as a whole (shells, human and animal bodies, tools that ended their life) in order to express gratitude to nature, sending the spirits back and asking for their return to life (e.g., Nakamura, 1991; 2005; Takanashi, 2018). The frequent identification of shell midden deposits in no longer used dwelling pits has been also seen as a strong evidence of the ritual character of Jomon shell midden formation (Maeda, 1994; Nakamura, 2005). Whether all shell middens (including those without funerary and other clear ritual activities) can ultimately be classified as ritual places, based only on the fact that they are composed of remains of dead animals (shells), is a question up for discussion. However, even if such a wide perspective is adopted, it would not explain the differences that can be observed between shell middens regarding the presence/absence of specific ritual-related items and features. Therefore, distinguishing shell middens between those with evidence of specific/clearer ritual practices (other than shell accumulation) from those without seems relevant from a functional point of view.

Considering the abovementioned, it can be proposed that a fundamental division of shell middens in Atlantic Europe and Japan regarding site function should be firstly traced between sites with diverse and limited activities, instead of immediately applying the distinction between residential and non-residential/specialised sites without enough data and discussion. A low diversity of material remains at a site should not be automatically considered to be an indicator of a specialised or temporary occupation without evaluating the research contexts behind the lack of further archaeological evidence. However, it is necessary to have in mind that even the characterisation of ‘diverse’ or ‘limited’ activities is, despite being more factual, inevitably conditioned by the quantity and quality of available archaeological information. For this reason, the state of research of the sites is a highly relevant aspect that needs to be more properly taken into consideration when classifying and characterising shell middens from a functional perspective.

6.2.2. Shell middens and other littoral sites

An important issue regarding site function of shell midden sites is their role in settlement systems and their relationship with other site types, notably with other littoral, non-shell midden sites. Despite the abundance of shell middens in Late Mesolithic Atlantic Europe and Jomon Japan and their frequent occurrence in clusters, there are also many examples of littoral sites that are not shell middens.

Non-shell midden littoral sites are abundant in Ertebølle Denmark and predominant among the coastal sites in the region. Shell middens are found together with littoral non-shell midden sites and, except for the presence of shells, they appear to be identical settlement sites (Andersen, 2000; 2007). It should be noted that few graves have been found in the Ertebølle shell middens; therefore, a systematic use of these sites as burial grounds is not

found, contrary to many Late Mesolithic and Jomon shell middens in Portugal/France and Japan. In addition, according to Søren Andersen (2000, p. 365), the main factor for the choice of site location in Denmark seems to have been access to good fishing, instead of molluscs, which means that molluscs were probably exploited only if natural banks were available nearby. In this sense, shell middens were seen by the mentioned researcher as a simple variant of the Ertebølle littoral settlement sites, and not as unique sites with distinctive characteristics. Despite that position, the researcher stressed that further investigation is necessary to clarify whether these shell middens had a 'special' economic, social or ritual importance in the entire settlement system. In fact, the existence of different types of Ertebølle shell middens, some of which have large dimensions, long occupations, and central positions in the settlement systems, suggests that the function and social importance of these sites could have varied. However, the specific significance of the shell accumulations is still a difficult issue to address.

Although north-west France is known for the presence of shell middens, several non-shell midden littoral sites are also known in the islands and along the continental coast (Marchand, 2014; 2020). In this region, Late Mesolithic shell middens and other littoral sites seem to have been part of the same littoral settlement system characterised by groups with developed maritime mobility between the mainland and islands and a complete economy based on the exploitation of locally available resources. Occasional exchanges with groups from inland territories seem to have happened, as evidenced by the presence of littoral flint pebbles at inland sites (Marchand, 2003; 2020). However, further extended excavations are required to know more details about the non-shell midden littoral sites, which are mostly only known through surface finds. In addition, the absence of organic remains, but also of preserved features, have caused difficulties for the understanding of these sites.

Numerous littoral non-shell midden sites are also known in the Jomon archaeological record, including in areas with a high concentration of shell middens, such as Chiba prefecture. For example, around the Sanya shell midden (Sodegaura city), a large circular shell midden, several Late and Final Jomon non-shell midden sites are known a few kilometres away (Ito et al., 2016, p. 288). It seems likely that large shell middens in Chiba prefecture had exchanges with non-shell midden sites located nearby, although there is not a lot of detailed data concerning this topic. In contrast, there is more information about the relationships between shell middens, such as exchanges of certain objects (e.g., fishing tools, shell bracelets) (Ito et al., 2016, p. 290). Giving several examples of large circular shell middens formed by two distinct midden deposits from Chiba prefecture, Tatsuo Kobayashi highlighted that shell midden sites often exhibit the dualistic layout of Jomon sites more clearly than non-shell midden sites (Kobayashi, 2001, p. 23). However, several non-shell midden sites also provide evidence of this dualistic division through the arrangement of dwellings, burials, pottery discard areas or other elements, as mentioned by the same researcher.

In Okayama prefecture, numerous littoral non-shell midden sites are also known in areas with abundant shell middens. For example, the coastal site of Desaki Funakoshi Minami (Tamano city), located in the southern area of Okayama prefecture, was occupied in the Early Jomon period but had no shell midden (Matsumoto, 2007). Shell middens in Okayama prefecture seem to have been the predominant littoral sites in the Early and Middle Jomon

periods, but in the Late Jomon and especially in the Final Jomon periods, non-shell midden littoral sites became more frequent than shell middens. The decrease in the number and size of shell middens in the Final Jomon period has been related to the progressive reduction in the availability of molluscs in the area, the advance of the settlement to the alluvial plains and subsistence changes, with the increase in the consumption of plant food (Yamamoto, 2004). However, the abundant number of non-shell midden littoral sites in these later phases indicates that, despite the tendency for a progressive reduction on shell middens, the use of aquatic resources in general (notably fishing activity) remained significant for the populations, as also evidenced by the presence of fishing tools at several sites (Tajima, 2014; 2015b). In addition, littoral locations in general continued to be relevant, not only for aquatic food, but also for the acquisition and transportation of lithic raw material (sanukite) that came from Kagawa region and circulated in the Seto Inland Sea (Tajima, 2015b).

Overall, in Atlantic Europe and Japan, littoral non-shell midden sites have been less studied compared to shell middens. These sites are characterised by a lower degree of preservation of material remains in general compared to the contemporaneous shell midden sites, notably concerning organic material. This implies that in many cases, less information can be obtained about the nature of activities, chronology of occupation and subsistence from these sites, making them less attractive for research. Their lower visibility can also explain the rare identification of these sites in some regions where shell middens are known, such as Portugal (Carvalho, 2009).

The discrepancy of available information between shell middens and littoral non-shell midden sites poses serious limitations to the understanding of the relations between them. Despite that, it is likely that shell middens with burial grounds had a special character in the settlement systems in general. According to Tomoko Takanashi, even the fact that some individuals were buried in a shell midden, but others not, implies that at least some kind of ritual differentiation existed (Takanashi, 1998, p. 19). Cemeteries have often been associated with ideas of longer permanency, incorporation of the dead into the community life, increased ritual activity and territorial behaviour (Price and Brown, 1985), being thus usually considered to be an indicator of social complexity. However, based on the cases of the shell middens of the Tejo and Sado valleys in Portugal, Rita Peyroteo Stjerna argued that cemeteries are not always an indicator of continuous permanency in the site or higher complexity in relation to other funerary practices (Peyroteo Stjerna, 2016, p. 470). She highlighted the central role of mortuary ritual practice at these sites, arguing that site formation was closely related to the creation and maintenance of burial grounds, which would be meaningful places to be remembered over generations. According to her view, the frequent burial of the dead in these places was ‘...an act of historical consciousness motivated by the encounter and interaction with other bands frequenting the same environments’ (Peyroteo Stjerna, 2016, p. 37). Concerning the sites of Tévéc and Höedic, France, Grégor Marchand considered that they had an exceptional role in the ‘Mesolithic seascape’, noting that ‘the cemetery was a pivot in the social space of these maritime hunter-gatherers, a place they came back to regularly and which acted as a symbolic interface between the dead and the living’ (Marchand, 2020, p. 213). With respect to the Jomon shell middens with cemeteries, the burial types are more diverse than the Late Mesolithic ones,

despite the predominance of primary burials in pits. Some Jomon researchers also stressed that the presence of cemeteries does not automatically imply that a site was a long-term residence of a fully sedentary community or continuously occupied (Habu, 2004). At some Jomon sites, residential and burial features reveal chronological differences, and the function of the sites seems to have changed during their occupation, for example, from a primarily residential function to a funerary/ritual function.

Although several cautions should be taken, overall, it can be argued that Late Mesolithic and Jomon shell middens with burial grounds seem to have had a particular social relevance that was not limited to the main phases of funerary activity. Several sites in Atlantic Europe (notably those in Portugal and France) and Japan reveal prolonged funerary use over several centuries. This implies that, even if the activity was undertaken in a discontinuous way or with different moments of intensity, the symbolic role of these sites and consequent attachment of the communities to these places were kept over several generations. Also, burial grounds have been identified either in large and small Late Mesolithic and Jomon shell middens, which suggests that the formation of cemeteries was not necessarily conditioned by the dimension of the site or shell accumulations; however, it can be also stressed that large, mounded-type shell midden sites with remains of diverse activities were often used as burial grounds. This situation is a strong argument in favour of the idea of symbolism and intentional monumentality of the accumulation/construction of certain large shell middens. However, other questions rise without clear answers. How can we interpret the shell middens that contain only one or two burials? Was shell accumulation at sites without funerary activity irrelevant from a symbolic point of view? Were shell middens without funerary activity always equivalent to other littoral non-shell midden sites in settlement systems? Evidence of ritual activity in shell middens without identified human burials seems rare, or (more often) limited or not reported, as exemplified by the case of Beg-er-Vil, France (Marchand and Dupont, 2018). Interestingly, a case of Jomon shell middens approached in this study – Asanebana, Okayama prefecture – where despite the absence of human burials, an urn-burial with a skull of a macaque was identified (Kake Gakuen Maizo Bunkazai Chosa-shitsu, 1998), suggests that ritual deposits of faunal remains could be important for shell middens in general, even in those without human burial activity.

6.3. Shell midden site structure: features, materials, activities and spatial organisation

Many shell middens from the Late Mesolithic in Atlantic Europe and Jomon period in the Japanese archipelago were clearly more than simple deposits of shells and other remains, providing evidence of the practice of diverse activities at the sites. Furthermore, it can be observed in many cases that material remains and features are not randomly or homogeneously distributed over the sites. The available archaeological evidence indicates that certain rules of spatial organisation were followed during the formation and use of several shell middens, sometimes for relatively long periods.

In fact, the formation and preservation of a shell midden itself implies that significant quantities of shell remains were deposited at the same place or places over a certain period of time, continuously or not, by one or several different groups. The intentionality behind

shell midden deposition and accumulation activities – even if the deposits are found in a secondary position – implies a choice, use and modification of a specific place, instead of others. Although the organisation of space was not a new or a specific trend developed by the Holocene hunter-gatherers that constructed shell middens, it can be easily understood that the intensification in the exploitation of molluscs and reduction of residential mobility by these groups would have quickly generated large quantities of remains (shells) that were particularly durable and could become voluminous, visible, and smelly if accumulated in the frequented spaces, requiring some kind of management.

Huge accumulations forming mounds certainly had obvious impacts in the landscape, leading some authors to consider these features to be evidence of early monumentality and architecture (e.g., Takanashi, 2018; 2019; Tomioka, 2020). Large shell middens that preserved a specific layout of the shell deposits, such as the circular shell middens in Tokyo Bay in Japan, are obvious examples of the concern of these communities with the placement of shells and the maintenance of site spatial organisation in general. These cases in Japan indicate that shell deposition followed determined spatial rules over significant periods of time, while, at the same time, the deposits also served as markers defining intra-site areas. It is a generally accepted idea that the final layout of the shell deposits at these sites is a result of cumulative processes of occupation and accumulation, but studies undertaken on several sites highlight that a circular configuration existed in the beginning of the formation of the shell middens, undergoing changes in the following phases, such as exemplified by the case of Sanya (Ito et al., 2016) and Kasori North (Murata, 2013) in Chiba region, Japan. In Europe, it was observed that many Ertebølle sites in Denmark are composed of small shell heaps or layers of shells, indicating that each mollusc species tended to be processed and deposited separately (Andersen, 2000; 2007). The deposition of shell remains inside negative features (pits and dwelling pits), a phenomenon observed in several Jomon shell middens, and also sporadically in some Late Mesolithic ones, provides more evidence of a specific concern of the groups with the placement of shell remains, despite the variety of contexts and multiple interpretations that can be made regarding the function of these deposits. Also, particularly dense shell deposits have been frequently found in association with burials, directly covering the skeletons (e.g., Tajima et al., 2006). Some authors suggested that these groups could have previous knowledge about the properties of shells for the preservation of bones (e.g., Takanashi, 1998). However, despite being an interesting hypothesis, it seems difficult to prove considering that the deposition of shells can be simply explained by its symbolic meaning.

In addition to the placement of the shell accumulations, the existence of spatial structure in several Late Mesolithic and Jomon shell midden sites has also been documented by the distribution of other features. Features at these sites are rarely found isolated, often being grouped by type and sub-type. Burials, in particular, tend to be concentrated in specific areas of the sites and sub-divisions are identified in some cases – for example, between adults and children at Moita do Sebastião, Portugal (Roche, 1989), or between genders, as observed at Tsukumo, Japan (Kamaki, 1986; Kawase, 2006; Yamada, 2009). In addition, despite the abundance of primary burials placed close to each other at many of these sites, few situations of disturbance by later features are observed, revealing a general knowledge and respect for

each inhumation, even when they are separated by a long chronological gap. Non-burial features are also frequently grouped, as exemplified by the numerous stone concentrations and storage pits from Higashimyo site, Japan, which were found in different zones of the site (Nishida et al., 2016b). Even at Beg-er-Vil, France, where the number of identified features is much lower, the two probable dwelling features were found near each other (Marchand and Dupont, 2019). The distribution of features can also display specific layouts, such as found with the burials forming a semicircle at Vale de Romeiras, Portugal (Arnaud, 1989; 2000; Cunha and Umbelino, 2001), or the pit-dwellings and burials that followed a circular configuration in the large circular shell middens of Tokyo Bay. Situations of superimposition of combustion features or burnt shell lenses in the same areas of the shell middens, as found at some Ertebølle sites (Andersen and Johansen, 1986; Andersen, 2000), are also indicative of strong internal structuring of the sites over long periods.

The distribution of material remains can be less clear to interpret in terms of intra-site spatial organisation in shell middens, especially in the case of small lithics, which are easily affected by the frequent post-depositional actions. Also, the available data is highly conditioned by the strategies of excavation and post-excavation work that were used. Despite the constraints, analyses of the distribution of material remains at several sites have revealed relevant intra-site differences, which can be related with activities or patterns of discard that were undertaken differently according to the area of the site. In some Jomon sites, the distribution of artefacts with evident ritual/symbolic functions showed the existence of specific patterns of discard of this artefact type – this was the case at the Saihiro shell midden, Chiba prefecture, where figurines, stone rods and other ritual/symbolic artefacts were found mostly fragmented and concentrated in the central ‘plaza’ and in part of the western shell deposit (Tsuruoka et al., 2007), evidencing the importance of ritual activity in these areas. Ritual/symbolic artefacts have also been identified in high quantities inside certain large features, such as the case of pit-dwelling no. 112 at Kasori, Chiba prefecture, allowing researchers to interpret them as specific structures for ritual activities (Nishino et al., 2017). Unfortunately, the abundant presence of this type of artefacts is not the rule at all the sites.

The distributions of other remains can be more difficult to interpret from a functional point of view. For example, concentrations of animal bones, notably of deer and wild boar, without being in the context of a burial, negative feature or container, have been frequently identified at Late Mesolithic and Jomon shell middens. However, the function of these remains, some of which still articulated, has not always been clear (refuse from processing activities, ritual deposits or both). Substantial internal differences in the distribution of pottery, lithic and bone/shell tool remains have also been observed in several shell middens with diverse activities. At Saihiro shell midden, these remains were more frequently found in the shell midden deposits, but considerable differences between the western deposit (higher quantity of bone, shell and flaked stone tools) and the eastern deposit (higher quantity of pottery) were detected (Tsuruoka et al., 2007), allowing researchers to understand that there was a distinct discard behaviour between shell midden deposits and according to the object type.

Concerning the lithic remains, some sites, such as those analysed in the previous chapter, reveal differences on the distributions in terms of quantity of remains, and also regarding the

proportion of technological categories and tool types, the state of fragmentation, and other aspects. It is possible to understand that, in sites with diverse activities, lithics can be found in high quantities in areas with shell midden deposits, although in some cases their presence can be more significant in areas or layers without shell deposits. The presence of features does not seem to necessarily affect the lithic distributions in a negative way – contrary to this, lithic remains can be abundant in areas where features were constructed, such as hearths, a situation that can be related with the practice of processing activities.

Therefore, despite the image of ‘chaotic’ accumulations that shell middens can provide, several Late Mesolithic and Jomon sites where diverse activities took place effectively demonstrate the existence of *different discard behaviours, preferential areas for certain activities and other rules of distribution of material remains and features*. At the same time, *a general physical proximity between remains of different types of activities (residential, subsistence and ritual-related), living and dead things, and animal and human elements*, can be observed in these shell middens. Sites with larger dimensions and shell accumulations, which often developed in clusters and had several centuries of occupation, indicate that molluscs were exploited in a more or less continuous way from the same places, but also that remains of human activity were managed in the space according to rules that were respected during significant periods of time by different generations.

6.4. Hunter-gatherer lifeways and shell middens

6.4.1. Broad spectrum economies or resource specialisation?

Subsistence has been one of the main subjects of shell midden research in Atlantic Europe and Japan. In fact, and despite the variety of debated perspectives, Late Mesolithic and Jomon shell middens have been mainly regarded as direct and primary products of subsistence activities. However, the real importance of aquatic resources in the subsistence of the groups that developed these shell middens has been a huge topic of discussion.

Many authors have highlighted that the nutritional and caloric value of molluscs is relatively low compared to other types of food, and despite the high visibility and volume of generated shell detritus (Suzuki, 1989; Bailey and Milner, 2002; 2008; Balbo et al., 2011). It is also widely accepted that the large size of a shell midden does not necessarily mean that shellfish was consumed as a staple food, since it can be a result of accumulation over several centuries (Suzuki, 1989; Habu, 2004). At the same time, several characteristics of molluscs that make them a valuable resource have been stressed – abundance, availability (often year round, acquiring a particular relevance when other food resources are hard to find), predictability and easiness to be seen, collected and processed (Waselkov, 1987; Erlandson, 2001; Habu et al., 2011; Hardy, 2017).

Despite several discussions and regional variations, it seems clear that the presence of numerous shell middens in the Late Mesolithic and Jomon archaeological record of Europe and Japan indicates that molluscs had a *great significance* for many groups that left them. Several shell middens provide evidence of exploitation of aquatic resources over several centuries from the same places. Firstly, it can be assumed that the *presence* of numerous shells at these sites, mainly from edible mollusc species, is, at least at a first moment, mostly and primarily related with food acquisition, consumption, and/or processing for consumption (at the site

or elsewhere). Some mollusc shells found in shell middens were used for tool manufacture, notably adornments, symbolic items, and other tools, which undoubtedly attest that the importance of these resources was not limited to food consumption. However, in general, shell tools seem to only represent a small part of the shell midden accumulations in both regions. Yet, the interpretations can be more varied regarding the *deposition and accumulation* of shells. The diversity of contexts of deposition and accumulation in the Late Mesolithic and Jomon shell middens, sometimes even at the same site, suggests the existence of different actions with different purposes or meanings. Therefore, shell deposits cannot be all seen as result of simple actions of food debris discard. Modern concepts of waste as ‘useless’ or ‘dirty’ things cannot be applied to these societies.

Assuming a general perspective that the Late Mesolithic and Jomon shell middens of Atlantic Europe and the Japanese archipelago are primarily products of subsistence activities, it can be discussed whether their abundance in certain regions and phases resulted from the development of broad spectrum economies by groups with diets based on diverse food sources that included molluscs (Flannery, 1969; Zeder, 2012), or, instead, if these sites are a consequence of subsistence intensification and specialisation in aquatic resources.

Despite less data for earlier periods, the development of a high number of shell middens in the Middle and early Late Holocene in Atlantic Europe and Japan, many of them with particularly large dimensions, at a short distance from each other, and occupied more or less synchronously, indicates an ongoing intensification in the exploitation of molluscs and a significant reliance on aquatic resources in general as food by their constructors. Cases of overexploitation of the main collected mollusc species at some sites are suggested in a number of studies, notably through the identification of situations of a decrease in shell size through time. For example, in some large Ertebølle shell middens in Denmark, the size of oysters seem to have decreased through time (Andersen, 2007). In the eastern half of Tokyo Bay, in Japan, shell middens from the Middle Jomon period are characterised by the presence of *hamaguri* clams of small dimensions (Abe, 2014b, p. 94). The relevance of the exploitation of molluscs in the formation and evolution of shell midden sites is also evident, since the phases of decline of many sites are marked by an absence or decrease of shell accumulations. For example, at Hikozaki shell midden (Okayama), the Final Jomon phase is characterised by a clear decrease in the accumulation of shells (associated with sea regression) and a lower activity in general at the site, corresponding to the end of the relevant role of that place in the regional settlement system of Kojima Bay (Tajima et al., 2006; 2008; 2013). In addition, many shell middens have also provided evidence of exploitation of aquatic resources other than molluscs – although the preservation of bones is relatively more difficult, the exploitation of several species of fish is well-documented at several sites (e.g., Denmark, Portugal, Japan); remains of marine mammals have also been recovered in some cases (e.g., Denmark, France, Japan). In addition, the finding of a wide range of fishing implements in general indicates important improvements in onshore and offshore fishing and sea mammal hunting strategies. These various lines of evidence support the idea of an intensive exploitation of aquatic resources in general by these populations that left shell middens.

In most cases, however, the archaeological evidence from these shell middens does not suggest an exploitation of a single species or resource type. Several shell middens in Atlantic

Europe have been classified as ‘specialised’ in mollusc gathering due to the lack of ‘diverse’ archaeological evidence in the recovered assemblages (notably faunal remains, material culture or features). Nevertheless, many of these supposed specialised sites were not extensively or appropriately excavated, it being not possible to understand if the absences were real in the past or resulted from sampling error. Despite the large amount of archaeological data that is available about Late Mesolithic and Jomon shell middens, it is possible to understand that few sites are characterised as specialised shell middens through adequate archaeological evidence – the case of the Nakazato shell midden, in Japan, is a representative and rare example of a specialised site whose functional classification is archaeologically well-documented (Nakajima et al., 2018). Furthermore, even such specialised shell middens did not work in isolation – the sites were integrated in settlement systems that included multi-purpose residential sites where diverse activities were undertaken and a wider range of resources were exploited (Uetsuki, 2001; Nakajima et al., 2018). This situation is in accordance with the perspective of Kenneth Ames, who observed that aquatic hunter-gatherers may create few or no task specific sites, while processing activities can be concentrated at residential sites, which frequently provide evidence of a greater diversity of activities than is commonly associated with collector settlements (Ames, 2002, p. 46).

The available information about subsistence from other materials found in these shell middens is quite heterogenous. The results from isotope analyses of human skeletal remains from burials discovered at these sites, either in Atlantic Europe or Japan, indicate a significant variability in the diets of the groups. Several cases in coastal locations at relatively higher latitudes in north-west Atlantic and northern/north-east Japan (e.g., Hoëdic, France, several Ertebølle sites in Denmark, the Kitakogane shell midden, Hokkaido, Japan) indicate a strong contribution of marine food to diets (notably fish and marine mammals), with marine resources representing 50% or more of the proteins consumed by hunter-gatherers (Schulting and Richards, 2001; Schulting, 2015). Nevertheless, in many other situations, mixed diets based on terrestrial and marine/estuarine food appear to be recurrent, especially (although not exclusively) in areas to the south in Atlantic Europe and Japan (e.g., shell middens of the Sado valley in Portugal, Tsukumo and Funamoto shell middens in Okayama, Saihiro and Sanya shell middens in Tokyo Bay, Japan (Tsuruoka et al., 2007; Umbelino et al., 2007; Kusaka et al., 2010; Fontanals-Coll et al., 2014; Guiry et al., 2015; Diniz, 2016; Ito et al., 2016; Peyroteo Stjerna, 2016)). Isotope data from individuals excavated at Jomon shell middens reveal a great diversity, even inside regions with high densities of shell middens, such as Kanto or Tohoku (Habu, 2014b). Variations in dietary data have been frequently identified between different shell midden sites that are approximately contemporaneous and at a short distance to one another, and also between individuals found at the same site. Given this heterogeneity, it seems clear that the abundance of shell middens, even with large dimensions, does not necessarily imply that aquatic resources were the main staple food of these groups.

In fact, many Jomon and Late Mesolithic shell middens contain abundant remains of terrestrial fauna. A number of Jomon shell middens also provided a rich macrobotanical record, as exemplified by the sites of Awazu and Higashimyo in western Japan, evidencing a broad economic base, with a high importance of the exploitation of plant resources, even at

shell midden sites, in combination with aquatic food (Iba, 2005; Matsui, 2013). In addition, it has been found that the location of these shell middens often took place in ecotone areas with easy access to different and highly productive aquatic and terrestrial environments. Therefore, in many cases, the archaeological evidence indicates an exploitation of diverse and seasonally abundant resources from diverse environments and the practise of multiple types of activities from these sites. Some authors have even stressed the important role of Holocene forests in the establishment of aquatic adaptations, notably for providing raw material required for the construction of boats and fishing weirs (Wickham-Jones, 2014; Marchand and Dupont, 2016b). The recent identification of use-wear that can be associated with plant working on some lithic tools from shell middens in France (Beg-er-Vil, Tévéc, Höedic, Beg-an-Dorchenn) (Guéret et al., 2014; Calvo-Gómez, 2023) also seems favourable to this view. This means that the intensification in the exploitation of aquatic resources, as evidenced by these shell middens, can be regarded as a relevant trait of these groups that, simultaneously, had to be supported by other important activities.

In summary, it can be argued that Late Mesolithic and Jomon shell middens in general provide archaeological evidence of two subsistence tendencies of Holocene hunter-gatherer groups in Atlantic Europe and Japan developed in contexts of resource abundance that seem divergent but are related – *food diversification* (increased number of targeted resources) and *intensification of the acquisition and use of certain food sources* (aquatic food, but also plant food in many cases). The exploitation of particularly rich biotopes associated with aquatic environments that were formed during post-glacial times, notably on the coasts, was certainly crucial for the development of these general trends. The effective exploitation of diverse and seasonally abundant resources provided by these settings (*optimal resource zones* as described by Zeder, 2012 after Flannery, 1969) would have greatly contributed to the reduction of residential mobility, as well an increase in the attachment of these groups to certain areas and territoriality. These changes, however, were not uniform or necessarily gradual through time, occurring with different degrees of intensity in the multiple regional and temporal contexts that characterise Late Mesolithic in Atlantic Europe and the much longer Jomon period in Japan.

6.4.2. Shell middens, aquatic hunter-gatherers and social complexity

The European Late Mesolithic groups and Jomon groups that left shell middens are sometimes called ‘maritime’ or ‘coastal hunter-gatherers’ (Yesner et al., 1980; Bailey and Milner, 2002; Sakaguchi, 2007; Marchand and Dupont, 2014b). More frequently, the terms ‘maritime’, ‘littoral’ or ‘coastal adaptations’ have been used to characterise these groups (e.g., Akazawa, 1986; Bonsall, 1996; Matsui, 1999). However, many Late Mesolithic and Jomon shell middens attest to not only the exploitation of marine environments, but also of estuaries. Some rare cases of shell middens associated with freshwater lakes and rivers are also known. In this sense, although the largest part of the sites in Atlantic Europe and Japan are located in coastal areas (in a broad sense), the use of the terms ‘aquatic hunter-gatherers’ (Ames, 2002), or ‘aquatic adaptations’ (Erlandson, 2001) can be more adequate when referring to the Late Mesolithic and Jomon hunter-gatherer groups that left shell middens near aquatic environments. This broad concept of ‘aquatic hunter-gatherers’ includes ‘... those whose

production activities rely on water for procuring food, other resources, and for transportation' (Ames, 2002, p. 20), contrasting with the so-called 'terrestrially based' hunter-gatherers. It should be noted that the concept of 'aquatic hunter-gatherers' does not specify the level of economic dependence of the groups on aquatic environments; instead, it highlights the importance of aquatic resources for food, and for other purposes, such as access to fresh water, artefact production and transportation.

The numerous shell middens in Atlantic Europe and the Japanese archipelago from the Late Mesolithic and Jomon periods demonstrate an important use of water environments and aquatic resources by the groups that left them in a general way. The preservation of shells at these sites is a result of gathering, transport, and processing of significant quantities of molluscs, mostly for food, but also for production of tools and ritual items/activity. Frequently, crustaceans, fish, marine mammals and bird remains are also found, as well as fishing tools (e.g., harpoons, fishhooks, needles, net sinkers). Several large shell midden sites were used by different generations over periods of hundreds, and, in some cases, thousands of years, evidencing the relevance of these specific locations with access to water environments, the systematic use of aquatic resources and the progressive accumulation of shells and other materials over a long time. Although scant, direct evidence of watercraft technologies is known in the European Mesolithic record, notably a number of dugout canoes and associated equipment recovered from some Ertebølle sites in Denmark (Bailey et al., 2020). Several dugout canoes have also been found in Japan in contexts dated between the Early and Final Jomon period, notably in waterlogged sites (Habu, 2004, p. 236). Some were identified in shell midden sites, such as the case of Torihama, Fukui prefecture (Hokuriku region), a waterlogged Early Jomon shell midden site that also provided Incipient and Initial Jomon remains (Tanaka, 2016). A dugout canoe from the beginning of the Middle Jomon period was also found at Nakazato site, Tokyo, located just close to the Nakazato shell midden (Nakajima et al., 2018). The abovementioned canoe was dated to a period before the formation of the shell midden, confirming the frequentation of lowlands and the importance of watercraft already at that time. Overall, the discovery of dugout canoes and related material, both in Europe and Japan, provides direct evidence of active use of transportation through water routes by these Holocene hunter-gatherer groups. In addition, early pottery in Japan – which has been largely found in Jomon shell middens, and in other littoral and inland sites as well – can be seen as probable evidence of aquatic resource use, since the results from recent chemical and isotope analyses on ceramic samples from several sites indicate that Jomon vessels from Incipient, Initial and Early Jomon periods in various coastal and inland locations through the Japanese archipelago were mainly used to process aquatic resources (Lucquin et al., 2016; 2018).

Nevertheless, the dependence of these groups on aquatic environments and resources is, still, often difficult to quantify and compare with precision. The accumulation rates of the shell deposits (and the intensity of mollusc gathering) are hard to calculate for most sites, due to the rarity of detailed chronological data (notably sequences of absolute dates for the shell deposits) and the need to control a large quantity of variables, such as the dimension of the deposits, the sampling procedures, or the post-depositional loss of shells (Dupont and Marchand, 2021; Hausmann et al., 2022). Concerning diets, despite the increase in stable

isotope analyses of human remains, the results obtained on samples from Late Mesolithic and Jomon shell middens have been quite heterogeneous. General assumptions are thus difficult to make concerning this matter, although it seems clear that many individuals buried in Late Mesolithic and Jomon shell middens were not completely dependent on aquatic food, and tended to have developed mixed diets based on important components (although variable) of terrestrial and marine/estuarine food, as indicated by multiple lines of archaeological evidence.

It has been largely found worldwide through archaeology and anthropology that some of the most sedentary, populous, and complex hunter-gatherer groups developed in aquatic environments and exploited aquatic resources (Yesner et al., 1980; Bailey and Milner, 2002; Álvarez et al., 2011). Because of their location in intermediate latitudes and consequent richness in seasonal, productive and reliable resources from marine and terrestrial biotopes, temperate coastlines have been considered to be an environmental zone that tends to generate socio-economic complexity (Rowley-Conwy, 2004). Mainly established in the temperate zone, the Atlantic Europe Late Mesolithic and Jomon groups in general, and especially those in the coastlines, have frequently been considered ‘affluent’ or ‘complex’ hunter-gatherers (Koyama and Thomas, 1981; Habu, 2004; Cummings, 2014), which can be defined as hunter-gatherer societies characterised by an emergent cultural complexity.

The concept of hunter-gatherer ‘complexity’ or ‘affluence’ has been largely debated, but usually defined by the relative presence of certain characteristics, such as: more elaborate and specialised technologies, a greater degree of sedentism and territoriality, more intensive subsistence practices (including food storage), larger populations, higher population densities, and organisational changes in social, economic and ritual structures (e.g., logistical organisation, formation of burial grounds, emergence of social differentiation/inequality, labour organisation/specialisation, warfare and development of exchange relationships on a regional scale, among other things) (Yesner et al., 1980; Koyama and Thomas, 1981; Price and Brown, 1985; Arnold, 1996; Rowley-Conwy, 2004). In particular, the Ertebølle groups of southern Scandinavia have been characterised as an iconic example of complex hunter-gatherer societies of Mesolithic Europe, due to abundant and particularly well-conserved archaeological evidence of a broad spectrum economy, ceramics, prestige material culture and cemeteries (Price, 1985; Bailey and Milner, 2002; Cummings, 2014). Some other Mesolithic groups in Atlantic Europe have also frequently been characterised as complex hunter-gatherers, notably those associated with the Tejo shell middens in Portugal (Bicho et al., 2013a) or the Breton funerary sites (Téviec and Höedic) in France (Schulting, 1996), in which numerous burials were found. On the other side of Eurasia, the complexity of Jomon groups, especially those from northeast Japan, has often been highlighted due to their large settlements, high density of sites, low residential mobility, logistically organised subsistence strategies (including storage), development of cemeteries and ritual structures, sophistication of material culture (including pottery) and other characteristics (Habu, 2004; Matsumoto et al., 2017). In this sense, the formation of numerous and sometimes very extensive shell middens in Atlantic Europe and Japan during the post-glacial period has been seen as an indicator of increasing complexity of hunter-gatherer groups, since it can be related to the establishment of more sedentary lifeways, the exploitation of particularly rich environments

with abundant aquatic and terrestrial resources that could be easily obtained in large quantities and were highly predictable (economic intensification) and, in several cases, the development of burial grounds or cemeteries.

However, through advances in research it has become clear that the peoples in Late Mesolithic Atlantic Europe and Jomon Japan were actually very diverse and not all the indicators of hunter-gatherer complexity can be found in entire regions and archaeological contexts (Cummings, 2014). This heterogeneity can also be detected among the aquatic hunter-gatherer groups that constructed shell middens. The diversity of the Late Mesolithic and Jomon shell middens, as found through this work, seems to have been not only related to differences in ecological settings, but it also reflects different degrees of socio-economic complexity and aquatic adaptations of these groups. In particular, site structure and function are aspects that are deeply linked with the degree of complexity of the groups. Several authors noted that a higher complexity of hunter-gatherer groups is reflected in the characteristics of settlement sites, which tend to be more differentiated, either regarding their internal organisation (e.g., increased evidence of physical demarcation, higher quantity of features) and their typology and location (Price and Brown, 1985, p. 11; Lane, 2014, p. 116). This seems to also be applicable to the Late Mesolithic and Jomon shell middens.

The archaeological evidence from many Late Mesolithic and Jomon shell middens indicates a tendency for a concentration of activities of a different nature at the same sites. However, and despite the frequent difficulties in understanding the stratigraphy, several cases show the existence of intentional spatial arrangements of shell deposits, and also of other features, such as graves, hearths, pits and dwellings. Some distributions of material remains other than shells can also reveal different discard behaviours and places for specific activities. The formation and preservation of the shell midden itself is a result of a deliberate deposition/accumulation of deposits of shells and other material in specific places during a certain period, that can be relatively short or prolonged for centuries. Although the current visibility of such deposits can vary depending on several elements, such as dimensions, location or preservation, it is clear that they occupied a significant amount of space and, in most cases, were not invisible for the communities that constructed them and/or lived nearby. Instead, it is highly probable that large shell middens were relevant territorial markers for the communities, and that some sites, notably those with burial grounds, could have acquired a monumental nature (Takanashi, 2018; 2019; Tomioka, 2020). Sites with long occupations, even if discontinuities are sometimes registered, indicate that the communities developed a prolonged attachment to those places. In several situations, the same spatial rules were shared among several generations, as evidenced by cases of successive construction of structures of the same type in the same areas and continuous use of burial areas through time with few situations where previous graves were affected.

One of the most relevant characteristics that has often been associated with complex hunter-gatherer groups is the development of storage, which can be achieved through different methodologies concerning storage equipment/facilities (e.g., pits, containers, platforms, storehouses) and techniques to prepare food resources for storage (e.g., drying, smoking, freezing, charring, fermentation) (Testart, 1982). As noted in previous chapters, some finds in Late Mesolithic shell middens were related in the past to possible storage

purposes, notably the shell-filled pits (some with complete, unopened shells) found in Muge shell middens, Portugal (Corrêa, 1933; Roche, 1963; 1989) and some shallow pits from Beg-er-Vil, France with few ‘special’ artefacts of different types inside (Kayser, 1987b). However, a storage function seems dubious for both situations, which are more likely to correspond to deposits that occurred in small negative features as refuse or part of ritual activities. In fact, clear storage facilities (associated with stored material) seem to be absent from the Atlantic Europe Late Mesolithic shell middens, while they are known from a number of Jomon shell middens, both in western and eastern Japan. Jomon storage pits identified at shell midden sites usually contain remains of plant food, notably nuts, raw-materials or artefacts. Just to cite some examples from western Japan, storage pits with associated nut remains were found at Hikozaki (Okayama prefecture) (Tajima et al., 2006). At Higashimyo (Saga prefecture), numerous pits with woven baskets, other fibrous materials and nut remains inside were identified (Nishida et al., 2016b). At Araidani (Hiroshima prefecture), concentrations of lithic plates made of andesite have been documented (Araidani Kaizuka Hakkutsu Chosadan, 1976).

Direct and specific evidence of aquatic food storage is almost totally absent, not only in shell middens, but in Jomon littoral sites in general. Rare pits with abundant fish remains inside were identified in some Jomon shell middens. For example, at Komatsu shell midden, Ibaraki prefecture (mainly formed in the Late/Final Jomon period), two pits with fish remains dominated by eel and goby were found – however, according to the researchers, the use of these pits for fish fermentation is an uncertain hypothesis, considering, among other arguments, that the represented species do not move in congregations and seasonal mass capture would not be feasible (Sekiguchi and Kurozawa, 2012). In Europe, the most conclusive case (and earliest in the world) of a fish fermentation pit was identified at the Early Mesolithic site of Norje Sunnansund, in southern Sweden, which was clay lined and filled with cyprinid bones (Boethius, 2016). However, the pit is considered to be an exceptional discovery located at relatively low latitudes (compared to circumpolar regions) and constructed during the specific context of a cold event. In fact, ethnographically documented fermentation pits are only known in high-latitude hunter-gatherer contexts (Testart, 1982), since cold temperatures would be an essential element for the process, especially in the absence of salt use. Despite the uniqueness of the discovery, it demonstrates that some Early Holocene hunter-gatherer groups were, under favourable circumstances, already able to exploit seasonal fish migrations and to store large quantities of fish, reducing residential mobility and creating a surplus. It also becomes a more plausible idea that some storage practices of aquatic food, notably drying and smoking of fish and shellfish, were undertaken with some regularity by the Middle and early Late Holocene hunter-gatherers in Europe and, especially, in Japan, where storage of other food types is well documented.

Important indirect evidence of storage is provided by the large mollusc gathering and processing specialised Jomon shell midden sites in Japan. The best-known example is the Nakazato shell midden in Tokyo, in which high amounts of shell remains of a limited number of mollusc species (large individuals of *hamaguri* clams and oysters) were identified, in addition to specific features that would have been used for mollusc processing. In general, these sites have been regarded by Japanese researchers as the result of intensive production

of dried shell meat products, which would make it possible to extend the period of consumption and facilitate the transportation of shellfish to other sites (Nakajima et al., 2018). Recently, and based on results of organic residue analysis on sherds from several Jomon sites, including some shell middens, it was suggested that the first Jomon pottery could have been used for fermentation of aquatic foods in order to preserve these resources, since pottery may have been particularly advantageous for controlling the fermentation without the use of salt in temperate environments (Craig, 2021; Shoda, 2021). However, further analyses are required to obtain more details on the use of Jomon pottery vessels, especially those from later periods, such as the Middle and Late Jomon.

Overall, the presence and formation of numerous and diverse shell middens in the Late Mesolithic and Jomon archaeological record can be generally seen as a consequence of resource abundance in particularly rich environments with terrestrial and aquatic components and the development of trends of effective exploitation of those environments, subsistence intensification, reduction of residential mobility, increased territoriality and recurrent ritual practices by hunter-gatherer groups in Atlantic Europe and Japan. These developments can be broadly related to ongoing processes of socio-economic complexity. However, the diversity observed in the number, form, dimension, components, undertaken activities and internal organisation of the Late Mesolithic and Jomon shell middens also indicates that these trends were not developed with the same intensity in all regions of Atlantic Europe and Japan, and neither were they formed in a gradual way.

The large circular shell middens in Tokyo Bay, in Japan, are likely to reflect the highest levels of complexity achieved by hunter-gatherer groups that left shell middens in the Middle and early Late Holocene in Eurasia, as seen in several characteristics, such as: large dimension, high visibility, significant site density indicating high population density, strong internal site structure that includes maintenance of specific layouts of shell accumulations and other features, prolonged use of the sites, large number of features, including storage pits, and intense ritual activity (burial grounds, ritual deposits and other activities). However, even this remarkable phenomenon was not a continuous process, being characterised by situations of growth and decline during the Middle and Late Jomon periods (e.g., Nishino, 2007; Habu et al., 2011; Nishino et al., 2017). The formation of large shell middens classifiable as mollusc-processing specialised sites in Tokyo Bay, indicating subsistence intensification, labour specialisation and development of exchange relationships, can also be considered as more evidence of social complexification.

In western Japan, the degree of sedentism and social complexity of Jomon societies are generally considered to have remained lower compared to eastern Japan, and the characteristics of shell middens seem to reflect these differences, such as those in the Seto Inland Sea region. Some shell middens in the Okayama region occupied in the Late Jomon period provided evidence of some economic intensification, more complex ritual practices and intra-site spatial structure in comparison with earlier periods, a difference also evidenced by other settlement sites in general (Yamamoto, 2004). However, the different developmental trajectories of the Jomon groups do not seem to be only influenced by geographic (eastern/western Japan) or chronological factors (earlier/later phases of the Jomon period). The outstanding case of Higashimyo, dated to the end of the Initial Jomon

period, in the Kyushu region, provided evidence of a shell midden settlement site with a strong internal spatial structure, storage activities, sophisticated craft and significant ritual activity. The site reflects an important level of socio-economic complexity achieved in relatively early times of the Jomon period, which apparently had no immediate continuity in the region (Nishida et al., 2016b).

In Atlantic Europe, Late Mesolithic shell middens in general provided more limited signs of socio-economic complexity, notably: some large sites with prolonged occupations; the formation of cemeteries (in Portugal and France), with some situations of elaborated rituals; evidence of some site internal structuration (at larger sites); and inter-site differences that in some cases suggest site hierarchy (in Denmark). It can be highlighted that, despite the fact that the Ertebølle in Denmark is usually considered to be an example of complex hunter-gatherer culture in Europe, the shell middens from that region do not reveal evidence of a site internal structuration level as observed in eastern Japan, in part due to the rarity of identified dwellings and funerary features.

Shell midden phenomenon in the Middle and early Late Holocene in Atlantic Europe and Japan can be broadly related to ongoing processes of socio-economic complexification, but this does not mean that shell midden construction was an exclusive trait of more complex hunter-gatherers, or that all hunter-gatherer groups with high levels of complexity left shell middens. Clearly, different local ecological backgrounds, subsistence practices, levels of economic and social complexity and historic trajectories existed among the shell midden constructors in the diverse regions of Atlantic Europe and Japan.

Final considerations and conclusions

Despite being a subject with a long history of research, shell middens constructed by the Middle and early Late Holocene hunter-gatherer groups in Atlantic Europe and Japan continue to bring many challenges to researchers. Several efforts have been made to extract all possible information from these sites concerning environmental, economic and cultural aspects of the societies that left them. However, much less attention has been paid to the formation, functioning, and meaning of the sites themselves. Due to their richness, shell middens have been more regarded as archives of accumulated information, instead of places of activity by living societies in the past. In this sense, it can be suggested that future shell midden research should deal with both dimensions, which are obviously connected, in a more balanced way. The development of transcultural comparative approaches between Europe and Japan (and other regions) can be an interesting way to contribute to the construction of more balanced perspectives on shell middens. This type of investigation inevitably leads the researcher to go beyond the acquisition of data from local case studies, through the integration of the obtained information into wider discussions on human development.

Shell middens from the Late Mesolithic of Atlantic Europe and the Jomon of Japan are diverse in many aspects, such as location, dimension, site density, formation processes, features and material contents, which also reflect important differences in site structure and function. Despite this, the present study allowed us to understand a number of common characteristics that are shared by these shell middens, notably:

- 1) The high occurrence of sites from the Middle Holocene onwards (although many earlier sites would have been submerged);
- 2) The predominance of open-air sites (excepting some regions) associated with sheltered water environments (bays, estuaries, lagoons and other places) with salt or brackish waters;
- 3) The frequent location in ecotone areas and recurrent evidence of exploitation of diverse resources (terrestrial and aquatic);
- 4) The frequent presence of human burials, especially at larger sites, forming cemeteries in several cases;
- 5) The frequent evidence of diverse activities, especially in shell middens with larger dimensions and/or a high number of burials;
- 6) The frequent evidence of animal-related ritual activity (such as dog burials and deposits of certain elements, such as antlers or skulls of animals);
- 7) The low number of large mollusc-processing specialised sites identified through adequate archaeological evidence;
- 8) The frequent cases of prolonged use of the sites for several centuries and, in some cases, for more than one millennium (although occupations after shell midden formation were often short).

It was also possible to show that, despite the complex formation processes that can often characterise these sites, internal spatial organisation can be understood in several shell middens, notably those with evidence of diverse activities. Various indicators can be noted, such as:

- 1) The intra-site differences between shell deposits (contents, location and context);
- 2) The placement of features showing concentrations in certain areas, clustering by types and/or particular layouts;
- 3) The distribution of material remains indicating concentrations in particular areas and intra-site differences according to the material nature, typology or other characteristics (e.g., raw material, state of fragmentation).

The cases analysed in this study confirmed that the Holocene hunter-gatherer groups that constructed shell middens in Atlantic Europe and Japan – although classifiable as ‘aquatic hunter-gatherers’ – were also diverse in terms of economic, cultural, and social aspects. While the shell midden phenomenon is not an exclusive trait of more complex hunter-gatherers, nor do all hunter-gatherer groups with high levels of complexity leave shell middens, it could be observed that the degree of social complexity of the communities is strongly related to the site structure and function of shell middens. In general, it was observed that a higher social complexity is reflected in stronger evidence of site structuration (clearer intra-site differences in the distribution of material remains, structures and deposits) and inter-site functional differences (e.g., situations with the development of large mollusc-processing specialised shell middens near other shell midden sites and the formation of large sites with stronger evidence of symbolic activity in relation to others in the same settlement system). Regarding site function, it can also be said that many Late Mesolithic and Jomon shell middens in Atlantic Europe and Japan were multifunctional sites – several of them with abundant funerary/ritual activity – while few sites have provided enough evidence to sustain a classification as a mollusc-processing specialised shell midden. Also, in general, it was possible to understand that many shell middens were integrated into a wider network of littoral sites, although non-shell midden littoral sites tend to be less known and still require deeper research in both regions. Despite the existing gaps in the information, it can be highlighted that at least shell middens with burial grounds would have a particular social relevance and symbolic role, considering that many of these sites had a prolonged use, which indicates the attachment of different generations to these places and the preservation of memory. Large, mounded-type shell middens with evidence of diverse activities were often used for funerary purposes, some probably acquiring a landmark function.

It was also possible to show through this work that the methodologies of excavation and post-excavation analysis of shell middens have a great impact on the available information on these sites, and especially on the understanding of site function and structure. The examples from Europe and Japan have shown that the excavation of large areas of a shell midden, including the surroundings without shells, provide data that are substantially different from those that result from surveys or small trench excavations. The use of detailed methods of sampling, sieving and sediment sorting is another relevant aspect that bring enormous differences in terms of the amount and quality of the obtained information. Therefore, it can be pointed out that the interpretations of researchers concerning shell midden use, including site typological classifications, should more carefully reflect the limitations of the archaeological data that sustain them.

Constructing shell middens was a common behaviour to the aquatic hunter-gatherer groups of the Middle and early Late Holocene in Atlantic Europe and Japan. Some similar

characteristics can be found between the regions, but the phenomenon also acquired multiple configurations that had, certainly, multiple meanings that cannot be easily deciphered. Transcultural comparative approaches can be useful to cross various methodologies of research, scales of analysis and perspectives of interpretation to find similarities, but also to characterise in detail the diversity of this phenomenon and the human societies that were behind it.

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