Rita Peyroteo Stjerna

on

Death in the Mesolithic

or the

Mortuary Practices of the Last Hunter-Gatherers of the South-Western Iberian Peninsula, 7\textsuperscript{th}–6\textsuperscript{th} Millennium BCE

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Abstract

The history of death is entangled with the history of changing social values, meaning that a shift in attitudes to death will be consistent with changes in a society’s world view.

Late Mesolithic shell middens in the Tagus and Sado valleys, Portugal, constitute some of the largest and earliest burial grounds known, arranged and maintained by people with a hunting, fishing, and foraging lifestyle, c 6000–5000 cal BCE. These sites have been interpreted in the light of economic and environmental processes as territorial claims to establish control over limited resources. This approach does not explain the significance of the frequent disposal of the dead in neighbouring burial grounds, and how these places were meaningful and socially recognized. The aim of this dissertation is to answer these questions through the detailed analysis of museum collections of human burials from these sites, excavated between the late nineteenth century and the 1960s.

I examine the burial activity of the last hunter-gatherers of the south-western Iberian Peninsula from an archaeological perspective, and explain the burial phenomenon through the lens of historical and humanist approaches to death and hunter-gatherers, on the basis of theoretical concepts of social memory, place, mortuary ritual practice, and historical processes. Human burials are investigated in terms of time and practice based on the application of three methods: radiocarbon dating and Bayesian analysis to define the chronological framework of the burial activity at each site and valley; stable isotope analysis of carbon and nitrogen aimed at defining the burial populations by the identification of dietary choices; and archaeothanatology to reconstruct and define central practices in the treatment of the dead.

This dissertation provides new perspectives on the role and relevance of the shell middens in the Tagus and Sado valleys. Hunter-gatherers frequenting these sites were bound by shared social practices, which included the formation and maintenance of burial grounds, as a primary means of history making. Death rituals played a central role in the life of these hunter-gatherers in developing a sense of community, as well as maintaining social ties in both life and death.

Keywords: death, Late Mesolithic, hunter-gatherers, social memory, place, burial practices, mortuary ritual, historical process, south-western Iberian Peninsula, archaeothanatology, radiocarbon dating and Bayesian analysis, stable isotopes (carbon and nitrogen), shell middens, museum collections

Rita Peyroteo Stjerna, Department of Archaeology and Ancient History, Box 626, Uppsala University, SE-75126 Uppsala, Sweden.

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To my mom,

who worked hard to raise me, and whose love for History has always been an inspiration.
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Hunter-gatherers entered my life when I was little. Long before I was born, my dad travelled through Africa and met some of the last hunter-gatherers of this continent. With him, he brought photographs of these encounters, offerings and objects of exchange, and vivid memories which he shared with me and my sister as we were growing up. I have been curious about the strange lifeways of hunter-gatherers since then, but only many years later did I find that pursuing Archaeology was my way forward. My dad passed away early last summer, while I was working in a dig in Norway and writing the sections of this dissertation about the treatment of the dead among the last hunter-gatherers of Portugal, where I was born. As strange and awkward as everything felt this summer, I now realize how everything is interconnected and how through death we make sense of life.

As I write these lines I think of people and institutions to whom I wish to express my gratitude for helping me throughout the long and sinuous path that is a doctoral research programme.

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José Paulo Ruas photographed the human burials preserved in paraffin blocks at the National Museum of Archaeology, Lisbon, as well as all site plans. I am thankful for his professionalism, but mostly for his friendship, support, and delicious late dinners with Catia.

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Svartsjö, 11th January 2016
Rita Peyroteo Stjerna
Abbreviations

APMH: Personal Archive of Manuel Heleno, Arquivo Pessoal de Manuel Heleno
Excav.: excavation
Ind.: individual
m.a.s.l: metres above sea level
MG: Geological Museum, Museu Geológico (Lisbon, Portugal)
MHNUP: Museum of Natural History, University of Porto, Museu de História Natural da Universidade do Porto (Porto, Portugal)
MNA: National Museum of Archaeology, Museu Nacional de Arqueologia (Lisboa, Portugal)
MNI: minimum number of individuals
MUNHAC: National Museum of Natural History and Science, Museu Nacional de História Natural e da Ciência da Universidade de Lisboa (Lisbon, Portugal)
n/a: not available
n/d: not determinable
n/p: not published
Sk/Sks: skeleton/skeletons

Archaeological sites
ARA: Arapouco, Sado valley
CAM: Cabeço da Amoreira, Tagus valley
CAMS: Cabeço das Amoreiras, Sado valley
CAR: Cabeço da Arruda, Tagus valley
CP: Cabeço do Pez, Sado valley
MS: Moita do Sebastião, Tagus valley
VM: Várzea da Mó, Sado valley
VR: Vale de Romeiras, Sado valley

Chemical elements mentioned in the text
Ba: barium
C: carbon
Ca: calcium
Mg: magnesium
N: nitrogen
Sr: strontium
V: vanadium
Zn: zinc
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Death is a physical and a metaphysical phenomenon with a material representation. Because human attitudes towards death are never random, the intrinsic materiality of death is especially interesting for archaeology. Death’s materiality offers a window to past attitudes to the biological death of the individual and to the cultural aspects of the human engagement with death.

Archaeological evidence shows that the origins of mortuary burial practice go back to at least the Middle Palaeolithic, but until the Late Mesolithic the burial of the cadaver seems to be an exceptional occurrence. Likewise, the earliest places of frequent burial practice go back to the Middle and Upper Palaeolithic, becoming more common in postglacial scenarios in Europe and in the Near East.

Death in the Mesolithic sites of the Tagus and Sado valleys, Portugal

The Mesolithic shell middens of the Tagus and Sado valleys are remarkable because of the large number of human bodies buried in these sites, and constitute the archaeological material investigated in this dissertation. These sites aggregate some of the largest and earliest burial grounds known, arranged and maintained by populations with an exclusive hunting, fishing, and foraging lifestyle. Here, in the south-western Atlantic coast of Europe, the rise of sea levels during the Atlantic climatic optimum (c 6400–4350 cal BCE) resulted in the formation of large estuaries. The typical scattered settlement pattern known for the Pre-boreal, Boreal, and very early Holocene (c 9530–6400 cal BCE) became clustered by these new ecosystems in interior estuarine regions (Araújo 2003). Today, far from sight and influence of marine waters, these Late Mesolithic shell middens can be very large archaeological sites, many of them with well preserved human remains. This new form of settlement was accompanied by a different relation to death. At the Tagus and Sado valleys, burial practice was a common way of disposal of the dead. New born babies, children, young and old adults, men and women, were carefully buried in these places. From the 13 middens identified in the Tagus valley, nine have human burials with a total of at least 263 individuals (Bicho et al. 2013; Cunha and Cardoso 2001, 2002–03; Jackes and Meiklejohn 2008; Meiklejohn et al. 2009a; Paço 1938; Roksandic 2006; Santos et al. 1990). Similarly, in the Sado valley, there are 11 known middens, six of which with human burials to a total of c 113 individuals.
Introduction

(Cunha and Umbelino 1995–97; Diniz et al. 2014). This particular engagement with death contrasts with earlier and contemporaneous sites in the region; burial as a mortuary practice was known in the Iberian Peninsula, however, it was not common practice (Peyroteo Stjerna, forthcoming).

Shell midden sites with burial grounds have been interpreted in the light of economic and environmental processes as territorial claims to establish control over limited resources (Arnaud 1989, 621). In highly productive estuarine environments such as these, this is a compelling argument. However, subsistence alone does not explain the significance of the frequent disposal of the dead in neighbouring burial grounds, and how these sites were meaningful and socially recognized. Furthermore, the classic functionalist approach tends to reduce hunter-gatherers to highly adaptive humans with a functional responsive behaviour, and ignore that they were also agents of history with an historical consciousness and an intrinsic symbolic expression. Human burials in archaeological contexts are an opportunity and a challenge for researchers to investigate the non-utilitarian spheres that structured the hunter-gatherer lifestyle.

Aims of the dissertation

Research questions and theoretical framework

The aim of this dissertation is to understand the relevance of the formation and maintenance of burial grounds, and the significance of mortuary practices at the sites of the Tagus and Sado valleys. In this study, I examine the burial activity of the last hunter-gatherers of the south-western Iberian Peninsula from an explicitly archaeological perspective, and intend to explain the burial phenomenon through the lens of historical and humanist approaches to death and hunter-gatherers, on the basis of theoretical concepts of social memory, place, mortuary ritual practice, and historical processes. Theoretical framework formulated to address the research questions stems from the need to bridge archaeological evidence obtained from a set of archaeological methods strongly rooted in the natural sciences, with the actions of people in their historical context.

Methodological choices

The human burials excavated from the nineteenth century to the 1960s at the shell middens of the Tagus and the Sado valleys are at the centre of this research and constitute the archaeological material of this study. Understanding the significance of the burial activity at these sites requires we define how consistent and deliberate these practices were, who was buried in these places, as well as when and how. The examination of the burial activity through the analysis of the human remains in these archaeological contexts relies on the application of three methodologies:
Introduction

radiocarbon dating and Bayesian analysis, stable isotope analysis of carbon and nitrogen, and archaeothanatology. Following the aims of this dissertation, these methods are used to investigate human burials in terms of time and practice, which can be outlined as follows:

- to examine the chronological framework of the burial activity at each site and each valley;
- to characterize the dietary patterns of the burial populations in an attempt to define more closely who was buried in these sites;
- to reconstruct and define the central practices and gestures involved in the treatment of the dead.

The outcome

Evidence obtained from archaeothanatological and isotopic analysis within the chronological framework of the burial activity of each site, demonstrates that the mortuary programme at the Tagus and Sado valleys was governed by a core set of common practices that defined the proper burial. Despite the common mortuary programme, the people buried in each valley were part of regional bands with contrasting dietary patterns, suggesting that different groups were buried in each valley and in each burial ground. More significantly, these results challenge former interpretations which explained the Late Mesolithic settlement pattern in these regions in the framework of seasonal and logistic models.

This dissertation provides new perspectives on the role and relevance of the shell middens of the Tagus and Sado valleys. People frequenting these sites did not merely adapt to a new environment. Hunter-gatherer communities were structured within specific social scenarios in a historically situated world view. People were bound by shared social and historical practices, which included the formation and maintenance of burial grounds, as a primary means of history making. In this study, I wish to suggest that mortuary ritual practice had a central role in the formation and maintenance of these places, because this social practice is an act of cultural production and a powerful memory aid. Furthermore, I propose that the frequent burial of the dead in these burial grounds was an act of historical consciousness motivated by the encounter and interaction with other bands frequenting the same environments. With this approach, I wish to stress the active roles of memory and historical production, performed by mortuary ritual practice, which were central in the formation and reconstruction of these places. This aspect of social memory, the memory transmitted through bodily practices, has been widely neglected, particularly in hunter-gatherer studies. In this view, and in the scope of hunter-gatherer studies, the human burials are material representations of the historical practices of the last hunter-gatherers of the south-western Iberian Peninsula, and were recorded in these shell middens as depositional narratives of an historical process.

The topographical placement of the dead within the landscape of the living was a central element in the social dynamics of the last hunter-gatherers of the Tagus
Introduction

and Sado valleys. The formation of permanent burial grounds has been associated with an increasingly sedentary lifestyle. However, the more or less permanent use of these sites remains an open question, and it may have varied over time and between regions. While the funerary function of the places is undeniable, the residential nature of the sites remains unclear. As discussed throughout this dissertation, dietary patterns of protein consumption identified in the different burial grounds reflect a strong connection of the burial population to the ecology of each site. However, while this may indicate that these sites were used during long periods, it does not exclude the possibility of mobility, exploration, and use of other territories.

Among other possible features and interpretations, these shell middens were mutually a place for the dead, and a place of ritualized codes. Death rituals played a central role in the life of these hunter-gatherers in developing a sense of community within the landscape, as well as maintaining social ties in both life and death.

Outline of the dissertation

The dissertation is structured in three parts. In part one, Death, I introduce and explore the theoretical framework of this research by addressing central issues of the human engagement with death framed as acts of cultural practice and historical consciousness. In this part, I outline a short history of death in deep time with a focus on burial as a mortuary practice. This is followed by a brief examination on the core relationship between the discipline of archaeology and the spaces dedicated to the dead. I conclude this part with considerations on the role of archaeology in death studies and reflect upon the significance of studying death.

In part two, Bodies of Knowledge, I present the source material and archaeological evidence of this dissertation, from chapters 2 to 5. Chapter 2, Archaeological Material, presents a general description of the archaeological sites, the material selection, and an examination of the historical contexts of data production. Chapter 3, Methods, outlines the three methodological approaches applied in this study which were explicitly targeted towards the study of mortuary practices: radiocarbon dating and Bayesian analysis, stable isotopic analysis of carbon and nitrogen, and archaeothanatology. In this chapter, I present the central principles of each method and their application to this particular data set. Chapter 4, Results, presents the data obtained from the radiocarbon and Bayesian analysis, stable isotopic analysis of carbon and nitrogen, and archaeothanatological analysis. This chapter is organized by archaeological site. In the last section of Bodies of Knowledge, Chapter 5, Analysis and Synthesis of the Results, I present a synthesis of the results and examine the intersections of the empirical evidence from each archaeological site in the context of each valley and inter-valley.

In the last part of this dissertation, part three, Death in Place, I discuss the archaeological evidence from the perspective of mortuary behaviour on the basis of the concepts of social memory, place, mortuary ritual practice, and historical
processes. Chapter 6, The Places of the Dead as Places of Shared Narratives: Discussion, evaluates the boundaries of the mortuary phenomenon under study, in terms of practice, space, and people. I discuss the significance of the observed mortuary ritual practices in the formation and maintenance of the shell middens at the Tagus and Sado valleys. The volume is completed with the last section of this chapter, Conclusion: on the history of death and the last hunter-gatherers of the south-western Iberian Peninsula, where I address the central arguments in this dissertation and emphasize the relevance of further research in the field of archaeology of death so that we can better understand the social and historical dynamics of the last hunter-gatherers of the south-western Iberian Peninsula.

The appendix provides supplementary data and it is available online-only. Tables in the appendix are indicated by the letter A followed by a sequential number (e.g. Table A.1).
PART ONE: DEATH

Döden: Därför spelar du schack med Döden?
Riddaren: Han är en svår och skicklig taktiker men än så länge har jag inte givit upp en enda pjäs.

(Bergman 1957)
Introduction to part one

Death is a complicated field of research because it affects all of us. This is also why the field is so intriguing and captivating. Although each individual encounters the experience of death in different ways, the way we deal with the death of others and with our own personal awareness of death, has a major influence on how we, as researchers, think about death.

The opening part of this dissertation is dedicated to the subject of death as a central academic field of research, and is written from an archaeological point of view. In the first section, *The human engagement with death*, I outline a brief history of death in deep time. The burial practices of the last hunter-gatherers of the southwestern Iberian Peninsula are the object of this dissertation and this version of the history of death is biased towards these elements: burial and (Mesolithic) hunter-gatherers. This section is followed by *Archaeological thought and death*, where I discuss the importance of the places of the dead in the development of the discipline of archaeology. I then turn to the theoretical framework of this dissertation to address central issues of the human engagement with death framed as acts of cultural practice and historical consciousness – *Deathways of hunter-gatherers and historical processes*. Having death as a point of departure, I explore the role of mortuary ritual practices as powerful memory aids in the formation, maintenance, and reconstruction of places for the dead, by stitching together the spheres of death, memory, and place, with the thread of the historical process – *Memory in the landscape: rituals in practice*. In the last section, *Death in deep time: why does it matter?*, I argue for the potential of death studies to investigate changes of world view in a given society, and why knowing about how past societies dealt with death, grief, bereavement and commemoration, actually matters, highlighting why archaeology is in a privileged position to contribute to an interdisciplinary dialogue in the field of death studies.
Chapter 1
Death, Hunter-Gatherers, and the Historical Process

The human engagement with death

The human experience of death is unique in the animal kingdom and it reflects in a unique way the complexity of the human species. The paradox of the human engagement with death lies in its universality on the one hand, and its heterogeneity on the other. The universal concept of death, as the inevitable fate of all living beings, has paradoxically, a heterogeneity of meanings that only an emotional and creative complexity can explain. The invention of death (see Taylor 2003) rests on this antagonism, and it is one of the most particular aspects of the human condition. Awareness of death is possibly the most powerful challenge to human significance and destiny, and a cornerstone in the development of humanity (Davies 2005). For social and intelligent beings death is an emotional experience, both in terms of bereavement and consciousness. Despite symbolic and religious beliefs, grief was certainly powerful in the close-knit bands of past hunter-gatherers (Davies 2005; Tarlow 1999). Social experience is centred on emotions and materials (Gamble 2013; Gamble et al. 2011), and ritual responses to death act as bodily and material ways to cope with the crisis of death. Ritual responses to death have an integrating effect. Mortuary ritual practices make the link between death and life, while allowing a perspective upon life and the future (Davies 2005). Mortuary rituals act on the level of individual relationships but more importantly, they act on the cosmological level, between humans and the world around them (Nilsson Stutz 2014). For this reason, D. Davies (2005, 90) has argued in his book A brief history of death that “humanity became stronger because of death-awareness”.

The debate about the origins and human concept of death, as well as its meaning in the context of human evolution, is ongoing and multivocal. The development of language, carrying with it the communication and memory of the inevitability of death, along with cognitive developments associated with symbolic thought and the earliest ritual practices, are probably the origin of the development of a necessity/capacity for intentional and reflective funerary ritual practice. The core of this debate lies in the timing rather than the factors: when, in human evolution, did humans develop this consciousness of death? With modern humans only (c 35,000 years ago, in Europe), or is it an earlier development? For the immense time span between the Middle and Upper Palaeolithic, only c 150 possible funerary
Deposits have been identified (Pettitt 2011; Taylor 2003, 31), and in many of these contexts it is difficult to confirm the intentionality of the practices as funerary behaviour (see Zilhão and Trinkaus 2002, 519). Another set of questions in the scope of the debate about the origins of funerary behaviour relates to the significance and impact, in human evolution, of clear manifestations of intentional funerary ritual practices. These questions are important not only from the perspective of the development of ritual and symbolic behaviour associated with a consciousness of death, but also in the cognitive context of the formation of the self, society and cosmologies (Parker Pearson 2005, 146). In any field of research, questions related to theme of origins are always complex and controversial, and the debate on the origins of funerary behaviour is no exception (see Pettitt 2011).

Origins of human burial

In this brief overview I focus on the origins of human burial and on the formation of the first cemeteries in Europe. Following the aims of this dissertation, this review is focused on the act of human burial as a form of funerary practice, and for this reason some preliminary observations should be made.

The first observation concerns the different contexts where human remains can be found. The presence of human remains in a site is not necessarily correlated with funerary practice. Human remains can be found in a variety of cultural contexts. Human remains can be worn as ornaments, as well as amulets and relics; can be involved in an array of ancestral and religious rituals, as well as in demonstrations of power; can be found in scenarios of violence and conflict, as well as in contexts of accidental death; the list goes on. The funerary context is just one of the many contexts where human remains can be present, and the intentionality of the actions should be demonstrated (Duday 2009).

A second preliminary observation is that burial is just one of many possible cultural options in the complex diversity of funerary practices. Also, the act of burial is frequently just one part of the various episodes involved in the funerary process. Burial is, however, a practice that may be well preserved in the archaeological record (see Lyman 1994), hence the traditional interpretative focus on this practice, often ignoring other variables. As noted above, regarding the context of occurrence of human remains, a buried corpse is not necessarily correlated to a funerary practice either. Also, it should be emphasized that the development of a consciousness of death is not synonymous with marking its occurrence. Following these preliminary observations, a cautious and evidence-based approach is essential when interpreting the presence of human remains in archaeological contexts.

According to the available evidence, the earliest intentional burials known date from c 120,000 to 90,000 years ago, with evidence from Anatomically Modern Humans (AMH) and possibly Neanderthals (Pettitt 2011). These early burials are interpreted as the earliest evidence of deliberate creation of a space in which to deposit and cover a corpse (Pettitt 2011, 57). The remains of ten archaic AMH at the Mugharet-es-Skhul cave, Mount Carmel, Israel, are the earliest burials known,
dated to between 130,000 and 100,000 years ago. Archaeological evidence indicates that at least four individuals were placed in artificially excavated grave cuttings, attesting to the intentionality of the burial act (Belfer-Cohen and Hovers 1992; Pettitt 2011, 59–62). *Djebel Qafzeh cave*, Israel, contains the remains of 13 archaic AMH dated between 100,000 and 90,000 years ago, presenting what seems to be evidence for organization of the space with a dedicated area for the dead (Bar-Yosef and Vandermeersch 1993; Pettitt 2011, 63, 68–72). The reasons why these individuals were buried at Skhūl and Qafzeh are unknown and the nature of the ritual practices behind such depositions remain a question of debate. While some authors argue in favour of a degree of symbolic practices involved in the burials (Hovers et al. 2003; Pettitt 2011), other researchers question the ritual dimension of these early burials based on their simplicity and variability (Shea 2001). Evidence from possibly the earliest Neanderthal burials known comes from *Tabun cave*, Israel. The dating of the Tabun sequence is hotly debated (Bar-Yosef 2000; Millard and Pike 1999), but it seems probable that at least one of the three individuals found in the cave was buried c 120,000 years ago. While there is strong evidence for Neanderthal burials c 30,000 years ago, burial practices were rare and the archaeological data seems to indicate a more varied funerary activity among Neanderthals, even when compared with contemporary AMH populations (Pettitt 2011, 79).

The earliest burials of AMH in Europe emerge in the Mid Upper Palaeolithic, c 29,000–21,000 BP, and present clear evidence of mortuary ritual practices (Pettitt 2011, 168). The earliest burial known in the Iberian Peninsula is dated from this period, c 25,000–24,000 BP (Pettitt et al. 2002), and was found at *Lagar Velho* in the Lapedo valley, Portugal. This is an individual burial of a 4–5 year old child, buried in a shallow pit in a rock shelter, and was accompanied by a complex set of grave goods (Duarte et al. 1999; Zilhão and Trinkaus 2002). Despite the relatively complex burials known for this period throughout Europe, the preferred relationship with the dead is mobile. The bodies of the dead were fragmented and moved across the landscape. This mobility was possible through complex interaction with the cadaver and processing of skeletal elements into personal ornaments, amulets and relics. The archaeological evidence for the symbolic fragmentation of the human body is particularly strong for the European Mid and Late Upper Palaeolithic, also represented in parietal and portable art (Pettitt 2011), remaining a common practice throughout the Mesolithic (Gray Jones 2011).

The deliberate burial of dead (i.e., excavation of a grave; placement of the cadaver in the feature; covering of the cadaver) is a practice only known for two hominids: Neanderthals and AMH. However, throughout human history, burial as a funerary practice was always rare and certainly not the funerary norm (Pettitt 2011). Overall, burial evidence clusters into certain periods in particular regions, suggesting that burial practices were not transmitted continuously throughout the Middle and Upper Palaeolithic. Burial practice becomes more frequent in the later stages of the Upper Palaeolithic, during the Late Pleistocene, between 15,000 and 12,000 BP, in several regions of Europe and the Near East. During this time,
several places were clearly reserved for the formal burial of the dead suggesting incipient forms of cemeteries. These practices, first identified in the Late Pleistocene, during the final stages of the Upper Palaeolithic and the Early Mesolithic, continue into the Holocene (see Meiklejohn et al. 2009b). Human burial in dedicated spaces for the dead then becomes more frequent, suggesting that burial practice was charged with a new meaning, possibly in the context of new cosmologies and world views (Nilsson Stutz 2014; Pettitt 2011, 249). Burial was no longer an odd phenomenon dedicated largely to single individuals placed in secluded caves and rock shelters.

The formation of cemeteries is a phenomenon in the landscape (Pettitt 2011, 249) and presents a new relationship with death. The earliest examples of this practice can be traced in the Late Pleistocene (c 15,000–11,000 BP), but largely in caves. A new topographical relationship with death, with the formation of dedicated spaces for the dead in open air sites, is clearly an emergent phenomenon in the context of postglacial societies, with well known examples in the European Mesolithic. Although as we shall see later in this dissertation, burial practice in dedicated sites remains exceptional in the Iberian Peninsula, until the Late Mesolithic cemeteries at the Tagus and Sado valleys, c 8000 years ago (see Peyroteo Stjerna, forthcoming). The adoption of one or another funerary practice varies regionally and according to specific social dynamics.

The variability and discontinuity in mortuary practices through time and space suggests that burial practice is not the end point of a development of a funerary practice, nor the end point of an internal social development of hunter-gatherers. Modern western society retains the idea that, “the ways of physically removing the dead from the living have changed very little during the course of human history” (Davies 2005, 49), based on the misleading idea that earth-burial and cremation have always been the two basic forms of funerary practice. However, burial practice is one of many possible cultural options for the treatment of the dead, but many of these other practices do not leave traces in the archaeological record. Also, burial practice is not necessarily more complex than any other cultural option for the treatment of the dead, to which can be added that absence of burial is not equivalent to absence of mortuary practice either. From this perspective, mortuary practices cannot be approached in a progressive evolutionary way: burial is not a step in the directional development of hunter-gatherers.

Material nature of death

One of the main difficulties when analysing archaeological data is presented by the diversity of cultural responses, which is a central characteristic of human behaviour. Attitudes towards death constitute a good example of this great diversity. Is there a common denominator in cultural responses to death? One of the fundamental aspects of being human is the material form in which ideas are expressed and understood. The diversity of cultural responses to death has in common the materiality of death (Fahländer and Oestigaard 2008).
Death is a material event in both biological and cultural dimensions (Nilsson Stutz 2003a, 2008; Robb 2013). The death of the individual is a biological phenomenon with a corporeal representation: the deceased is a material entity. The human engagement with death, as an emotional and metaphysical phenomenon has also a material representation: by the manipulation of space, of objects, and the human body itself. Herein lies the advantage of the discipline of archaeology in the field of death studies: the material nature of death (fig. 1.1).

**Figure 1.1.** The archaeological study of death through its material remains.

Archaeological thought and death

In popular culture, archaeology and the spaces of death are practically intertwined. We are all familiar with two of the most popular fictional archaeologists: Dr. Henry Walton Indiana Jones Jr. and Lara Croft from the video game Tomb Raider. Both characters are known for their adventures in ancient tombs, chasing mysterious artefacts of ancient funerary practices, while fighting the troops of doom. Despite the fact that neither of these fictional characters pursues archaeology in the modern sense, there is a hint of truth behind this representation of the discipline. In fact, the development of archaeology as a scientific subject is closely related to mortuary spaces. This is because, the spaces reserved for the dead are frequently preserved and maintained over generations, as places of commemoration and memory. Often, these can also assume monumental proportions and are frequently easy to identify because of their visibility in the landscape; typically by contrast
with settlement sites built with perishable materials which are easy to renovate but
decay quickly, becoming more subtle in the landscape, and in the archaeological
record.

In this section, I present a brief overview of the development of archaeological
thought in terms of the importance of the places of the dead in the development
of the discipline. In the last part of this section Historical and humanist approaches to
death and hunter-gatherers, I outline the theoretical framework of this dissertation
formulated to address the particular questions of this research.

Chronology and typology

It was in the late eighteenth century that the first systematic excavations took
place, with the recovery of a great quantity of artefacts that constituted the assem-
blages of the first museums (Chapman and Randsborg 1981, 2–3). It is in this con-
text that in the mid nineteenth century, C. J. Thomsen and his collaborator J.
Worsaae developed the method of relative chronology (Trigger 2007, 124) begin-
ning with a chronological approach to the analysis of funerary contexts, named The
Worsaae Law. According to this principle, the objects that accompanied the funer-
ary deposition would be in use in most cases, during the same time period. This
principle was at the root of all chronological associations in funerary context
(Rowe 1962, 129), and constitutes the basis of the first typological series, being the
first contribution of mortuary archaeology to the study of past human societies.

The cultural paradigm, normative and diffusionist

In the first half of the twentieth century, in continuity with the chronological and
typological approaches of the previous century, the great interest in funerary con-
texts stemmed from the assumption of its potential as cultural indicator (Childe
1945). The comparative analysis of the great quantity of artefacts, recovered mostly
from funerary contexts, motivated the recognition and definition of cultural areas
in space and time, with the development of typological series always becoming
more refined. The normative concept of culture, introduced by the new theoretical
framework developed by G. Childe (1929) guided research during this period.
Changes in material culture were interpreted from a diffusionist perspective, re-
placing previous unilinear and evolutionist theories. In the context of the norma-
tive and diffusionist paradigm, the appearance, diffusion and decline of cultural
groups could be identified through behaviour patterns (Childe 1956, 9–10).
Likewise, this approach explained funerary rituals within the same normative and
diffusionist framework (Chapman and Radsborg 1981, 4). Even though the defini-
tion of culture involves a great variety of aspects, as recognized by G. Childe
(1956, 122), many of these so-called cultural groups, such as the Europeanell beaker group, were defined from data recovered and known from funerary con-
texts only. Despite substantial criticism of these assumptions, the cultural and
normative interpretation of the funerary ritual as an ethnic marker remained
popular in the archaeological narrative throughout the twentieth century (Chapman and Randsborg 1981, 4).

The “New Archaeology” and the social approach to death

Archaeological data retrieved from funerary contexts during the first half of the twentieth century was used as evidence to support arguments of the cultural paradigm, but the data was never interpreted according to the perspective of the funerary practices per se. The rare interpretative proposals based their observations on ethnographic data known from anthropological studies, which was applied to archaeology in a more or less speculative way. In 1969, P. Ucko called attention to this problem with the article *Ethnography and archaeological interpretation of funerary remains*, also known in the literature as *Ucko's cautionary tale* (Chapman and Randsborg 1981; Nilsson Stutz 2003a, 109; Parker Pearson 1999, 21; Tarlow 1999, 11). This cautionary text, written from the critical analysis of ethnographic cases, resulted from reflection on the relationship between the society of the living and the material remains of their funerary practices. Ucko criticized diffusion theories and demonstrated that, even within societies with strict and formal funerary practices, there will be variation in the ritual treatment of the dead, as well as in the different individual and collective interpretations. One society or culture has not one, but various ways to treat their dead. He argued that this variability, which the archaeological method should be able to discuss, may in fact indicate differences in social status rather than being the result of external influence by ways of cultural diffusion (Ucko 1969, 270). Ucko emphasized, although without being specific, that social status may have been of various types, and called attention to the fact that absence of grave goods was not necessarily indicative of low status or poverty of the individual or social group. Likewise, the similarities found in disposal of the dead may not have directly correlated to contact between people from different groups (Ucko 1969, 275). Ucko did not reject ethnographic parallels but their incautious use, and defended the use of knowledge obtained through ethnography by archaeologists in order to expand their interpretative horizons when reading the archaeological material (Ucko 1969, 262, 264). This text is considered emblematic of the positivist fervour in the archaeology of funerary practices during the 1970s, but the optimism and cautions expressed by Ucko, gradually faded (Nilsson Stutz 2003a, 110). As criticized by Chapman and Randsborg (1981, 8), many researchers have ignored this text. However, its most important premises, especially those aligned with the historical-culturalist critique and with the demand to integrate a social approach to death studies, found continuity through the work of Saxe (1970) and Binford (1971).

The archaeological spaces of the dead were once again at the centre of archaeological debate and constituted the central argument in Binford’s critique of historical-culturalist perspectives (Chapman and Randsborg 1981, 6). From the 1960s onwards, with the expansion of archaeology as a discipline, some of the earlier pessimism was mitigated, about the potential of archaeology to access certain
spheres of human action, besides the traditional economic and technological questions. The new inquiry proposed for the archaeological analysis of funerary contexts had a significant role in the emergence of the New Archaeology, and determined the bases for its theoretical development and methodological application. The body of work developed by L. Binford (1962, 1965, 1968) was in this context fundamental. Binford denied any limitation on accessing the past and introduced the conviction that questions of social organization, already explored by anthropology in the early twentieth century by Durkheim and his followers, could potentially be addressed through archaeological analysis. Binford's argument was based on a systemic approach to the analysis of the internal dynamics of cultural systems, through which the relations between material culture and other elements of the cultural system could be identified (Chapman and Randsborg 1981, 6). The analysis of funerary contexts played a central role in the demonstration of this argument, culminating with the publication of the highly cited thesis of A. Saxe (1970), and a compilation of seminal texts edited by J. Brown (1971) with contributions from Binford, Saxe, and Brown. These works had the merit of finally introducing the social dimension of funerary practices to the context of the archaeological research.

Contrary to the irregularities proper of the material recovered in settlement areas, the funerary spaces were considered representative of an intentional behaviour, enclosing a special interest for the approach of the New Archaeology. In this perspective, the analysis of the material remains in the funerary context is considered particularly informative in terms of organization of the society. Following this premise, Binford (1971) considered that the social structure of a given society would be mirrored in the funerary practices of the group. In this view, the social organization would determine the patterns and variability of the funerary practices. For the New Archaeology, the treatment of the dead was correlated with the nature of the social system of the group, rather than to cultural specificities, such as the identification of certain funerary rituals with particular ethnic groups, as claimed by the historical-culturalist archaeologists. The critique of Binford (1971) was aimed at shifting the focus from ethnic differences, and to concentrate on a new scale of analysis focused on the differences within social groups. In this approach, funerary rituals should be interpreted as evidence of social variability, status differentiation, and social complexity (Binford 1971, 4). This new framework was based on a central theoretical element borrowed from social anthropology: theory of roles and the concept of social persona which Binford (1971) adapted and applied to archaeological questions, through a new methodology based on quantitative analysis and studies of compared ethnography (Trigger 2007, 399, 405). Binford recognized five dimensions in which the social persona may be represented through funerary practices: age, sex, hierarchy or social ranking, social affiliation and circumstances of death (Binford 1971, 17). In this model, human groups are divided according to their subsistence practices – hunter-gatherers, farmers, and shepherds – in an increasing state of social complexity, which would be reflected in the treatment of the dead. In this view, the more complex the society, the more
dimensions would be represented in funerary contexts, suggesting that social complexity is proportional to the complexity of the group’s funerary practices. Funerary practices were then analysed through the lens of social complexity and explanations of social diffusion were rejected. In this perspective, the variability of funerary ritual was a direct consequence of the social structure of the population under study (Trigger 2007, 405), and the treatment of the dead was assumed to be related to the nature of the social system rather than to its cultural specificities. In this logic, the more complex a society is the more complex its funerary practices will be.

Despite the relevance of funerary contexts in the development of archaeology as a discipline, it was only in the 1970s (Brown 1971) that the discipline developed a theoretical framework able to deal with and interpret mortuary data (Chapman 2003, 305; Chapman and Randborg 1981, 2). It was under the umbrella of the New Archaeology that the archaeological approach to material remains of past funerary practices was coined as The Archaeology of Death (Chapman et al. 1981). Unfortunately, the investigation of the spaces for the dead was the conduit for the analysis of social structure of the living, rather than the study of human engagement with death.

Postprocessual reaction: rituals in action

Theoretical discussion initiated by the New Archaeology, explicitly advanced by Binford’s (1977) call for theory building was a turning point in the history of archaeological thought (Trigger 2007). As in any discipline, this paradigm shift generated much controversy and heated debates. A few years later, the postprocessual reaction to the premises of the New Archaeology strongly criticized the positivist, functionalist and evolutionary approach to human societies; emphasizing symbolic, structural, and critical approaches to the study of archaeological data (Hodder 1982; Trigger 2007). The postprocessual reaction introduced archaeology to a broad range of theoretical positions, particularly those in the historical and social sciences (Hodder 2012) that the New Archaeology had ignored. Its impact in the field of death studies derived particularly from the recognition that ritual practices are a fundamental aspect of human societies (Hodder 1980). This was a major shift of focus, because the ritual perspective of mortuary practices had been naively neglected in the processual approach to the archaeology of death (Nilsson Stutz 2003a, 119). Early postprocessual works argued that variation in mortuary treatment of the dead could not be interpreted as a reflection of everyday social life mirroring certain dimensions of social identity, and emphasized the importance of multiple lines of evidence in order to interpret mortuary ritual practices in their social context (Pader 1982, quoted in Nilsson Stutz 2003a, 122). Despite the clear shift in perspective, ritual was often approached as a form of ideology and symbolic power (Shanks and Tilley 1982; Trigger 2007, 451), and status and power remained central aspects in the postprocessual mortuary narratives (Parker Pearson 1982, 1984). Unfortunately the idiosyncrasies of the human engagement with death
remained largely ignored (Tarlow 1999, 12), despite the creative influx, broader range of theoretical positions, and the open spectrum of the questions promoted by postprocessual archaeologists. Nevertheless, postprocessual archaeologies brought into studies of death theoretical propositions which remain highly influential in today’s agenda, which in multiple ways informed the reading of the archaeological data in this dissertation.

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Throughout the history of archaeology, the material remains of death have always been a primary source in the development of theoretical and interpretative approaches. However, for the most part, the specificities of death-related contexts, and of the human engagement with death as an event or a process, have been largely overlooked (Robb 2013; Tarlow 1999). The description and analysis of grave goods, and the spatial analysis of mortuary contexts remained central in archaeological studies. Other studies, focusing on the human remains recovered in mortuary contexts continued, providing relevant information about the life of the individual, by assessment of age at death, sex, height and robustness, as well as identification of diseases, pathologies or body modifications, along with recent improvements on the characterization of past diets, and genomic data of ancient populations. These are invaluable lines of evidence for archaeological research, inside and outside the spectrum of death studies. However, in the scope of funerary archaeology, the aim is to investigate funerary practices in all their dimensions, as well as to document, identify and contextualize cultural responses to death, from the material remains of past populations. This emphasis is important, because these are in fact independent questions, although related, but frequently confused with the questions of physical and biological anthropology.

In recent years, the subject of death has gained new importance, certainly encouraged by a broader spectrum of perspectives motivated by the postprocessual reaction and a new maturity of the discipline in the twenty-first century, which would hardly have happened without the critical approach to method and theory promoted by the New Archaeology. Archaeology of death now problematizes central aspects of the human engagement with death, having death at the centre of the research and mortuary ritual practices as the point of departure (see Nilsson Stutz and Tarlow 2013), exploring dimensions such as cognition and symbolic thought, emotion and experience, the body, ritual and social relations; through the lens of human attitudes towards death in the archaeological record (see e.g., Brandt et al. 2015; Croucher 2012; Fahlander and Østigaard 2008; Murphy 2008; Nilsson Stutz 2003a; Pettitt 2011; Sofaer 2006; Tarlow 1999).

Historical and humanist approaches to death and hunter-gatherers

Theoretical framework formulated to address the research questions of this dissertation stems from the need to bridge archaeological evidence obtained from a set of archaeological methods strongly rooted in the natural sciences, such as biology
and chemistry, with the actions of people in their historical context. In this study, I examine the burial activity of the last hunter-gatherers of the south-western Iberian Peninsula from an explicitly archaeological perspective, and attempt to explain the burial phenomenon through the lens of historical and humanist approaches to death and hunter-gatherers, on the basis of theoretical concepts of social memory, place, mortuary ritual practice, and historical processes.

Humans are historical creatures. People shape history through actions and representations, and in this sense, “history is the process of cultural construction through practice” (Pauketat 2001, 87). History is shaped by the relations between individuals and between individuals and groups (Robb and Pauketat 2013, 21). The way people acted, the way they represented themselves and embodied their traditions, has shaped history (Pauketat 2001, 86). Practices are historical processes which often involve a material representation (Pauketat 2001; Sassaman and Holly 2011). Monuments and cemeteries are among the most obvious material manifestations of historical practices. Other archaeological favourites, such as patterns of settlement and exchange also express historical processes as they may reveal movement of people and objects, migration, interaction, alliances, and so forth (Sassaman and Holly 2011, 8).

Hunter-gatherers are makers of history and enjoy historical consciousness (Sassaman and Holly 2011), like any other human group. Hunter-gatherers live in a world they understand, with a past and a future, and act culturally within this historically situated world view (Ingold 2000; Sassaman and Holly 2011). The formation of burial grounds and shell middens by the last hunter-gatherers at the Tagus and Sado valleys in Portugal, are acts of historical production. This approach provides insights into the long-term history of the cultural production of these places. It allows us to examine the significance of mortuary practices during the formation, maintenance and development of these shell middens. To understand the mortuary practices of the last hunter-gatherers of the south-western Iberian Peninsula through the archaeological material from the shell middens in the Tagus and Sado valleys, I work in the framework of social memory, concepts of place, mortuary practices, and historical agency. These theoretical principles allow me to discuss the central questions of this dissertation, enquiring about the relevance of the formation and maintenance of burial grounds, and the significance of mortuary practices and formal places for the dead in the lives of these hunter-gatherers.

History was recorded in the shell middens at the Tagus and Sado valleys, not as a literary enterprise, but through non-literate acts of history-making (Randall 2011; Sassaman and Holly 2011). In this perspective, depositional narratives are viewed as the primary means of history-making (Randall 2011), and burial practice as an act of cultural production. From this point of view, depositional narratives constitute the acts that give meaning to these places, rather than the shell mound in its monumental and unitary form (see Kidder 2011; Pauketat and Alt 2003). When burial grounds in shell middens are approached as historical processes we can focus on the history of people in their context and move from functionalist
interpretations that regard these deposits as simply refuse heaps, of humans and food debris.

**Deathways of hunter-gatherers and historical processes**

Deathways of hunter-gatherers are varied and may present a more or less complex set of related activities. As discussed in an earlier section of this chapter, the social interaction between the living and the dead has a long history. Mortuary practices did not evolve in a linear fashion and present significant regional cultural variation over time (Pettitt 2011). At the shell middens of the Tagus and Sado valleys, burial was a common method of disposal of the dead. This particular way of interacting with the dead is expressed through depositional narratives the material remains of which are the object of this dissertation. These burials represent social practices and the history of these hunter-gatherers unfolds from the way they engaged with death. The history of death itself correlates with the history of human relationships (Davies 2005, 28). The encounter with “others” often leads to changes in cultural production, as profound as the creation of new cosmologies and new social relationships, in order to cope with diversity or resistance to change (Sassaman and Holly 2011, 8). Cultural diversity among hunter-gatherers is a consequence of interaction rather than isolation (Sassaman 2011, 189). Following this, could the new way of dealing with the dead that was recorded at the Tagus and Sado valleys, characterized by the burial of the dead in dedicated burial grounds, be motivated by encountering other bands?

**Memory in the landscape: rituals in practice**

Places with burial grounds reveal a commitment of the living to the dead, expressed by continued depositional events reproduced over a more or less long period of time. These practices required bodily performances which were central in processes of remembering. Social memory was created and renewed at these places through mortuary ritual practices. The stress on memory emphasizes the role of ritual practice in the construction of the landscape. This approach acknowledges the archaeological record of burial practices as material traces of memory construction. In this perspective, mortuary rituals are viewed as central elements in the construction of places. Following this, I would like to argue that it is through mortuary ritual practices that these sites were remembered and kept meaningful in the landscape.

Memory, understood as shared memory of a social order, requires certain mechanisms to be maintained and transmitted within the social group over time and across generations. Memory can be inscribed in monuments and texts. In archaeological contexts, monuments are evident traces of memory and commonly emphasized, but incorporated memory leaves archaeological traces as well (Preucel and Meskell 2004, 216; van Dyke 2010, 279). Memory can be materialized in representations, objects, ritual behaviours, and places (van Dyke and Alcock 2003). Of particular interest to this dissertation is the ritual behaviour which can be revealed
through the observation of the remains of mortuary practices in the archaeological
context (Nilsson Stutz 2003a).

As Connerton (1989) demonstrates, embodied or incorporated memory, mani-
fested through performative rituals and physical behaviour, is much more effective
in the production and transmission of social memory. In his work How Societies
Remember, Connerton (1989) shows through various case-studies that memory is
transmitted in non-textual and non-cognitive ways through ritual practice. This is
shown to be a powerful system to enhance memory because ritual practice is a
formalized, sequential, and repetitive performative language that implies continuity
with the past (Connerton 1989, 45). Thus, Connerton (1989) argues, incorporating
practices through embodied behaviour provides a particularly effective system of
mnemonics. Nevertheless, inscribed memory is commonly considered the privi-
leged form for the transmission of the memories of a given society. In archaeology,
this aspect of social memory, the memory transmitted through bodily practices has
been widely neglected, particularly in hunter-gatherer studies, as authors such as
Sassaman and Holly (2011) have pointed out. However, it has been shown that
systems of inscription, even the more complex, do not correlate to the capacity of
a society to remember (Connerton 1989, 102). Thus, following Connerton’s (1989)
premises, mortuary ritual practices are determinant in the process of memorializa-
tion of these places.

Death in deep time: why does it matter?

Death paradigms
The history of death is entangled with the history of changing social values, as
shown by anthropological and sociological research, as well as by philosophical and
theological approaches to death studies. In this view, the shift in the meaning of
death, i.e., death’s paradigm shift will be consistent with the changes of world view
of a given society (Davies 2005).

The human engagement with death is complex and varied and can be expressed
in multiple ways. Regardless of beliefs and symbolic associations to death, dead
bodies require a physical action from the living, which largely relates to a world
view (Davies 2005; Nilsson Stutz 2014). Mortuary ritual practices are defined
within a cosmology in the way people see the world and express their emotions
and materiality (Nilsson Stutz 2014; Tarlow 1999). The history of death and the
history of human relationships are closely related, as well as the place of death and
human identity (Davies 2005, 38). Changes of world view present significant con-
sequences in the cultural understanding of death and have a strong impact upon
mortuary ritual practices (Davies 2005). This materiality of change, in world views
and attitudes to death, is part of the archaeological record and their interpretation
provides relevant assets for the understanding of past human relations with death and with each other.

Death studies and archaeology: an archaeological manifesto

Death studies and archaeology are fully interconnected. Death studies deal with the complex nature of death within its biological, emotional, metaphysical, and material dimensions. This complexity requires multidimensional approaches and challenges researchers from diverse fields. Archaeology can provide a solid bridge to this interdisciplinary dialogue. Archaeology has access to human behaviour over long periods of time and in vast geographic areas. Archaeology brings temporal depth to the great variety of human agency with an exceptional perspective on what makes us human. This database of knowledge – on what makes us human – has no parallel, and it is of great interest to us as archaeologists, to work with other disciplines that deal with death, ritual and society. It is only within an interdisciplinary framework that we can reach a meaningful and holistic approach within the humanities.

The richest information about past mortuary practices is of archaeological nature (Nilsson Stutz 2014, 714), and it is our responsibility as archaeologists dealing with ancient death ways to provide a robust and theoretically informed explanation of death in deep time. This knowledge about past human engagement with death, grief, bereavement and commemoration, matters in terms of human evolution, in terms of understanding our place in the world, in terms of understanding other world views, and ultimately, it matters in terms of understanding what makes us human.
PART TWO: BODIES OF KNOWLEDGE

Jöns: Varför håller du på med såna kladderier?
Målaren: Jag tänkte man skulle påminna folk om det faktum att de ska dö.
Jöns: Det blir de inte gladare av.
Målaren: Varför i helvete ska man alltid göra folk glada? Man kan ju skrämma dem lite ibland.
Jöns: Då blundar de och tittar inte på din tavla.
Målaren: Du kan tro de tittar. En dödskalle är mycket intressantare än ett naket frun- timmer.

(Bergman 1957)
Introduction to part two

The biological remains of a human body found in archaeological context are invaluable elements of research, and no other find brings us so emotionally close to the past. In archaeological sites, when preservation allows, the most common type of human remains are hard tissues. Skeletal elements, such as bone and teeth, are the most durable tissues of the body, and it is only under very exceptional conditions that soft tissues are preserved. Nevertheless, the bones of the individual are extremely informative in terms of the life and death of the person within their social and cultural context.

The second part of this dissertation, Bodies of Knowledge, is structured around the empirical evidence which forms the basis of the central arguments in this dissertation. In Chapter 2, Archaeological Material, I present the historical source material of this study in terms of its possibilities and limitations. I start with a general description of the shell middens of the Tagus and Sado valleys and discuss the selection of material, outlining the primary biases of the assemblages. The chapter concludes with a brief history of research from the perspective of the context of data production which I believe is fundamental for a full understanding of any archaeological material in historical collections. In Chapter 3, Methods, I outline the methodological approaches to the study of the mortuary practices at the sites. The chapter is divided into three main sections, each dedicated to a method: radiocarbon dating and Bayesian analysis, stable isotope analysis of carbon and nitrogen, and archaeothanatology: chaîne opératoire of mortuary practices. The following chapter, Chapter 4, Results, is organized by archaeological site where I present the results obtained in the course of this study. In the last chapter of Bodies of Knowledge, Chapter 5, Analysis and Synthesis of the Results, I examine the results in terms of the chronology of burial activity, in terms of defining the people in each burial ground through their isotopic signatures, and in terms of the treatment of the dead through archaeothanatology, emphasizing the common elements identified in the treatment of the dead. The results are examined at the scale of the site and valley, and thereafter compared across the Tagus and Sado valleys.
Chapter 2
Archaeological Material: Human Remains in the Shell Middens of the Tagus and Sado valleys, Portugal

General description of the shell midden sites in the Tagus and Sado valleys, Portugal

The archaeological material under analysis is the human remains excavated from the nineteenth century to the 1960s at the Late Mesolithic shell midden sites of the Tagus and Sado valleys in Portugal (fig. 2.1).

These sites are characterized by the anthropogenic accumulation of marine animals, terrestrial fauna, and artefacts made of stone and bone. This type of site is known as a *shell midden* after its most visible feature, the sea shells. Here, in the south-western Atlantic coast of Europe, the relatively rapid rates of sea level rise during the Atlantic climatic optimum (c 6400–4350 cal BCE) resulted in the forma-
tion of large estuaries in the Tagus and Sado Rivers with marine waters moving towards the inland areas of these river valleys (Arnaud 1989; van der Schriek et al. 2007; Walker et al. 2009). The scattered settlement pattern known for the Early Mesolithic, during the Pre-boreal, Boreal, and very early Holocene (c 9530–6400 cal BCE), becomes clustered in the innermost areas of large estuaries, by the new ecosystems formed during the Holocene Atlantic chronozone (Araújo 2003, 2015). Today, far from the sight and influence of marine waters, these Late Mesolithic shell middens can be very large archaeological sites, many of them with well preserved human remains. These sites are also rich in faunal remains (Detry 2003, 2007; Lentacker 1986, 1994; Marques-Gabriel 2015; Rowley-Conwy 2004, 2015) providing evidence for the consumption in situ of a varied range of food sources, both marine and terrestrial (Umbelino 2006; Umbelino et al. 2007). According to these studies there is no evidence for domesticated plants or animals, except for the domestic dog (Detry and Cardoso 2010; Diniz et al. 2012). Stone tool production is also well documented for all stages of the chaîne opératoire (Araújo 1995–97; Diniz and Nukushina 2014; Marchand 2001; Nukushina 2012). The relatively few ceramic fragments found in some of these contexts are attributed to later occupations, to the Early and Late Neolithic (Diniz 2010) and Chalcolithic (Santos et al. 1972).

The shell middens at the Tagus valley are located in the Ribatejo region, c 80 kilometres north-east from the river mouth in Lisbon. The sites are located on the banks of three tributaries to the Tagus River: Fonte da Moça, Muge and Magos. The shell middens of the Sado valley are located in the Alentejo region, c 120 kilometres south of Muge and c 80 kilometres east from the river mouth in Setúbal. The sites are located near or on the banks of the Sado River. A common geographic trait of all these sites is their location by the palaeo-estuaries of large rivers. In the Tagus valley all sites are located at the low terraces by the shores of the palaeo-estuary, subject to occasional floods. This location close to the aquatic resources seems to be the privileged position for the development of the site. At Sado, however, some larger sites are situated further inland and all are located at relatively higher altitudes. Here, a location with good visibility through the valley seems to be more important than proximity to aquatic resources (Diniz and Arias 2012, 147).

There is a fundamental difference in site formation in these two valleys which is reflected in their stratigraphic complexity and ultimately in the spatial position of the human remains in the sites. In the Tagus valley, these artificial mounds are formed by the superposition of cultural layers and can reach c 4 to 5 metres in classic vertical stratigraphy (Roche 1965, 1967). In contrast, the middens in the Sado valley are relatively shallow and visually difficult to identify. Here, the site formation is mainly on a horizontal logic of occupation with a current stratigraphic depth of c 60 to 80 cm at most (Arnaud 1989; Diniz and Arias 2012; Larsson 1996). However, according to the site plans of the Sado valley sites, the human remains recovered in 1959 from Cabeço das Amoreiras were found at a depth of c 120–150 cm and in 1960, at Poças de S. Bento, between c 130 and 170 cm deep.
The stratigraphic difference between the sites at the Tagus and Sado valleys is possibly related to the relative location of the sites to aquatic sources but also to ecological constraints under study (Diniz and Arias 2012).

Another common characteristic is the placement of the human remains in clusters within the sites, as observed from the available field records from the old excavations. Although the records are sparser for the Tagus valley, this seems to be also the case at Cabeço da Arruda, Moita do Sebastião, and Cabeço da Amoreira. Unfortunately there are no records for the other sites with human remains at the Tagus valley. At the Tagus valley most of the burials known were recovered from the bottom layers of the shell middens. However, there are some cases of burials through the stratigraphy and in the upper layers, confirmed by recent fieldwork in both Cabeço da Arruda (Roksandic 2006) and Cabeço da Amoreira (Bicho et al. 2013; Roksandic 2006). Similarly, in the Sado valley, most burials were found in the sandy bottom layers. In general, the burials seem to be spatially organized in tight areas within a larger area of the site. The relation between these burial clusters and the remaining areas of the sites remains an open question.

These sites are remarkable because of the large number of human bodies buried within them. A review of the archaeological data on mortuary practices during the earliest stages of the Holocene, i.e., Early Mesolithic, in the Iberian Peninsula, prior to the Late Mesolithic burial grounds in the Tagus and Sado valleys (Peyroteo Stjerna, forthcoming), shows strong evidence for activities involving manipulation of human remains, but the practice of funerary burial was rare. This review indicates that there is an increase of burial practice from the Early to the Late Mesolithic in the Iberian Peninsula, as the evidence for open air sites increases as well. However this growth in burial practice in open air sites during the Mesolithic in Iberia is only valid when we add the data from the great concentration of burials from the open air shell middens at the Tagus and Sado valleys. The mortuary practices in the Tagus and Sado valleys are not only in contrast with previous Early Mesolithic sites but with contemporaneous sites in the Iberian Peninsula, stressing the regional and social character of mortuary ritual. Interestingly, this regional relationship with death is consistent with the particular settlement known in this region, also unique in the Iberian Peninsula—the formation of large shell midden sites clustered by the banks of the palaeo-estuaries of the Tagus and Sado Rivers. This relationship will be discussed further in chapter 6.

Material Selection

From the 13 middens identified in the Tagus valley, nine have human remains yielding a total of at least 263 individuals (Bicho et al. 2013; Cunha and Cardoso 2001, 2002–03; Jackes and Meiklejohn 2008; Meiklejohn et al. 2009a; Paço 1938; Roksandic 2006; Santos et al. 1990) (table 2.1, fig. 2.2), although the historical records seem to account for c 340 individuals (chapter 4). At the Sado valley, there
are 11 known middens, six of which with human burials yielding a total of c 113
dividuals (Cunha and Umbelino 1995–97; Diniz et al. 2014) (table 2.2, fig. 2.3).

Table 2.1. *Tagus valley: 13 shell midden sites identified, nine of which with recorded human remains.*

<table>
<thead>
<tr>
<th>Tributary</th>
<th>Site</th>
<th>MNI</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fonte da Moça</td>
<td>Fonte da Moça 1</td>
<td>1</td>
<td>fragments of bones and teeth</td>
</tr>
<tr>
<td></td>
<td>Fonte da Moça 2</td>
<td></td>
<td>fragments of bones</td>
</tr>
<tr>
<td></td>
<td>Mage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fonte do Padre Pedro</td>
<td>2–3</td>
<td>Meiklejohn et al. 2009a</td>
</tr>
<tr>
<td></td>
<td>Flor da Beira</td>
<td>4–5</td>
<td>Meiklejohn et al. 2009a</td>
</tr>
<tr>
<td></td>
<td>Cabeço da Arruda</td>
<td>110</td>
<td>Cunha and Cardoso 2002–03; Roksandic 2006</td>
</tr>
<tr>
<td></td>
<td>Moita do Sebastião</td>
<td>85</td>
<td>Jackes and Meiklejohn 2008</td>
</tr>
<tr>
<td></td>
<td>Cabeço da Amoreira</td>
<td>29</td>
<td>Bicho et al. 2013; Cunha and Cardoso 2001; Roksandic 2006</td>
</tr>
<tr>
<td></td>
<td>Magos</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cova da Onça</td>
<td>32 or 36</td>
<td>Cunha and Cardoso 2002–03; Meiklejohn et al. 2009a</td>
</tr>
<tr>
<td></td>
<td>Cabeço dos Ossos</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magos de Cima</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magos de Baixo</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cabeço da Barragem</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cabeço dos Morros</td>
<td>1, one cranium</td>
<td>Paço 1938, 74</td>
</tr>
</tbody>
</table>

Table 2.2. *Sado valley: 11 shell midden sites identified, six of which with known human remains.*

<table>
<thead>
<tr>
<th>Site</th>
<th>MNI</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arapouco</td>
<td>32</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>Cabeço do Rebolador</td>
<td>0</td>
<td>Report, MNA, APMH, 2/3/7/3, p. 29–32</td>
</tr>
<tr>
<td>Cabeço das Amoreiras</td>
<td>6</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>Poças de S. Bento</td>
<td>16</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>Vale de Romeiras</td>
<td>26</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>Cabeço do Pez</td>
<td>32–36</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>Várzea da Mó</td>
<td>1</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>Barrada das Vieiras</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Fonte da Mina</td>
<td>0</td>
<td>Santos 1967, 1968</td>
</tr>
<tr>
<td>Barranco da Moura</td>
<td>0</td>
<td>Santos 1967, 1968</td>
</tr>
<tr>
<td>Barrada do Grilo</td>
<td>0</td>
<td>Correspondence, MNA, APMH, 5/1/654/46</td>
</tr>
</tbody>
</table>
Figure 2.2. Tagus valley: shell midden sites with human remains. Site, MNI: Fonte da Moça 1 and 2, fragments of bones and teeth; Fonte do Padre Pedro, 2–3; Flor da Beira, 4–5; Cabeço da Arruda, 110; Moita do Sebastião, 85; Cabeço da Amoreira, 29; Cabeço dos Morros, 1; Cova da Onça, 32 or 36 (see table 2.1 for references).

Figure 2.3. Sado valley: shell midden sites with human remains. Site, MNI: Arapouco, 32; Poças de S. Bento, 16; Cabeço das Amoreiras, 6; Vale de Romeiras, 26; Cabeço do Pez, 32–36; Várzea da Mó, 1 (see table 2.2 for references).
Sites selected

This dissertation relies largely on source material from historical collections and documentation in museum archives as well as on previously published literature. The source material and documentation available varies greatly from site to site, depending on the approach of the different excavation teams but also on the curation of the material. The selection of the sites for this study was based on the following criteria:

- maintenance of the human remains in natural blocks of concretion or artificial preservation in blocks of paraffin wax;
- access to and quality of the field records regarding graphic documentation of the human remains such as photographs, drawings, and site plans;
- access to written documentation, such as field notes, diaries, letters, and reports.

Following these criteria, the material selection comprises two sites in the Tagus valley: Moita do Sebastião and Cabeço da Arruda, and five sites in the Sado valley: Arapouco, Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó. The archaeological evidence retrieved from these seven sites is presented in chapter 4 and constitutes the core of the argument in this dissertation. The sites of Cabeço da Amoreira in the Tagus valley and Poças de S. Bento in the Sado valley are not treated in detail, but for a more robust analysis of the local setting they have been included in the discussion of the results (chapters 5 and 6).

A note on the museum collections

The current location of the collections results from the long and complex history of research which became more complicated due to the lack of a central administration for archaeological work in Portugal, only established in the early 1980s (Fabião 1999, 2011). The archaeological material excavated at the shell middens of the Tagus and Sado valleys is housed in three main museums (table 2.3).

The scattered provenance of the assemblages results from the institutional affiliations of the excavation leaders, who normally chose to deposit their newly excavated archaeological material in the affiliated museum. Two other institutions hold a small part of the assemblages. These are the National Museum of Natural History and Science, University of Lisbon (Museu Nacional de História Natural e da Ciência, MUHNAC) which keeps the cranial remains of a few individuals excavated in the nineteenth century, possibly from Cabeço da Arruda; and the Research Centre for Anthropology and Health, University of Coimbra, which holds the human remains excavated in the Tagus valley from the 2000s to the present.
Table 2.3. Museums curating archaeological material excavated at the shell middens of the Tagus and Sado valleys.

<table>
<thead>
<tr>
<th>Museum</th>
<th>Excavation year/team</th>
<th>Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological Museum, Lisbon</td>
<td>19th c./Geological Commission</td>
<td>Tagus valley, all</td>
</tr>
<tr>
<td>Museu Geológico, MG</td>
<td>1960s/Dir. J. Roche</td>
<td>Cabeço da Amoreira</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cabeço da Arruda</td>
</tr>
<tr>
<td>Museum of Natural History,</td>
<td>1930s/Dir. M. Corréa</td>
<td>Cabeço da Amoreira</td>
</tr>
<tr>
<td>University of Porto</td>
<td></td>
<td>Cabeço da Arruda</td>
</tr>
<tr>
<td>Museu de História Natural da Universi-</td>
<td>1950s/Dir. J. Roche</td>
<td>Moita do Sebastião</td>
</tr>
<tr>
<td>dade do Porto, MHNUP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Museum of Archaeology, Lisbon</td>
<td>1950s–present</td>
<td>Sado valley, all</td>
</tr>
<tr>
<td>Museu Nacional de Arqueologia, MNA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are no comprehensive inventories published or available in the museums. The only exception is Moita do Sebastião, an inventory of human remains for which was published in detail (Ferembach 1974; Roche 1972). Inventories of the human remains recovered at the Tagus valley have been drawn up by independent researchers at least four times: in 1969 by C. Meiklejohn, in the 1980s by C. Meiklejohn and M. Jackes, in 1995 by E. Cunha and C. Umbelino (later with F. Cardoso), and more recently by M. Roksandic (see Jackes and Meiklejohn 2004; Meiklejohn et al. 2009a). The material from the Sado valley was studied by E. Cunha and C. Umbelino (Cunha and Umbelino 1995–97, 2001).

Notation of the human remains

Typically, the skeletons were numbered sequentially by each excavation team, resulting in duplicate numbers in several site assemblages. In this dissertation, all skeleton numbers are accompanied by the year of excavation and abbreviation of the name of the site (e.g., CAR1937, Sk7, meaning Cabeço da Arruda, 1937, Skeleton 7). In the beginning of this dissertation, I provide a list of abbreviations, including those adopted for the names of the sites.

In recent excavations the nomenclature is more explicit, and in these cases I follow the excavator’s terminology. This is the case for the material excavated in the early 2000s at Cabeço da Arruda and Cabeço da Amoreira, where the first part of the nomenclature refers to the name of the site (abbreviated), followed by the year of excavation and sequential number of the individual (e.g., CA–00–01, meaning Cabeço da Arruda, 2000, Skeleton 1) (Roksandic 2006). Similarly, recent material excavated at Cabeço da Amoreira is first identified by the type of context (burial), followed by the year of excavation and sequential number of the skeleton (e.g., Burial 2011.2) (Bicho et al. 2013).
A note on the historical documentation

Tagus valley

Field notes of the nineteenth century excavations in the Tagus valley are extremely rare. The only documentation known was identified in the 1980s in the archives of the Geological Museum in Lisbon, but was possibly recently moved to a central archive (see Jackes and Alvim 2006). These short notes were published and commented upon by M. Jackes and P. Alvim (2006). The few known field photographs taken in the nineteenth century have also been published (Cartailhac 1886; Ribeiro 1884).

The written documentation for the fieldwork done in the 1930s and the years between the 1950s and 1960s, and produced by archaeologists established in institutions in Portugal is published, at least for the most part, and partially facsimiled (Abrunhosa 2012; Cardoso and Rolão 1999–2000; Jackes et al. 2014). During the course of this study I tried to locate the personal archives of Jean Roche, a French archaeologist who carried out extensive work at the sites of the Tagus valley between 1950s and 1960s. J. Roche (1913–2008) (Debénath 2008) was an abbot. After his death, his belongings remained at his monastery but his archives were allegedly destroyed due to lack of storage facilities of the religious group, and apparently due to lack of interest from French institutions allegedly contacted by the religious institution (Grégor Marchand, pers. comm.). Fortunately, J. Roche, unlike most pioneer archaeologists, published regularly, offering detailed analyses and extensive descriptions of stratigraphy, spatial organization, and archaeological material (Roche 1956, 1959, 1964–65, 1965, 1967, 1972, 1974, 1989).

Sado valley

Systematic fieldwork at the Sado valley begins with Manuel Heleno (1894–1970) who was the director of the National Museum of Archaeology (MNA) from 1929 to 1964 (Raposo 2013). It was under his leadership that the first and largest excavations took place at the shell middens of the Sado valley, between 1955 and 1964. Recently, the museum acquired from his family, the Personal Archive of Manuel Heleno (Arquivo Pessoal de Manuel Heleno, APMH). This is an invaluable research source and consists of graphic and written documentation, extensively used in the course of this study. In this dissertation, references to documentation from the Archive of Manuel Heleno are identified with the museum’s reference code (MNA, APMH). In the case of written documentation, the original date and/or location of the document may be added for further reference (e.g., MNA, APMH, 5/1/664/89, 2/2, Água Derramada, 19 Aug. 1964).

The graphic documentation in APMH comprises hundreds of photographs (c 12 cm x 8 cm) taken during fieldwork at numerous sites excavated during his directorship. Unfortunately several of these photographs were already in very poor condition when acquired by the museum.

The written documentation consists mainly of excavation reports and letters received by M. Heleno, from Jaime Pereira Roldão, who was the main excavator and
responsible for all fieldwork. The original documents are archived at MNA and are available in digital format (jpeg file) at the museum. The excavation reports (relatórios) are the field notes handwritten by J. Roldão in a diary format. The entries are direct and simple and while J. Roldão is not very detailed in his descriptions, he writes in a systematic manner. Typically, he starts by identifying the area under excavation, including basic stratigraphic information, and normally, at the end of each entry he lists the material recovered during that particular day. In between these two almost obligatory fields – area under excavation and list of material – he writes down some of his observations and short descriptions. Unfortunately he did not make any sketches to illustrate his notes, just plain written text (fig. 2.4).

![Image of a handwritten excavation report](image)

**Figure 2.4.** Excavation report of Cabeço do Pez 1959, page 1. Handwritten by J. Roldão. (MNA, APMH, 2/3/7/2, p.1)

The archive of correspondence consists of handwritten letters sent from J. Roldão to M. Heleno (MNA, APMH, 5/1/654, Box 12, Sado valley, shell middens). Most letters were sent from Torrão and a few were sent from neighbouring localities, such as Vale do Guizo. The letters are short, and like the excavation reports, not very rich in detail.

This documentation is particularly useful to reconstruct the chronology of the excavations and to understand how much time and effort was dedicated to each site. It also informs us on excavation methods and documentation, and most
importantly, it helps us understand which archaeological materials were selected to recover and register. The excavation of human remains was the main focus of the fieldwork, and it is clear that if no human remains were found, the excavation work would halt and move to another site. Yet there is an acute interest and attention to the recovery of microliths, even the very small.

The letters mention in more or less detail work done at: Cabeço do Pez (1959), Cabeço do Rebolador (also known as Vale do Guizo) (1959), Vale de Romeiras (1959, 1960), Várzea da Mó (1959), Barrada do Grilo (1960), and Poças de S. Bento (1960, 1964). There are only a few comments about Arapouco (1960), and the fieldwork at Cabeço das Amoreiras is not mentioned in the available correspondence. The correspondence is incomplete and the letters reporting the first excavations at Cabeço do Pez in 1956, the fieldwork at Cabeço das Amoreiras in 1959, and the excavations at Arapouco in 1961 and 1962 are missing from the archive. Written data directly related to the recovery of human remains is limited. Most of it seems to be lost (the reports only mention the excavation of one skeleton at Cabeço do Pez identified on 1st June 1959), and the few descriptions in the letters are very brief.

Other sources of graphic documentation at MNA consist of field sketches, drawings and site plans. The archives of drawings and site plans are in the department of inventory at MNA. The site plans are in Archive A and are identified with the letter A along with serial number (e.g., A118). Archive B contains all detailed drawings such as those of human skeletons or animal bones, which are identified with the letter B along with serial number. A separate folder holds the original field sketches which have no archive number. The material dated to 1956 was drawn by A. Paiva, while all documentation after 1958 was drawn by Dario de Sousa. During the course of this dissertation I digitalized (tiff format) all photographs, sketches and drawings with human remains at MNA. All site plans in the archives of the museum were photographed and processed digitally (tiff and jpeg formats) by José Paulo Ruas in 2013.

Sites excluded

**Sites with human remains**

Several sites with human remains were not analysed in detail in the scope of this dissertation. This was in part due to time constraints, and the sites with best documentation were prioritized. However, most of these sites have little or no documentation, and the human remains are in general poorly preserved not allowing the type of analysis proposed in this study. These sites are: Fonte da Moça 1 and 2, Fonte do Padre Pedro, Flor da Beira, Cabeço da Amoreira, Cova da Onça, and Cabeço dos Morros in the Tagus valley; and Poças de S. Bento in the Sado valley.
Chapter 2

Tagus valley, Fonte da Moça: Fonte da Moça 1 and 2

The sites of Fonte da Moça 1 and 2 are located on the banks of the tributary with the same name, north of the Muge area (fig. 2.2). Site 1 was excavated in 1981–83. The human remains recovered from FM1 are fragments of crania and mandibles, unidentified bones and various loose teeth. The skeletal elements were found in layer 4 just above the basal terrace sands (layer 5) where a few perforated shells were recovered (Santos et al. 1990, 34). Site 2 is located c 2.3 kilometres from site 1 and is partially destroyed. Fieldwork done in 1986, on the basal sand layer, identified several fragments of human bone including cranial fragments (Santos et al. 1990, 37). The minimum number of individuals identified on both sites is unknown.

Tagus valley, Muge: Fonte do Padre Pedro

The shell midden at Fonte do Padre Pedro is located on the right bank of the Muge tributary (fig. 2.2), and was already destroyed in 1880 (Roche and Ferreira 1967, 20). Documentation about this site is extremely limited. The human remains recovered by C. Ribeiro consist of one femur found on the surface layer along with fragments of shells and faunal remains (Cardoso and Rolão 1999–2000, 121; Ribeiro 1884, 281).

The site was surveyed by M. Corrêa in June 1930, but the two test pits revealed just a few fragments of shells, which were followed by a sterile layer. The only artefact mentioned in O. V. Ferreira’s field notes is “one beautiful flint point” (Cardoso and Rolão 1999–2000, 144). M. Corrêa visited the site in August 1930 reporting that it was completely destroyed by the vineyard (Cardoso and Rolão 1999–2000, 144). The last note about Fonte do Padre Pedro is from August 1931, when apparently a skeleton was found while planting the vineyard (Gonçalves 1986).

The human remains are curated at MG in mixed and disarticulated state. Recent anthropological analysis by M. Roksandic indicates a MNI of 2–3 (one child, and one or two adults) (Meiklejohn et al. 2009a, 13). It is unclear if this estimate includes the latest skeleton found in 1931.

Tagus valley, Muge: Flor da Beira

Flor da Beira is located on the right bank of the Muge tributary between Fonte do Padre Pedro and Cabeço da Arruda (Paço 1938) (fig. 2.2). The site was discovered in 1935 by H. Cabaço (Paço 1938) and reported to be destroyed (Paço 1940).

The human remains are curated at MG in mixed and disarticulated state. Recent anthropological analysis by M. Roksandic indicates a MNI of 4–5 (Meiklejohn et al. 2009a, 13). There is no documentation for this site and the first published reference is probably by A. Paço (1938) (Umbelino 2006, 89).
Tagus valley, Muge: Cabeço da Amoreira

Cabeço da Amoreira is a shell midden site located on the left bank of Muge tributary on the opposite side to Cabeço da Arruda, and just c 700 metres east of Moita do Sebastião (fig. 2.2). The site was excavated in the nineteenth century by the Geological Commission, in the 1930s by M. Corrêa, in the 1960s by J. Roche, in 2001–03 by J. M. Rolão, and since 2008 by N. Bicho.

Graphic documentation is limited but published, at least partially (Abrunhosa 2012; Cardoso and Rolão 1999–2000). Unfortunately the human remains are in general poorly preserved, stored in disarticulated state, mixed and mislabelled in some cases. The MNI currently curated at MHNUP is 21 (Cunha and Cardoso 2001, 326), but according to the excavation reports this number could be between 28 and 29. Recent excavations have recovered 7–8 individuals (Bicho et al. 2013; Roksandic 2006). Field notes (Cardoso and Rolão 1999–2000, 121, 160), site plans and early literature (Newell et al. 1979; Roche 1964–65) indicate that 11–12 individuals were excavated in the 1930s, however, the anthropological analysis indicates 15 individuals (10 adults and 5 non-adults) in the assemblage (Cunha and Cardoso 2001, 326; 2002–03, 175). Of these, only three are almost complete skeletons; seven are incomplete and two individuals are represented by one bone each. Sex determination was possible for six skeletons: three males and three females (Cunha and Cardoso 2001; 2002–03). Field documentation from J. Roche’s excavations in the 1960s indicates the excavation of 17 individuals (Cardoso and Rolão 1999–2000).

The MNI adopted in this study (29) follows the estimates by E. Cunha and F. Cardoso (2001) (MNI 21), in addition to the recently excavated material (MNI 7–8) (Bicho et al. 2013; Roksandic 2006) (table 2.1).

Tagus valley, Magos: Cova da Onça

Cova da Onça, also known as Arneiro do Roquete, was the first shell midden to be identified in Portugal, in April 1863 (Ribeiro 1884). The site is located on the right bank of Magos tributary (fig. 2.2) near another midden named Cabeço dos Ossos (meaning, hill of the bones). The two sites are located in a larger area named Quinta da Sardinha and are separated from each other just by a small depression (Paço 1938, 67). Both Cova da Onça and Cabeço dos Ossos have been destroyed. Apparently, at the time of the discovery of Cova da Onça, the site was not excavated because C. Ribeiro did not get the permission from the landowner. Later, A. Paço (1938, 1940) mentions that the Museum of the Geological Commission (nowadays MG) was storing some material under the name of Cova da Onça, but unfortunately he does not mention of which kind.

There is no historical documentation known for this site. It is only known that the site was relocated by H. Cabaço in 1935 (Paço 1938), and that the skeletal remains of more than 30 individuals are curated at MG. The human remains are stored in disarticulated state and all skeletons are mixed in a few containers (Cunha and Cardoso 2002–03; Meiklejohn et al. 2009a). The material is marked with a
Chapter 2

handwritten label from 1915. It is unknown when the skeletons from Cova da Onça were excavated and it is difficult to explain the year written on this label (1915) because there are no excavations reported between 1885 and the 1930s (Paço 1938; Roche 1965). There is however a brief reference to the recovery of unspecified anthropological material (Corrêa 1940; Paço 1938). A. Paço mentions only the recovery of some lithic and anthropological material, as well as some shells excavated from test pits at Cabeço dos Ossos, Cova da Onça and Cabeço dos Morros (Paço 1938, 69).

The MNI is 32 (Cunha and Cardoso 2002–03) or 36 (8 non-adults; 28 adults, Meiklejohn et al. 2009a). One radiocarbon date on human bone confirms the Mesolithic chronology of the human remains (Cunha and Cardoso 2002–03) (table A7).

Cova da Onça was surveyed in 1984 by A. M. Flores and V. Gonçalves, to evaluate the preservation of the shell midden. During these few weeks, the team recovered abundant lithic material, two perforated shell beads (Trivia monacha), two fragments of ceramics on the top layer, and identified a hearth, and an unspecified negative feature. There is no reference to the excavation of human remains (DGPC 2015).

Tagus valley, Magos: Cabeço dos Morros

Cabeço dos Morros is located on the left bank of Magos tributary (fig. 2.2). The site was described as a large shell midden possibly similar to Cabeço da Arruda, but mostly destroyed (Paço 1938, 67).

In the 1860s, C. Ribeiro recovered a few fragments of human remains (Cardoso and Rolão 2000, 87). In the 1930s, one cranium (no mandible) was found by H. Cabaço. This cranium was sent to M. Corrêa (Institute of Anthropology, University of Porto) who recognized similarities with the crania found in Muge which M. Corrêa identified as the Homo afer taganus race (Paço 1938, 74) (see below, Understanding the context of data production: brief research history). The site was recently excavated by J. M. Rolão between 1997 and 2001 (Detry 2008, 53), and there is no reference to the excavation of human remains.

Sado valley: Poças de S. Bento

Poças de S. Bento is located at the Sado valley (fig. 2.3), and unlike most sites, it stands on a plateau c 3 kilometres from the river valley at 85 m.a.s.l. (Arnaud 1989; Araújo 1995–97; Diniz and Arias 2012).

Archaeological material and documentation available for Poças de S. Bento is curated at MNA. The site was first excavated by the museum staff from September 1960 (MNA, APMH, 5/1/654/54, 6 Sep. 1960) until the end of November. The second and last field season organized by the museum, started in August 1964 (MNA, APMH, 5/1/664/89, 2/2, Água Derramada, 19 Aug. 1964) until at least the end of September of the same year (MNA, APMH, 5/1/654/94, 2/2, 27 Sep. 1964).
The site was excavated in 1986–88 by J. M. Arnaud and L. Larsson (Arnaud 2000; Arnaud and Larsson 1994; Larsson 1996, 2010). The trial excavation in 1986 uncovered one skull in the basal sand. According to the excavators, these remains were possibly associated with skeleton 11, excavated in the 1960s (Larsson 1996, 2010). The skull was dated (UA–425, 5390 ± 110 BP, Larsson 2010; Lars Larsson, pers. comm.), and despite its stratigraphic position it represents a relatively recent date, possibly contemporaneous with a few polished stone tools excavated at the site (Arnaud 1990). The isotopic values of this measurement are not available and the calibration of this sample is uncertain. If the individual had a full terrestrial diet, the calibrated date range for his/her death would be 4448–3984 cal BCE (95% confidence). The ranges become slightly more recent when calibrated with the marine curve. For example, with an assumed marine diet of 30%, the calibrated date range is 4365–3819 cal BCE (95% confidence) (table A14).

J. M. Arnaud and L. Larsson identified the remains of one individual (individual 13) eccentric to the main burial area identified in 1960 (Larsson 1996, 131). Unlike the skeletons found in the early excavations in the bottom layer, this individual was found on the top layer, just above the layer with shells. The cranium and mandible of the skeleton were not identified and the bones of the trunk were poorly preserved (Larsson 1996, 130). This material was not radiocarbon dated (Lars Larsson pers. comm.).

Graphic documentation at MNA consists of two site plans with all burials in the excavation context (MNA, 1960, D. Sousa, A118, A119) (fig. 2.5), several individual drawings of the human remains (individuals 1 to 12) and one drawing of a group of faunal remains. The quality of the 68 field photographs available for Poças de S. Bento (MNA, APMH, 2/11/57) is poor and most images are unclear.

The human skeletons are in disarticulated state and stored in containers. The material is poorly preserved and incomplete due to fragmentation. The assemblage was studied by a team of anthropologists in the 1990s (Cunha and Umbelino 1995–97, 2001; Umbelino and Cunha 2012) who estimated a minimum number of individuals of 15 (11 adults; 4 non-adults). The poor preservation of the remains did not allow sex determination or more precise age estimates (Cunha and Umbelino 1995–97, 168).

Recent excavations directed by M. Diniz and P. Arias (2010–ongoing) identified the burial of a dog (*Canis familiaris*) on the opposite side of the burial area with the human remains (Diniz et al. 2012), as well as the burial of a female adult near the area where all human burials were found in the 1960s and 1980s (Diniz et al. 2014).
Sites without known human remains

The human remains excavated in the shell middens at the Tagus and Sado valleys constitute the core material of this research. The sites without known human remains were not investigated in the scope of this dissertation.

In the Tagus valley these sites are located on the banks of the Magos tributary: Cabeço dos Ossos (also known as Monte dos Ossos), Magos de Cima, Magos de Baixo, and Cabeço da Barragem. Although speculative, the lack of known human remains in these sites could be explained by the poor preservation of the middens when identified, due to floods and farming.

In the Sado valley, the sites without known human remains are: Cabeço do Rebolador (or Vale do Guizo), Fonte da Mina, Barranco da Moura, Barrada das Vieiras (also known as Portancho), and Barrada do Grilo. Cabeço do Rebolador was excavated in the summer of 1959 (MNA, APMH, 2/3/7/3, pp. 29–32) and no human remains were found. Fonte da Mina and Barranco da Moura were partially excavated, but the small test pits had few results and no human remains were found (Santos 1967, 1968). Barrada das Vieiras (or Portancho) was the first shell
midden identified at the Sado valley but apparently it was never excavated, or at least never reported to be. Barrada do Grilo was largely excavated by the museum staff but no human remains were found (MNA, APMH/5/1/654/46, 2/2, Torrão, 7 Aug. 1960). In the inventory of MNA, the site of Barrada do Grilo is wrongly identified as the same site of Várzea da Mó, when these are in fact two sites (MNA, APMH/5/1/654/26, Torrão, 2 Aug. 1959; Santos et al. 1972). For this reason, Barrada do Grilo was mistakenly published as a site with one burial (Marchand 2001) when in fact this burial was excavated at Várzea da Mó.

Total funeral

The archaeological remains of the mortuary practices of the last hunter-gatherers of the Tagus and Sado valleys most likely represent just a portion of the total funeral. Practices involving the treatment of the body after death, such as washing or clothing of the cadaver, the ritual words, the stories told and the songs intoned, the dancing, and any other bodily gestures performed before, during and after the placement of the cadaver in the grave, are normally not accessible to archaeology because they do not leave material traces. Our reconstruction of the mortuary practices is thus limited to what remains in the archaeological record and to what the archaeologist can read from it.

Another related limitation is expressed by the archaeological notions of incompleteness and the total record (see Lucas 2012, 18–73). The archaeologist is well aware of the fragmentary nature of the archaeological record, which can be understood in terms of its representativeness of past human actions, preservation of the material remains and rate of recovery during archaeological excavation (Lucas 2012, 19). In order to overcome these challenges, it is important to consider carefully the relationship between the archaeological assemblage and the human groups under study. How representative are the burials in relation to the original group? Are we dealing with a full collection as excavated? What is the relationship of the excavated sample to the site as a whole? Are the excavated areas representative of the cemetery as a whole or of only discrete areas of the cemetery (Mays 2010)? How does our sample signify the universe of funerary practices carried out at a certain place and time in the past?

Preservation and research bias

Organic preservation

The first aspect to consider concerns the preservation of organic material in the Mesolithic sites known in the Iberian Peninsula. A review of the archaeological data available for the mortuary practices during the earliest stages of the Holocene in the Iberian Peninsula (Peyroteo Stjerna, forthcoming) shows that human remains are preserved in c 37 sites, which is less than 20% of the c 200 Early and
Late Mesolithic sites known in Iberia. However, 117 of these sites have faunal assemblages (Gallego Lletjós 2013, 452), indicating bone preservation in at least 60% of the sites. Moreover, some of these sites have been excavated quite intensively, and if these sites had had human remains, these would have been preserved and found, at least in many of them.

**Settlement network bias**

Another aspect to consider when evaluating the representativity of the data is related to inevitable research bias. It is true that the concentration of sites with human remains corresponds to the areas where archaeological research is also more intense (Gallego Lletjós 2013). Also, and despite the geoclimatic variability in Iberia, it has been shown that when a specialized systematic survey is done, new sites are identified (Arias et al. 2009). Yet new finds have been very limited and have not changed the current Mesolithic paradigm for settlement patterns, despite recent survey programmes and large archaeological rescue projects in the context of local construction and land development (Araújo 2015).

**Visibility of the archaeological record**

The visibility of these sites is also an important issue to consider. The apparent lack of open air sites without shell layers and potentially with human remains could be a result of research bias, as these sites are obviously more difficult to identify than caves or shell middens. I have shown (Peyroteo Stjerna, forthcoming) that the shell midden/shell layer component is not a determinant variable for the presence of human remains during the Mesolithic. There is evidence for the disposal and preservation of bone in both situations, with and without shell layers. Interestingly, the sites with shell midden layers tend to contain more inhumations than the sites without. The relationship between shells and burials is discussed further in chapter 6, and is likely not just the result of good bone preservation in such environments, but of cultural choices.

**Representativeness of the sample under study**

The sites selected for this study are Moita do Sebastião and Cabeço da Arruda in the Tagus valley and Arapouco, Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez and Várzea da Mó in the Sado valley.

Moita do Sebastião and Cabeço da Arruda are the largest shell midden sites known in Portugal, with the highest number of human burials. The sites have been extensively excavated and the current assemblage is likely representative of the population buried in these sites. The analysis may be biased if we consider these two sites as representative of the mortuary practices at the scale of the entire Tagus valley. For this reason, Cabeço da Amoreira in the Muge area in the Tagus valley was included in the discussion, although not treated in detail because of the limitations of the source material.
In the case of the data selection for the Sado valley, I included all sites with human remains with the exception of Poças de S. Bento due to poor preservation of the skeletal material and unclear documentation. Overall, the assemblage is smaller than for the Tagus valley, however, the nature of the documentation for the Sado material allows a more detailed analysis. With the possible exception of Vale de Romeiras, none of these sites were completely excavated, and ongoing fieldwork has shown that a few more human burials may be preserved in these sites (Diniz et al. 2014). However, I believe we can be confident about the representativeness of the current assemblage due to the efficient recovery methods employed by the museum staff in the 1950–60s (Arnaud 1989, 615, 2000, 24–27). The strategy in these earlier excavations, when more than 100 burials were recovered, consisted of opening long narrow trenches along the recognized limits of the site. Then, if human remains were found these trenches were expanded. In all sites the human remains were found in one trench, later expanded as the main excavation area. One exception is the large site Cabeço do Pez, where the site plan from 1956 (MNA) shows two areas with human remains.

Of great utility to this study, are the skeletons preserved in natural or artificial blocks. In some cases, the human remains were recovered with the sediment concretion enveloping the bones, maintaining the skeleton in the position it was when excavated. In other cases, the skeletons were covered with paraffin wax and transported in blocks to the museums. This later procedure contaminated the bones limiting reliable chemical analysis of the human remains. However, the position of the skeleton in the archaeological deposit was maintained.

The great limitation of this analysis lies in the quality of the field documentation. The field notes when available are short and the description of the human remains is in general brief and superficial. The graphic documentation is absent for many sites and of variable quality. Each site has particular constraints and many possibilities, and these are described in detail in chapter 4.

**Hunter-gatherer death rate vs burial population**

Representativeness of the archaeological burials in relation to the original population can be estimated by the calculation of death rate of an assumed group size, within a chronological framework.

Ethnographic evidence indicates that nomadic foragers live most of their lives in small groups, often fewer than 25 persons, although they might periodically gather in larger groups (Kelly 2013, 172). Recent reanalysis of Binford’s (2001) dataset of 339 hunter-gatherer groups (Hamilton et al. 2007) suggests the following numbers for group units of nomadic foragers:

- Families: 4–5 people
- Residential group: 14–17 people
- Social aggregations (e.g., at winter camps): 50–60 people
- Periodic aggregations: 150–180 people
- Ethnic population: 730–950 people
Death rate patterns observed in several groups of historical hunter-gatherers (Gurven and Kaplan 2007) (table 2.4) along with knowledge of typical hunter-gatherer group sizes can be useful to test different scenarios.

Table 2.4. Death rate among hunter-gatherers. Data from ethnographic studies, compiled by M. Gurven and H. Kaplan (2007).

<table>
<thead>
<tr>
<th>Group</th>
<th>Environment</th>
<th>No. yrs studied</th>
<th>No. of individuals</th>
<th>No. of deaths</th>
<th>Deaths/year estimate (no.)</th>
<th>Deaths/year estimate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>!Kung</td>
<td>Kalahari desert, Botswana/Namibia</td>
<td>11</td>
<td>500</td>
<td>94</td>
<td>8.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Ache</td>
<td>Tropical forest, Paraguay</td>
<td>14</td>
<td>971</td>
<td>353</td>
<td>25.2</td>
<td>2.6</td>
</tr>
<tr>
<td>Agta</td>
<td>Tropical to humid sub-tropical, Philippines</td>
<td>24</td>
<td>176</td>
<td>117</td>
<td>4.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Hadza</td>
<td>Topical savannah, Tanzania</td>
<td>10</td>
<td>706</td>
<td>125</td>
<td>12.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Hiwi¹</td>
<td>Tropical savannah, Venezuela</td>
<td>2</td>
<td>375</td>
<td>107</td>
<td>53.5</td>
<td>14.3</td>
</tr>
</tbody>
</table>

To test one possible scenario at the Tagus and Sado valley sites one may speculate on the number of deaths per year (table 2.4) in one residential group of between 15–17 people. If such a group had low death rate, such as the value estimated for the !Kung from the Kalahari desert (1.7 percent per year), this group would experience 0.3 deaths per year, or three deaths every ten years (30 deaths in 100 years). In the case of higher death rate, such as the value estimated for the Agta from the forests of the Philippines (2.8 percent per year), a residential group of 15–17 people would experience 0.5 deaths per year, or 5 deaths every ten years (50 deaths in 100 years). Osteological analyses of the human remains from the Tagus and Sado valleys do not show evidence for inter-personal violence (Cunha et al. 2004; Jackes 2004), thus the high death rate estimated for violent groups such as the Hiwi, can be excluded from the current estimate.

In an archaeological population, calculating the death rate of a residential group of hunter-gatherers is not sufficient to estimate the representativeness of the burial population in relation to the living group. Chronological resolution is fundamental, and without this control one can only speculate how representative these burial grounds are of the people using them, and of their mortuary practices. M. Jackes and colleagues (1997, 652) have suggested that the group size of the hunter-gatherers frequenting the sites at the Tagus valley was small, and calculated that only approximately three women of child-bearing age in each generation lived in the area of Muge. This suggestion and other aspects related to whether these burial grounds provide a full picture of how the remains of the dead were handled is discussed further after the analysis of the radiocarbon data in chapters 5 and 6.

¹ The Hiwi are known for well documented inter-group violence (Gurven and Kaplan 2007).
A note about longevity among hunter-gatherers

M. Gurven and H. Kaplan’s (2007) study on the death rate of hunter-gatherers suggests that modal lifespan is 68–78 years (Gurven and Kaplan 2007, 349), in contradiction to previous claims suggesting that among early humans, few individuals passed forty years, and it was exceptional to pass fifty (Vallois 1961, 222). The authors conclude that extensive longevity appears to be a novel feature of *Homo sapiens* although juvenile mortality is high in hunter-gatherer populations (Gurven and Kaplan 2007).

Following this, in this dissertation I have assumed that a human generation represents 25 years. For a maximal human lifespan I have considered 75 years, though the average was presumably shorter (see Whittle et al. 2007, 131–2).

Understanding the context of data production: brief research history

The Mesolithic shell middens located in Portugal have been the subject of research for more than 150 years and the history of their research overlaps with major developments in archaeological thought in Portugal and elsewhere. The aim of this section is to summarize and contextualize the most relevant phases of shell midden research in Portugal within its historical background. Understanding the context of production of the archaeological data is fundamental when studying historical collections, as it allows better evaluation of the possibilities and limitations of the archaeological material at our disposal.

This brief review follows a chronological order and links each research phase to its historical background, emphasizing the scientific and/or political perspectives of the time which, for the purposes of this dissertation, I consider relevant to highlight. Also, for the scope of this work, I treat the context of data production in the historical collections (nineteenth century–1960s) in greater detail. This section starts with the discovery of the Portuguese shell middens and the birth of prehistoric archaeology in Portugal in the context of contemporaneous scientific debate on the antiquity of mankind. Then, I discuss the research work on the shell middens in the light of the use of archaeology in political discourse, in a section titled *From the antiquity of mankind to the antiquity of nations: human remains and discourses of identity*. After defining these two early phases of research, I focus on the first modern approaches to archaeological research during the 1950s and 1960s in the field and in the laboratory, and I present a summary of the research done over the last 30 years.
Portuguese shell middens and the birth of prehistoric archaeology in Portugal

The first shell middens identified in Portugal are located in the Tagus valley by the Muge and Magos tributary rivers. These archaeological sites were discovered by geologists commissioned to survey the country for geological and natural resources (Fabião 2011, 105–7). Between 1863 and 1885, the Geological Commission (Comissão Geológica do Reino) identifies five and excavates four shell midden sites, all of them with human remains (Cova da Onça, Fonte do Padre Pedro, Cabeço da Arruda, Moita do Sebastião, and Cabeço das Amoreiras). During this pioneer phase, more than 250 human skeletons were excavated at Fonte do Padre Pedro, Cabeço da Arruda, Moita do Sebastião, and Cabeço da Amoreira (Paula e Oliveira 1884, 1888–92; Pereira da Costa 1865, Ribeiro 1884). The Portuguese middens were immediately compared to the well known kokkenmøddinger (or kitchen middens) in Denmark discovered in 1831 (Anderson 2007). Interestingly, in the earliest publications about the Portuguese shell middens, the sites are named kjökkenmöddings or kioekkenmoeddings, after the Danish term, even though the texts were written in Portuguese and/or French by Portuguese researchers (Paula e Oliveira 1884, 1888–92; Pereira da Costa 1865; Ribeiro 1884).

The antiquity of mankind

The goals of this national geological inventory were naturally very distinct from an archaeological survey. However, the theme of the antiquity of humankind was not marginal to the members of this commission (Fabião 2011, 107). Interest in human antiquity is well framed in a European trend at the time (Renfrew 2008; Schnapp 1997; Trigger 2007), and reinforced by the clear antiquity of certain finds recovered during fieldwork.

The works of C. Darwin On the Origin of Species (first published in 1859 and translated into French in 1862) and The Descent of Man (first published in 1871 and translated into French in 1872) were known among Portuguese scholars and writers (Fabião 2011; Pereira 2001). However, The Geological Evidence of the Antiquity of Man by C. Lyell (first published in 1863 and translated into French in 1864) had a greater influence at the time, at least among the scholars involved in geological and archaeological fieldwork. This is well illustrated by Pereira da Costa, the author of the first study published about the Portuguese shell middens and credited as the first work in prehistoric archaeology in Portugal: Da existência do homem em epochas remotas no valle do Tejo. Primeiro opusculo. Noticia sobre os esqueletos humanos descobertos no Cabeço da Arruda, which translates to On the antiquity of man in the Tagus valley. Part one. Note about the skeletons found at Cabeço da Arruda – bilingual edition in Portuguese and in French (Pereira da Costa 1865). This pioneering study shows a clear knowledge of C. Lyell’s work and an evident concern with the antiquity of mankind in the Portuguese territory, which subsequent studies followed.

Following the developments in the natural sciences, during the nineteenth century there was an increase in the use of the term: archaeology – parallel to its
emergence as an independent discipline (Schnapp 1997, 275–6). At this time many societies were formed in Europe focused on themes of anthropology, ethnology and prehistory. In Portugal, the Association of the Portuguese Archaeologists was founded in 1863 (Associação dos Arqueólogos Portugueses), and the Ethnological Museum in 1897 (Museu Etnológico), nowadays the National Museum of Archaeology (Museu Nacional de Arqueologia, MNA). The first course in anthropology and archaeology started in 1885 at the University of Coimbra: Antropologia, Palaeontologia Humana e Arqueologia Pré-historica – Anthropology, Human Palaeontology and Prehistoric Archaeology (Fabião 1999).

The birth of prehistoric archaeology is closely related to the developments in biology, geology, and other sciences within the Positivist paradigm at the time (Diniz and Gonçalves 1993–94; Trigger 2007). In Portugal, this happened in a clear geological framework but with contributors informed by other natural sciences: Pereira da Costa, for example, was a Professor in mineralogy and geology with a degree in medicine as well (Fabião 2011, 106). This is an important point because these prehistoric shell middens were intriguing not only because of their geological and anthropogenic formation, but also because they enclosed the biological remains of past humans, thus providing the impetus for the development of prehistoric archaeology in Portugal.

From the antiquity of mankind to the antiquity of nations: human remains and discourses of identity

Historical background

Portugal has been an autonomous territory with stable borders since the thirteenth century (Ventura 2007). Perhaps for this reason, “there have been no remarkable cases in Portugal of nationalistic appropriation of archaeological interpretations or uses of archaeological monuments as national symbols” (Fabião 1996, 90). Nevertheless, some historical moments received special attention in the formation of a national identity: the foundation of the country and its defence against other peninsular Christian kingdoms, in particular against the Muslim power; the several conflicts with Castile (Spain); and the illustrious Age of Discoveries (Fabião 1996, 90).

In the early nineteenth century, A. Herculano (1810–77), the first Portuguese historian in a modern sense, defined the birth of the nation as an act of political will. Based on this argument, Herculano rejected any relationship between the Portuguese people and any other prior populations in the Portuguese territory. In this view, and breaking with the previous humanist paradigm, Herculano urged special protection of “the truly Portuguese monuments rather than for the relics of remoter ages”, that is, protection of the medieval roots rather than those of Roman heritage or earlier (Fabião 1996, 93). This thesis of the medieval origins of the Portuguese state was adopted by other influential and popular historians. Ever since, all Portuguese archaeological work with nationalistic purposes has
attempted, without great success, to integrate the ancient heritage into a concept of historical identity (Fabião 1996).

**Prehistoric remains**

During the second half of the nineteenth century, the pioneer studies of the newly born discipline of prehistoric archaeology were concerned with the discovery of the great antiquity of humankind, greatly inspired by the revolutionary works of C. Darwin and C. Lyell.

The nineteenth century was rich in important changes of scientific paradigms but also in political transformations of national character in Europe. In this context, and throughout the twentieth century, archaeology was used and abused by national states in order to support various claims of territorial and cultural identity (Trigger 2007). Following this, in the early twentieth century, there was a significant emphasis on the idea of a *primeval Portugal*. This idea, supposedly based on archaeological evidence, proposed that the pre-figuration of the Portuguese nation was to be found in prehistoric times, hence in contradiction to the previous mentioned thesis of a medieval origin for the Portuguese people. Two main personalities, both influential archaeologists but also great adversaries (Fabião 1999, 2011), were involved in this shift of identity discourse: M. Corrêa and M. Heleno. Interestingly and not coincidentally, both were involved in excavations at the prehistoric shell midden sites in the Tagus valley (M. Corrêa) and in the Sado valley (M. Heleno).

M. Corrêa (1888–1960) was the pre-eminent researcher of the Muge middens during the 1930s, the second great moment of research into these shell middens. M. Corrêa had a degree in medicine and was the founder of the Institute of Anthropology of University of Porto (Cardoso 1999). He proposed that the human remains excavated in the Muge shell middens were of African origin (Corrêa 1919, 1933). This theory was strongly debated and opposed by other anthropologists, such as H. V. Vallois (Vallois 1930, 1940) (see Ferembach 1974, 12–5), but M. Corrêa was confident in his assumptions and even referred to the Muge specimens as *Homo afer taganus*. Later however, M. Corrêa revised his theories and accepted other interpretations, such as the Mediterranean origin of the Muge populations (Corrêa 1956). Yet this idea of an African ancestry went well with the national propaganda at the time. The *multiracial* and *pluricontinental* Portugal were important ideological concepts in the nationalistic dictatorship with political and institutional control over Portugal and several territories in Africa and Asia. For the first time, although for a brief period, the Muge finds with claimed African ancestry, were placed in the national history.

In the same vein, but in a purely nationalistic rhetoric, M. Heleno, director of the Museum of Ethnology Leite de Vasconcelos in Lisbon (1929–64) (nowadays the National Museum of Archaeology, MNA), had put forward the idea that the Portuguese nation and people had shared moral and unity determined since the New Stone Age. He emphasized that this unity descended from the *Muge Men*, who prevailed throughout the Bronze to the Iron Age, developing through the Roman
period to medieval times when Portugal was finally constituted a state, although rejecting M. Corrêa’s thesis of a possible African ancestry in the Early Stone Age (Fabião 2011, 171–72). Furthermore, and based on no firm archaeological evidence, Heleno compared the spread of the megalithic culture to a prehistoric imperialism which source of development was of Portuguese genesis (Fabião 1996). Because of the animosity between these two personalities, M. Corrêa and M. Heleno (see Fabião 1999, 2011), the National Museum of Archaeology was never involved in the excavations at the Tagus (Muge and Magos) shell middens. It is in this context that the first shell midden sites were identified in the Sado valley, c 100 kilometres south from Muge (Barradas 1936). However it was only some decades later, between 1955 and 1964 that M. Heleno and the National Museum, focused on systematic fieldwork in the region, excavating and identifying several shell middens in the Sado valley (see below). Unfortunately, contrary to M. Corrêa, M. Heleno never published anything about the vast archaeological material excavated during these years in the Sado valley, and the question of what Heleno thought about these human remains and the origins of the Portuguese people remains a mystery.

Overall, these ideas had a certain impact and some of the misconceptions remained in the archaeological discourse for many years. However, never again were prehistoric remains part of the narrative on the genesis of the nation, a topic that was not in the processual agenda of Portuguese archaeology after the 1970s.

From the late nineteenth century throughout the first half of the twentieth century, European archaeology studied its human osteological collections from racial perspectives, aiming at finding national identities based on narratives of origins, selected relations and networks. Although based on different motivations, these narratives had strong nationalistic accents. As discussed, in Portugal, the Tagus valley collections were implicated, although modestly, in arguments related to identity, ancestry, and origins. These observations were especially interesting to a colonial power such as Portugal, interested in supporting its ancestral connections with Africa. However, this African perspective ceased to exist, and in fact during the second half of the twentieth century, the southern coast of the Mediterranean disappears from European archaeological maps (see Diniz 2007).

In a country such as Portugal, with a very long history, located in a geographic space where no reasons besides political ones could justify its independence, it seems quite obvious that nationalistic discourses favoured historical periods rather than prehistory, classical antiquity or the early Middle Ages. Even so, Portuguese archaeologists with nationalistic aims have tried, with little success to relocate the roots of the nation deeper in history, chiefly as an attempt to achieve social relevance in the eyes of both political power and public opinion. But, ‘in a country with so many national “glorious events” to celebrate, who needs poor and controversial archaeological remains from remote ages?’ (Fabião 1996, 105).
The 1950s–60s: towards a systematic archaeology

In the second half of the twentieth century, archaeology became more systematic discipline with its own field methods and recording techniques (Trigger 2007). In Portugal, archaeology remained a fragmented discipline, marked by individual personalities, and with few exceptions, it remained an amateur discipline (Fabião 2011, 177). Nevertheless, in the case of shell midden research, the data production during this period was outstanding, pioneering in the application of methods and techniques, such as the first radiocarbon dating in Portugal carried out in the Muge middens, or the use of the Wheeler method at the Sado valley (fig. 2.6).

The excavations done at the Muge sites remained under the control of M. Corrêa (Institute of Anthropology of University of Porto). Corrêa did not carry out the fieldwork himself but invited the French archaeologist Jean Roche to direct the excavations (Roche and Ferreira 1967). Interestingly, and following the research tradition at these sites, J. Roche was assisted by Octávio da Veiga Ferreira, member of the Geological Services of Portugal (Serviços Geológicos de Portugal) – the institution born from the earlier Geological Commission behind the discovery of the first middens in the nineteenth century. J. Roche was meticulous and published his finds regularly. The same can be said about O. V. Ferreira who assisted J. Roche and directed the excavations in his absence. It was during these decades that the first radiocarbon measurements were done on archaeological material from Portuguese sites, obtained from samples of charcoal collected by J. Roche at Moita do Sebastião, and later from Cabeço da Arruda and Cabeço da Amoreira. This sampling for dating was done at the request of M. Corrêa who wanted solid data to establish the absolute chronology of the Tagus shell middens (Roche and Ferreira 1967, 32). Also, the first and only monograph ever published on any of the Portuguese shell middens was authored by J. Roche (1972) on the site of Moita do Sebastião.

It is also during these decades, between 1955 and 1964, that M. Heleno, director of the National Museum of Archaeology focused his attention on the shell midden sites discovered in the 1930s in the Sado valley. Most middens were identified during this period and more than 100 skeletons were recovered. These were the first and the largest excavations ever carried out at these sites but unfortunately the archaeological material remained unexplored for several decades and nothing was ever published. Curiously, during this time the Sado middens were never mentioned in the literature, except in a brief note by Heleno (1956). This is well illustrated by the published work by J. Roche, O. V. Ferreira, and D. Ferembach, who were active and prolific researchers of the Muge middens, but never mentioned the middens in the Sado valley, which could have been used for comparison with their finds. This omission in the literature was most probably because nobody knew anything about the archaeological material excavated at the Sado sites, except M. Heleno and the staff of the museum. The archaeology of the Sado valley remained unknown until the 1980s, just blooming in the twenty-first century.
Figure 2.6. Excavations at the Sado middens were among the earliest sites where the Wheeler method was applied in Portugal. Above: sketch with detail of excavation area at Cabeço do Pez, 1958. Below: field photograph at Arapouco, 1961. (MNA, 1958, D. Sousa; MNA, APMH, 1961, F644)
The 1980s–90s: old collections, physical anthropology, and selected fieldwork

Since the identification and excavation of the shell midden sites in the Tagus and Sado valleys in the late nineteenth century and in the mid twentieth century respectively, the archaeological research was focused on excavation of artefacts and human remains. The researchers in charge of fieldwork flooded their institutions and museums with excavated material: hundreds of human skeletons, thousands of lithic artefacts, and several kilograms of shells and sediment. With a few remarkable exceptions, most of this material remained unstudied for more than one hundred years, stored in the archives of the Geological Museum in Lisbon (MG), the Institute of Anthropology, University of Porto (now MHNUP), and the National Museum of Archaeology in Lisbon (MNA). Fortunately there was a shift in focus in the early 1980s, and research was targeted towards detailed studies of the historical collections along with selected fieldwork.


It is also in the early 1980s that a group of Canadian researchers, M. Jackes, D. Lubell, and C. Meiklejohn addressed the historical collections of the Muge middens and presented pioneer studies strongly based on detailed osteological analyses (Jackes 1988; Jackes and Lubell 1995, 1999; Jackes et al. 1997a–b; Lubell and Jackes 1985, 1988; Lubell et al. 1989, 1994; Meiklejohn et al. 1986). At this time the questions of race and origins, so in fashion in the 1930s to 1940s, had become completely irrelevant, and the team worked mainly on questions related to the Mesolithic-Neolithic transition. This research group presented the first radiocarbon dates on human bone collagen, as well as the first isotopic analysis, on bones from Portuguese sites (Lubell and Jackes 1985, 1988; Meiklejohn et al. 1986). Throughout the years of their research, Jackes and colleagues have produced a significant body of work dedicated to the Muge sites, not only at the level of the osteological collections, but also on the laborious task of reconstructing spatial organization and stratigraphic history of the sites, based on detailed study of the human remains and historical documentation (Jackes, forthcoming; Jackes and Alvim 2006; Jackes et al. 2014, 2015, forthcoming; Roksandic and Jackes 2014).

Finally, in the 1990s a team of anthropologists examined the Sado osteological collection as a whole, and published it for the first time (Cunha and Umbelino 1995–97, 2001; Cunha et al. 2002, 2003). B. Kaufmann from the University of
Basel studied the material in the 1980s but his results were never published (Umbelino 2006, 139). From E. Cunha and C. Umbelino’s research we now have access to site estimates of MNI, demographic profiles (age at death, sex), morphological information (height, robustness), as well as elements of health and pathology. Along with this pioneering anthropological study this team provided the first radiocarbon dates on human bone collagen from the Sado valley (Cunha and Umbelino 2001).

The last decades of the twentieth century are marked by other ground-breaking studies on zooarchaeology of the middens (Lentacker 1986, 1994; Rowley-Conwy 2004), as well as by the first comprehensive studies on Mesolithic lithic technology, this time focused on the Sado collections (Araújo 1995–97; Marchand 2001).

**Maturity in the twenty-first century: Sado valley out of the archives**

Archaeological research on the shell middens of the Tagus and Sado valleys gained new impetus in the twenty-first century, particularly at the level of the Sado valley shell middens. New interdisciplinary fieldwork started and is ongoing at both valleys (Arias et al. 2015; Bicho et al. 2011, 2013; Diniz and Arias 2012; Rolão et al. 2006), along with ever more sophisticated studies of the museum collections of fauna (Detry 2003, 2007; Marques-Gabriel 2015), lithic technology (Diniz and Nukushina 2014; Nukushina 2012), and history of research (Abrunhosa 2012).

The human remains continued to be a central element of research. C. Umbelino expanded her pioneering study on Mesolithic and Neolithic osteological collections with an in-depth and remarkable study on palaeodiet based on trace elements and isotopic analysis (Umbelino 2006; Umbelino et al. 2007). Other in-depth isotopic analyses of carbon and nitrogen followed, this time exclusively dedicated to the Sado collections (Fontanals-Coll et al. 2014; Guiry et al. 2015). Initial DNA analyses have been done on samples from Muge (Bamforth et al. 2003) and Sado (Chandler et al. 2005), and were compared with findings from Neolithic populations. While the Muge assemblage suggested genetic continuity between the Mesolithic and Neolithic in Portugal, the study based on the Sado assemblages seems to indicate discontinuity between the Mesolithic and Neolithic groups. These are interesting results but without further evidence should be interpreted with caution, not only because these analyses were done during the early stages of the development of the method (Matioso-Smith and Horsburgh 2012), but also because the sample sizes were small, requiring further testing to confirm or reject these hypotheses.

The research at the shell middens of the Tagus and Sado valleys is strong, and the following years promise to be exciting in terms of upcoming results from ongoing excavations. Hopefully, and perhaps more importantly, researchers will remain interested in the historical collections in the archives of these, and other museums, which hold abundant and some of the richest archaeological material we will ever have.
Despite the unusual number of human burials, these sites have been studied almost exclusively from the perspective of settlements for the living. The archaeological remains of the dead were first used to determine or reject an African ancestry for the Portuguese nation. Afterwards, within the framework of processual archaeology, these sites were in the centre of the debate about ecological and economic issues related to the lifestyle and strategies of the last hunter-gatherers of Europe. Models of seasonal occupation have been proposed (Arnaud 1989; Marchand 2001; Rowley-Conwy 2015); detailed studies on palaeodiet (Umbelino 2006) and palaeo-populations focused on the Mesolithic-Neolithic transition have been done (Jackes and Lubell 1995; Jackes and Meiklejohn 2008), and just very recently brief syntheses on mortuary practices were published (Jackes and Lubell 2012; Jackes et al. 2014; Roksandic and Jackes 2014; Roksandic 2006; Umbelino and Cunha 2012).

Although the dead have been the main reason why these sites have been excavated and internationally recognized, their place in archaeological interpretation has been largely ignored. The following painting by the French archaeologist H. Breuil (1949) (fig. 2.7) illustrates this perspective well, making no allusion to mortuary practices (Peyroteo Stjerna 2015). Interestingly, by this time, more than 250 burials had been recovered from the Muge shell middens. The painting is accompanied by a page long text with only a very brief reference to burial practices:

They must have lived in straw or reed huts quite near their heaps of shell-fish, in which they often buried their dead; the bodies were generally doubled up. (Breuil 1949, 93)

Figure 2.7. Daily life in a Muge shell midden, Tagus valley, Portugal. (Reproduced from Breuil 1949, 94–5)
Methodological choices in this study

Understanding the significance of the mortuary activity at the shell middens of the Tagus and Sado valleys requires we define how consistent and deliberate these practices were, who was buried in these places, as well as when and how. The human remains recovered from these archaeological sites are at the centre of this research and I relied on three methodological approaches: radiocarbon dating and Bayesian analysis, stable isotope analysis of carbon and nitrogen, and archaeothanatology.

To answer the question when, in relation to the chronology of the burial activity, I developed a radiocarbon dating programme, using the radiocarbon measurements on human bone collagen from 15 individuals previously dated (16 measurements) and 30 new dates obtained during the scope of this study. The radiocarbon data, previous and new, was carefully scrutinized for reliability of measurements. The statistical treatment and modelling of the data follows the Bayesian approach to the interpretation of radiocarbon dates. Each site was analysed individually and a model for the chronology of the burial activity in each site has been proposed.

To answer the question who, in order to define the people in each burial place, I considered previously published isotopic signatures of carbon and nitrogen, and plotted these with 30 new signatures obtained in the course of this dissertation. Despite the current limitations to the application of the isotopic method to this particular data set, discussed further in this chapter, these data can be particularly informative in terms of mortuary practices, which can now be analysed within a greater chronological resolution compared to previous studies.

To answer the question how, in relation to the treatment of the dead, I analysed 82 individuals with the method of archaeothanatology. This number represents a natural population with all age groups and both sexes represented. In several cases, due to the fragmentary nature of the material and unclear documentation, the analysis was limited to a few elements. This is however a dynamic method, which with the combination of various observations allows a close reconstruction of the chaîne opératoire from the human remains recovered in the archaeological context to the original funerary feature.

In this chapter, I present the central principles of each method in relation to the investigation of the mortuary activity based on the analysis of the human remains.
in archaeological context. The first section is dedicated to the radiocarbon dating method and Bayesian analysis, slightly overlapping in terms of central principles with the second section which is focused on stable isotope analysis of carbon and nitrogen. The third and last section of this chapter is centred on the method of archaeothanatology where I also introduce and discuss relevant terminology.
Radiocarbon dating method and Bayesian analysis

Introduction

Chronological resolution in prehistory
Time in prehistoric sites is frequently defined by a couple of absolute dates and a significant amount of typology. Typological relative dating of lithic and ceramic assemblages may provide a satisfactory broad range chronological framework, and in many cases absolute dating methods are frequently used simply to support the typological argument with a suitable calendar date. This approach to the prehistoric time stems from an enquiry concerned with a generic chronological framework; however, the large narrative over a long time period is not the only possible approach to prehistoric sites, as it in fact may be not only misleading but wrong (Bayliss et al. 2007; Whittle et al. 2011). Also, as good practice, the archaeologist should always aim for better and more precise chronologies, because time is our trade.

Chronology is the cornerstone of any archaeological interpretation, and the consistent use of radiocarbon data combined with accurate stratigraphic data in prehistoric contexts allows us to refine our chronologies. Radiocarbon data can be used explicitly because it offers the best probabilistic estimates “of real dates when things happened by the agency of particular people in specific places” (Bayliss et al. 2007, 1). This is important because the construction of refined chronologies brings into focus the social context and actions of people (Whittle et al. 2011). A calendrical time scale can provide solid evidence for when an activity occurred, and for how long, allowing more meaningful comparisons, beyond the stratigraphic and typological series (Bayliss et al. 2007).

Our enquiry into chronology will influence the scale of our archaeological narrative. In this dissertation, first, I focus on the short term scale: on the human burial as an event. Second, I focus on the short term event in relation to the long term scale: the duration of the burial activity in each site. With this chronological enquiry my aim is to model formally the specific parameters of a particular problem: the use of each site as a burial ground.

Enquiry-dependent chronologies: the radiocarbon dating programme in this study
A radiocarbon dating programme was developed in the course of this study to determine the chronology of the burial activity in each site and in each valley. The chronological models proposed are thus dependent on this interpretative and research framework.
The shell midden sites of the Tagus and Sado valleys are attributed to the Late Mesolithic which in Portugal ranges from c. 6350–5250 cal BCE (Araújo 2015) slightly overlapping with the earliest phase of the Mesolithic-Neolithic transition c. 5500–5300 (Carvalho 2009, 2010). This chronological framework was established on typological analysis (Araújo 1995–97; Breuil and Zbyszewski 1947; Marchand 2001; Nukushina 2012; Roche 1967, 1972) and on several radiocarbon dates (Arnaud 1989, 2000; Bicho et al. 2011, 2013; Cunha and Cardoso 2001, 2002–03; Cunha and Umbelino 2001; Cunha et al. 2003; Delibrias and Roche 1965; Detry and Cardoso 2010; Jackes et al. 2013, 2014; Lubell and Jackes 1985, 1988; Larsson 1996; Martins et al. 2008; Meiklejohn et al. 1986, 2009; Roksandic 2006; Roche 1957; Soares and Cabral 1984; Umbelino 2006).

This study examines the use of the shell midden sites in the Tagus and Sado valleys as burial grounds. One of the main problems at the beginning of this research was the lack of direct dates on the human remains excavated from these sites, as well as the unclear association between the radiocarbon dates on non-human material and the burial activity. This was particularly problematic at the sites of the Sado valley where only four individuals from four sites had direct dates (table 3.1), all four with problematic calibrations (see below, Reliability of the isotopic measurements). The situation was better in the case of the Tagus valley where 20 individuals from four sites were dated, six of which from recent excavations (table 3.2).

| Table 3.1. Sado valley: human remains with radiocarbon dates published before 2013. |
|--------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Site                                | Arapouco        | Poças de S. Bento | Cabeço das Amoreiras | Cabeço do Pez    |

| Table 3.2. Tagus valley: human remains with radiocarbon dates published before 2013. |
|--------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Site                                | Moita do Sebastião| Cabeço da Amoreira | Cabeço da Arruda | Cova da Onça     |
| Individual, year of excavation      | CT, 19th c.     | 7, 1937         | A, 19th c.      | 1 individual   |
|                                     | 22, 19th c.     | CAM-00-01       | D, 19th c.      | (without no.)  |
|                                     | 24, 19th c.     | CAM-01-01       | N, 19th c.      |                |
|                                     | 41, 19th c.     | Burial 2011.2   | 6, 19th c.      |                |
|                                     | 16, 1952–54     |                 | 42, 19th c.     |                |
|                                     |                 |                 | CA–00–01        |                |
|                                     |                 |                 | CA–00–02        |                |
The radiocarbon dating programme was centred on the seven sites under study: two sites in the Tagus valley, Moita do Sebastião and Cabeço da Arruda, and five sites in the Sado valley, Arapouco, Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó. The objectives of the dating programme were site-specific and are described in detail for each site in chapter 4. The general aim was to establish a chronology for the use of the sites as burial grounds, which can be outlined by specific objectives as follows:

- to define the duration of the human burial activity, in each valley in general and in each site in particular;
- to estimate the frequency of the burial activity, in each valley in general and in each site in particular;
- to estimate when the burial activity started and when it ended, in each valley in general and in each site in particular;
- to identify synchronic and diachronic similarities and differences in burial patterns.

The dating programme was planned in two phases. The first phase consisted of the selection of samples organized around site-specific and general questions. The second phase of sampling selection was centred on particular questions generated by the results of the first phase.

**This section**

**Structure**

The section *Radiocarbon dating method and Bayesian analysis* concentrates on methodological issues related to the main principles of the radiocarbon method and the interpretation of radiocarbon measurements. This methodological review was written from the perspective of the analysis of unburnt prehistoric human bone in Holocene archaeological contexts in the temperate zone of the northern hemisphere, concerning south-western Europe in particular, and for this reason, issues relevant to other archaeological contexts may not have been addressed. Methodological choices for the selection and screening of samples in this study are presented in the last part of this section.

The results of the radiocarbon dating programme, the analysis and interpretation of the absolute dating evidence, and the formal chronological models are presented by archaeological site in chapter 4. The results and the chronological models are analysed and contextualized in chapter 5.

**Terminology and conventions**

Radiocarbon determinations and calibrated dates are reported following the revised conventions published in *Radiocarbon* (Millard 2014). Accordingly, the following elements are considered and included along with the presentation of the data:

- The laboratory code for each determination.
• Identification of the sampled material. Biological materials should be identified to genus and species when possible.

• The laboratory pre-treatment method applied and the quality control measurements.

• It should be clear whether the $\delta^{13}$C values were obtained by accelerator mass spectrometry (AMS) during the process of $^{14}$C measurement or independently by isotope-ratio mass spectrometry (IRMS). This is important because the AMS values should not be used for dietary reconstructions or reservoir corrections (Millard 2014, 557; Taylor and Bar-Yosef 2014, 117).

• The laboratory measurement is reported as a conventional radiocarbon age in radiocarbon years BP ($^{14}$C yrs BP).

• The calibration curve(s) used and respective version number(s).

• The reservoir offset used, when applicable.

• The software used for calibration and respective version number.

• The calibrated date is given as a range (or ranges).

• The associated probability, such as 68% or 95%, is given for each range. The terms “1-sigma” ($1\sigma$) and “2-sigma” ($2\sigma$) should not be used to describe calibrated dates (Millard 2014, 557).

• The calendar timescale used is clearly identified (e.g., cal BP, cal BCE).

These conventions are the recommended minimum requirements for good practice (Millard 2014). The advantages of following these standards are that it allows the replication of results and ensures that the published data can be used by other researchers as methods and techniques improve.

In this dissertation, calibrated/calendar ages are primarily reported as “cal BCE” (Before Common Era). This option was based on the history of research of these sites, which have been studied from a Mesolithic-Neolithic perspective, and where dates are typically reported as cal BCE. Additionally, the radiocarbon tables may present a second calendar timescale, “cal BP” (Before Present, where Present is 1950 CE), for easier comparison with other sites and research traditions where cal BP is conventionally used.

All radiocarbon measurements presented in this study are calibrated with OxCal 4.2 (Bronk Ramsey 2009) using atmospheric curve IntCal13 (Reimer et al. 2013). Samples where carbon is derived from atmospheric and aquatic reservoirs are calibrated using the atmospheric curve IntCal13, the aquatic curve Marine13 (Reimer et al. 2013) and the regional reservoir offset. In each sample, the percentage of non-atmospheric carbon derived from aquatic reservoirs is estimated using two methods clearly identified as marine 1 and marine 2. The calibrated ranges quoted in italics derive from mathematical modelling and are posterior density estimates. The presentation of the results for each site adopts in general the structure presented by A. Whittle and colleagues (2011).
Radiocarbon dating method

The principles of radiocarbon dating were established after the Second World War (Libby et al. 1949) following the development of atomic physics and rapidly tested and applied to archaeological samples of known historical date (Arnold and Libby 1949). This major scientific innovation transformed archaeology (Trigger 2007, 382) and was the most important breakthrough in the study of prehistory since the scientific demonstration of the antiquity of man in the mid 1800s (Renfrew 2008, 37). The first set of samples (Arnold and Libby 1951), submitted from sites around the world, included classic prehistoric sites. A charcoal sample came from the Palaeolithic cave Lascaux in France and a sample from a wooden platform from the Mesolithic open air site Star Carr in England. Later, in 1960, W. Libby (1908–80) was awarded the Nobel Prize in Chemistry for his method of age determination:

Professor Willard Libby has been selected to be the prize-winner for his method of age determination of materials of biological origin by use of carbon-14 as a measurer of time. His method has obtained widespread use and has become indispensable in archaeology, geology, geophysics and other sciences. Fortunately, it is so simple – which is probably not always the case with chemical research distinguished with the Nobel Prize – that everyone should be able to understand the conditions and principles for its execution. (Westgren 1960)

Radiocarbon dating is the most useful, reliable and widely used scientific method for determining the age of a carbon-containing substance formed over the last fifty thousand years (Bronk Ramsey 2008; Bronk Ramsey et al. 2006; Reimer et al. 2013).

The method works from the observation that the chemical element, radiocarbon, is absorbed and fixed into organisms during their lifespans, and decays at a constant rate over time after their biological death (Arnold and Libby 1949; Libby et al. 1949). The decay rate can be counted and an age can be determined for when the organism died, that is, when the organism stopped absorbing radiocarbon from the environment. For the estimation, interpretation and critique of radiocarbon measurements it is important to understand the basic principles of the method (see Bronk Ramsey 2008; Taylor and Bar-Yosef 2014). As discussed further, the archaeological material under study in this dissertation offers a set of complexities which are difficult to analyse and interpret if the radiocarbon dating methodology is not well understood.

Basic principles

Radiocarbon (\(^{14}\text{C}\)) is the radioactive isotope of the element carbon, while \(^{12}\text{C}\) and \(^{13}\text{C}\) are its stable isotopes (non-radioactive) (Pollard et al. 2007). Carbon and its isotopes enter the biosphere mainly through the process of photosynthesis in plants, algae, and cyanobacteria, and enter the food chain directly via herbivore animals and indirectly in the case of carnivores and omnivores. In reality, the \(^{14}\text{C}\)
method dates the photosynthesis event when $^{14}$C enters the food chain, however, "terrestrial food chains are also sufficiently short that in most instances the carbon in any animal’s diet will have been fixed from the atmosphere within the past few years" (Bronk Ramsey 2008, 253). Thus carbon is incorporated in living organisms from the food they eat. Animals will use incorporated carbon in the production of structural proteins such as keratin (present in hair, horns, nails, claws, hooves, feathers, and beaks), collagen (present in bone and tooth dentine), and also in the formation of exoskeletons (e.g., reptile shells, shells in snails, bivalves and other molluscs). This is useful for archaeological research because, once formed, these structural proteins retain the isotopic record ($^{14}$C, $^{13}$C, $^{12}$C, among other elements) of that moment in time, and many of these structures survive relatively well in archaeological contexts.

From the point of view of $^{14}$C dating, the next stage in the cycle of incorporated carbon that is important to keep in mind is that, over time unstable atoms such as $^{14}$C go through a process of radioactive decay, also known as nuclear decay or radioactivity, and will fall off at a regular and known exponential rate independently of all environmental conditions (Bronk Ramsey 2008; Pollard et al. 2007). When the organism dies the uptake of $^{14}$C ceases and the steady concentration of $^{14}$C in the organism begins to decline. The age of the dead organism can thus be calculated by measuring the amount of $^{14}$C left in the sample, with reference to the known rate of $^{14}$C decay. The rate of decay used in the laboratories for the calculation of $^{14}$C ages is the so-called Libby’s half-life of 5568 ± 30 years (Anderson and Libby 1951) and it is the conventional value in use since 1965 until the present (Bronk Ramsey 2008, 254; Stuiver and Suess 1966, 536).

In the context of the application of the $^{14}$C dating method to archaeological samples, one must acknowledge that the production of $^{14}$C is not constant through time (Anderson and Libby 1951). However this fluctuation has been examined and continuously studied for different timescales following the reference work of M. Stuiver and H. Suess (1966) (see Reimer et al. 2013). Furthermore, research has shown that the fluctuation of $^{14}$C in the atmosphere is different between the northern and southern hemispheres, a variation also known as the hemispheric offset (Hogg et al. 2002, 2013; McCormac et al. 1998, 2004). Yet the fluctuation within each hemisphere does not seem to vary locally or regionally, at least significantly (Bronk Ramsey 2008, 251–252).

Radiocarbon produced in the atmosphere is in dynamic equilibrium with that on the surface of the hydrosphere (Bronk Ramsey 2008, 253). The concentration of $^{14}$C in waterbodies is generally lower than that in the contemporary atmosphere due to a slower mixing rate between the chemical elements in the atmosphere and the water surface (Bronk Ramsey 2008; Keaveney and Reimer 2012; Stuiver and Polach 1977; Stuiver et al. 1986). Because of this relative depletion in $^{14}$C, the organisms grown in aquatic reservoirs, either in marine, brackish or freshwater habitats, will variably present relatively older $^{14}$C ages. This offset is a phenomenon known as the reservoir effect ($\Delta R$) and is discussed further below (Stuiver and Polach 1977; Stuiver et al. 1986).
Unlike the concentration of $^{14}\text{C}$ in the atmosphere, the concentration of $^{14}\text{C}$ in aquatic ecosystems has great geographical variation (see CHRONO 2015). Various factors, such as the upwelling phenomenon in marine environments (Stuiver and Braziunas 1993; Monge Soares 1993; Monge Soares and Dias 2006) or the local multi-sources of carbon in freshwater systems (Keaveney and Reimer 2012; Lanting and van der Plicht 1998) may contribute greatly to these variations. When applying the radiocarbon dating method to archaeological samples, it is fundamental to identify the sources of $^{14}\text{C}$ for each archaeological sample, because in the case of animal samples, their foods may derive from a greater or lesser variety of sources of different primary reservoirs.

In summary, in the context of the application of the $^{14}\text{C}$ dating method to archaeological samples, the key points to keep in mind about the carbon cycle and $^{14}\text{C}$ in the environment are:

- The production of $^{14}\text{C}$ is not constant through time. This fluctuation has been examined and continuously studied for different timescales.
- Food sources from different primary reservoirs, terrestrial or from the various aquatic systems, will determine the $^{14}\text{C}$ incorporated in each archaeological sample.
- Once formed in animal tissue, structural proteins retain the isotopic record ($^{14}\text{C}$, $^{13}\text{C}$, $^{12}\text{C}$, among other elements) of that moment in time, and many of these structures survive relatively well in the archaeological record.
- Once the organism dies, the uptake of $^{14}\text{C}$ ceases and the steady concentration of $^{14}\text{C}$ begins to decline (i.e., decay) in a steady exponential rate, independently from all environmental conditions.

The $^{14}\text{C}$ age obtained from the laboratory is a measurement of the isotope ratios $^{14}\text{C}/^{12}\text{C}$ and $^{13}\text{C}/^{12}\text{C}$ converted to a radiocarbon “date”, based on the assumption of constant $^{14}\text{C}$ concentration equal to that of the atmosphere in 1950 and a decay rate of $^{14}\text{C}$ based on Libby’s half-life reference (Bronk Ramsey 2008, 260). Following this, it is important to acknowledge that the laboratory measurement reflects the isotopic composition of the sample and not its “true” age. The only way to convert it to a calendar age in absolute terms is through the process of calibration (Bronk Ramsey 2008, 261–262; 2009, 341).

**Interpretation of $^{14}\text{C}$ measurements**

When used for chronological purposes, $^{14}\text{C}$ measurements must be interpreted on the basis of the current knowledge of the past environment. In this process, two main aspects have to be taken into consideration: the carbon fluctuation through time and the place of the organism (sample) in the environment (Bronk Ramsey 2008, 260). This conversion from isotopic measurement to calendar age is known as *calibration* and provides a statistical estimate for the “true” age of the sample. For this reason, once the calibration process is resolved, the $^{14}\text{C}$ dates should go
through statistical treatment in order to construct the best possible chronological model based on the currently available evidence.

**Carbon fluctuation through time: calibration curves**

It is known that $^{14}C$ ages do not directly express calendar years. As observed since the early stages of the method, the concentration and production of carbon in the atmosphere fluctuates through time (Anderson and Libby 1951; De Vries 1958; Stuiver and Suess 1966).

IntCal13 (Reimer et al. 2013) is the current internationally-agreed calibration curve for the mid-latitude northern hemisphere atmospheric reservoirs and can be applied from 0 to 50,000 cal BP. The calibration curve Marine13 (Reimer et al. 2013) is used for samples derived from any marine reservoir, from the northern or southern hemisphere, but must be applied with the available data for regional oceanic variations (see below, *Reservoir offsets*). These curves replace IntCal09 and Marine09. With some minor changes, the calibration curve IntCal13 is similar to IntCal09 from 0–12,000 cal BP, but it is slightly different between 12,000–13,900 cal BP, and it presents greater updates for the older portion of the curve between 14,000–50,000 cal BP (Reimer et al. 2013). The data available from 0 to 12,000 cal BP, and to some extent between 12,000–13,900 cal BP, is fairly robust, and later updates have not changed this portion of the calibration curve substantially (Bronk Ramsey et al. 2006; Reimer et al. 2004, 2009, 2013). Thus, the European Mesolithic chronologies can be calibrated with a high degree of confidence and resolution, and it is unlikely that the continuous revisions of the curve will affect these significantly.

The International Calibration (IntCal) curves are produced by the IntCal Working Group (IWG) and are recommended and ratified by the International Radiocarbon Conference. These provide the most comprehensive, up-to-date consensual knowledge of the past variation in $^{14}C$ (Bronk Ramsey et al. 2006; Reimer et al. 2009). Alternative curves are available and may be used, however, it is imperative to explicitly state which curve or data set has been used and to present the original uncalibrated $^{14}C$ data. In this study, the calibration curves used are IntCal13 and Marine13 (Reimer et al. 2013).

**The place of the sampled organism in the environment**

*Reservoir offsets ($\Delta R$)*

As discussed, when applying the $^{14}C$ dating method to archaeological samples it is fundamental to know the sources of $^{14}C$ for each archaeological sample. Radiocarbon data must be always interpreted in the environment context and we must identify the reservoir source(s) of the carbon present in our sample (Bronk Ramsey 2008).

A marine calibration curve must be applied in the case of organisms grown in aquatic environments or samples which indirectly, via the food chain, incorporate carbon fixed in non-terrestrial reservoirs. Such samples are depleted in $^{14}C$ and will
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present an offset in $^{14}$C age in relation to coeval material containing atmospheric carbon exclusively. Thus, if these samples are calibrated with the terrestrial curve only the dates of these specimens will appear older than their real calendar date. The Marine13 curve is the best current estimate to correct these $^{14}$C ages, but because of the large variability of marine reservoir corrections in some regions it must be applied together with the local marine reservoir offset ($\Delta R$).

A number of factors related to time and location contribute to the high variability of the $\Delta R$ parameter (Lanting and van der Plicht 1998). The $\Delta R$ varies with the size of the carbon reservoirs, and shallow lakes for example may present identical values to the atmosphere (Stuiver et al. 1986). The $\Delta R$ can also change over time depending on local factors such as latitude, sedimentary basins, upwelling regions and other oceanographic factors (Reimer et al. 2009, 1114).

Reservoir offsets in this study

The Western Atlantic coast of the Iberian Peninsula is influenced by a dynamic upwelling which strongly affects the fluctuations in the ocean reservoir offset on the western coast of Portugal during the Holocene (Monge Soares and Dias 2006). This is a marine phenomenon that occurs in the open ocean and along coastlines, when deep water rises and replaces the surface water. The upwelling activity varies through time and research has shown that coastal values of $\Delta R$ in these regions are not constant as previously suggested (Stuiver et al. 1986) and may exhibit significant variability (Monge Soares 1993; Monge Soares and Dias 2006; Monge Soares and Martins 2009; Stuiver and Braziunas 1993).

It is estimated that throughout the Holocene, the $\Delta R$ values on the Portuguese coast varied between $940 \pm 50$ to $-160 \pm 40$ $^{14}$C years (Monge Soares and Dias 2006). Wind-driven coastal upwelling is influenced by climate conditions and it has been suggested that positive high $\Delta R$ may be correlated to a strong upwelling as opposed to weak or even nonexistent upwelling denoted by low or negative $\Delta R$ values (Monge Soares and Dias 2006; Monge Soares and Martins 2009). Along a dynamic coast such as the Portuguese coast, the determination of a mean $\Delta R$ is meaningless and the archaeologist must use the determined $\Delta R$ value that is closer to the $^{14}$C age to be calibrated (Monge Soares and Martins 2009, 2881), which for this study corresponds to the time frame c. 7000 BP. Palaeo-estuarine environments such as the Tagus and Sado are also affected by the depletion of $^{14}$C relative to the concentration in the atmosphere, and the appropriate reservoir correction must be applied (table 3.3). As good practice, all adopted reservoir corrections must be clearly stated and referenced (Millard 2014; Stuiver and Polach 1977).
Table 3.3. Reference record of reservoir ages for the Portuguese coast and estuaries. *Originally published as a positive value due to a typographical error (Monge Soares pers. comm.).

<table>
<thead>
<tr>
<th>Region in Portugal</th>
<th>Time frame</th>
<th>ΔR weighted mean in 14C yrs</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>West coast</td>
<td>Modern</td>
<td>250 ± 25</td>
<td>Monge Soares and Dias 2006</td>
</tr>
<tr>
<td>West Coast of Estremadura, Alentejo and Algarve regions</td>
<td>c 7000 BP</td>
<td>95 ± 15</td>
<td>Monge Soares pers. comm.</td>
</tr>
<tr>
<td>Tagus valley (Muge, Magos)</td>
<td>c 7000 BP</td>
<td>140 ± 40</td>
<td>Martins et al. 2008</td>
</tr>
<tr>
<td>Sado valley</td>
<td>c 7000 BP</td>
<td>–100 ± 155*</td>
<td>Martins et al. 2008</td>
</tr>
</tbody>
</table>

**Dietary sources and the calibration of samples of human bone**

Collagen is the main organic component in bone and one of the most common molecular forms of carbon used in $^{14}$C dating. In archaeological contexts, the collagen in bones may be preserved for thousands of years, “particularly in cool and stable environments, and is extremely resistant to post-mortem diagenetic alteration of stable isotope ratios” (Ambrose 1993, 72). Bone collagen is formed primarily by the protein consumed by the organism. Consequently, the collagen component in the bone of a specimen will reflect the total carbon and nitrogen ingested by the organism (Ambrose and Norr 1993), so when we are dating a skeleton, what is being measured is the radiocarbon age of this dietary protein (Bayliss et al. 2004, 568). To interpret the $^{14}$C measurements of a sample of bone collagen two main aspects have to be taken into consideration: the bone collagen turnover and, most importantly, the sources of carbon which formed the sampled collagen.

The bone collagen turnover is a slow process. The rate of this turnover is not well-known, but it is estimated that complete replacement may take 10–30 years (Ambrose 1993) depending on growth and ageing of the individual. Experimental work has consistently shown that bone collagen reflects the diet of a human adult over a much longer period of time than 10 years (Hedges et al. 2007).

As discussed, the sources of carbon which formed the bone collagen in the sample can be varied. This can be a particularly complex task when analysing samples of human bone. Humans, as other omnivores, may have a very diverse diet and obtain protein foods grown in different environments. Because terrestrial and aquatic reservoirs contain different concentrations of carbon at a given moment in time, it is essential to know where the individual derives its carbon, i.e., the protein component of its diet. In this process, the reservoirs of carbon must be identified and the proportions of consumed carbon, if derived from more than one reservoir source, must be estimated (Bronk Ramsey 2008, 260). The measurements of the stable isotope ratios of carbon ($^{13}$C) and nitrogen ($^{15}$N) on bone collagen can be used to some extent to identify and estimate the sources of protein consumed by the dated individuals (Ambrose 1993; Richards and Hedges 1999). This is a fundamental step for the correct interpretation of $^{14}$C measurements because “any
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uncertainty in our knowledge of the contribution of non-terrestrial food sources compromises our ability to get good chronological resolution” (Bronk Ramsey 2008, 260). Even if there is no evidence of non-terrestrial intake, it cannot be ruled out without chemical evidence (Bronk Ramsey 2008, 261).

There is significant variation in the isotopic composition of food sources in different habitats and climates (Ambrose 1993, 85) and the diet of the individual cannot be inferred solely on the basis of its measured isotopes. One must be careful with these estimates, because, as S. Ambrose (1993, 100) has pointed out “translating the delta (δ) values into precise percentages of marine versus terrestrial resource use would be unwarranted without further information on the isotopic composition of the local food web”.

Here, for the purposes of calibration of 14C measurements on samples of human bone, I present the methodology used in this study to estimate the proportions of atmospheric and non-atmospheric sources of carbon present in each sample.

Sources of protein component in human bone collagen: calculation estimate

In this study, for the purpose of correction of radiocarbon measurements, the marine (i.e., non-atmospheric) fraction of each sample is calculated by the application of two methods, indicated as method marine 1 and method marine 2 or in a simplified form, marine 1 and marine 2 (M1, M2). All estimates were calculated by using the carbon stable isotope values of each sample ($\delta^{13}C$). Both methods assume a margin of error of ± 10%.

Method marine 1

In this method, the percentages of marine versus terrestrial resources in a diet are estimated from the $\delta^{13}C$ or $\delta^{15}N$ value of bone collagen (Ambrose 1993, 83). This method presented by Ambrose (1993) draws from pioneering work developed in the 1980s on the reconstruction of palaeo diets from stable isotopes in human skeletons (Schwarz et al. 1985; White and Schwarz 1989). It determines a value for the marine fraction needed for the correction of 14C ages, and because it requires a detailed knowledge of the local ecosystem, it may provide relatively accurate information about the diet of the individual (fig. 3.1).

\[
\% \text{ marine (±10)} = \left( \left( \frac{\text{measured value}}{\delta^{13}C \text{ or } \delta^{15}N \text{ sample}} \right) - \left( \frac{\text{estimated average value}}{\delta^{13}C \text{ or } \delta^{15}N \text{ terrestrial resources}} \right) - \left( \frac{\text{estimated value}}{\delta^{13}C \text{ or } \delta^{15}N \text{ diet-tissue fractionation factor}} \right) \right) \times 100
\]

Figure 3.1. Calculation of the percentage of marine resources in a diet, estimated from the $\delta^{13}C$ or $\delta^{15}N$ value of bone collagen. (Adapted from Ambrose 1993; Schwarz et al. 1985)
In this equation, the estimated average δ\textsuperscript{13}C value of terrestrial dietary resources is related to the type of plants, C\textsubscript{3} and/or C\textsubscript{4}, available for consumption. In the case of C\textsubscript{3} plant environments the average δ\textsuperscript{13}C value is −26.5‰ (Ambrose 1993). C\textsubscript{4} plants fix carbon with average values of −12.5‰ (Smith 1972). Likewise, this equation considers an estimated average δ\textsuperscript{13}C value of marine resources. This average value will depend on the adopted endpoint values, which in this study are −12‰ to −20‰, with an average value of −16‰ (see section, Stable isotope analysis of carbon and nitrogen). Finally, this equation also takes into account the isotope enrichment in collagen relative to that of the diet, which can be quite variable, but where terrestrial resources are of C\textsubscript{3} plants, such as in Mesolithic Europe, the estimated value is +5‰ (Ambrose 1993, 84) – diet-tissue fractionation factor. Accordingly, an individual with a measured δ\textsuperscript{13}C value of −16.9‰ will present an average of 43.8 ± 10 % of marine protein:

\[
\% \text{ marine (±10)} = \left[ \frac{(-16.9) - (-26.5) - (5)}{(-16.0) - (-26.5)} \right] \times 100 = 43.8
\]

Method marine 2

In this method, the percentages of marine versus terrestrial resources are estimated from the measured δ\textsuperscript{13}C value of bone collagen by the application of a simple linear interpolation equation (fig. 3.2) between the adopted endpoint values (Arneborg et al. 1999; Richards and Hedges 1999) (figs. 3.3, 3.4). Like the previous method, it determines an adequate value for the marine fraction needed for the correction of 14C ages, however, it is less detailed in the assessment of the individual’s place in the environment thus potentially less accurate regarding the diet of the individual. It is a practical method when the aim is the calibration of 14C ages, particularly when details of the local environment are not available.

\[
\frac{(y-y_0)}{(x-x_0)} = \frac{(y_1-x_0)}{(x_1-x_0)} \iff y = y_0 + \frac{(y_1-y_0)}{(x_1-x_0)} (x-x_0)
\]

Figure 3.2. Mathematical equation: linear interpolation between two known points. The equation is solved for \(y\) which is the unknown value at \(x\) (Meijering 2002).
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Figure 3.3. Graphic representation of the calculation of percentage of marine foods in a diet. Percentage is estimated from the $\delta^{13}$C value of bone collagen applying linear interpolation between two known points. The terrestrial endpoint ($x_0$) corresponds to 0% marine diet ($y_0$), and the marine endpoint ($x_1$) corresponds to 100% marine diet ($y_1$).

\[
\% \text{ marine} (\pm 10) = \left( \frac{\text{measured value} \ \delta^{13}\text{C}_{\text{sample}} - \text{estimated value} \ \delta^{13}\text{C}_{\text{terrestrial endpoint}}}{\text{estimated value} \ \delta^{13}\text{C}_{\text{marine endpoint}} - \text{estimated value} \ \delta^{13}\text{C}_{\text{terrestrial endpoint}}} \right) \times 100
\]

Figure 3.4. Application of linear interpolation equation for the calculation of the percentage of marine foods in a diet. Percentage is estimated from the $\delta^{13}$C value of bone collagen.

Accordingly, an individual with a measured $\delta^{13}$C value of $-16.9\permil$ will present an average of $38.8 \pm 10$ % of marine protein:

\[
% \text{ marine} (\pm 10) = \frac{([-16.9] - [-20.0])}{([-12.0] - [-20.0])} \times 100 = 38.8
\]

The linear method using $\delta^{13}$C values (method marine 2) has been criticized because while the carbon values help to identify a marine diet, it is unlikely to identify a freshwater diet, the impact of which on the real age of the sample may be significant (Cook et al. 2001). This critique can be extended to method marine 1, and when using any of these methods the significance of the $\delta^{15}$N values of each
sample must be evaluated. A more reliable approach for environments where the consumption of freshwater fish may be high – based on archaeological data, proximity to a rich riverine biome and elevated $\delta^{15}N$/low $\delta^{13}C$ – would be to apply the linear interpolation using $\delta^{15}N$ values (Cook et al. 2001, 458). In this dissertation, while every $\delta^{15}N$ value was carefully evaluated, the estimate of aquatic food intake was based on $\delta^{13}C$ values, because of the uncertainties in the knowledge about $\delta^{15}N$ trophic level variation in the regions under study, and the lack of clear indications of heavy reliance on freshwater fish (estuarine environments with influence of marine waters).

In summary, all $^{14}C$ measurements need to go through the process of calibration to convert $^{14}C$ ages into $^{14}C$ dates (i.e., calendar dates):

- In every case, an up-to-date atmospheric calibration curve must be used, such as IntCal13.
- In the case of organisms such as humans, that may derive their carbon from terrestrial and/or non-terrestrial reservoirs, an estimate of the terrestrial versus aquatic protein component of the individual's diet must be calculated, in accordance with the original living environment.
- If it is shown that the protein intake is of mixed origin, terrestrial and aquatic, an up-to-date marine calibration curve must be used, such as Marine13, and applied according to the calculated marine percentage.
- As discussed, the concentration of carbon in the atmosphere varies through time and between hemispheres. However, the concentration of carbon in aquatic habitats varies not only through time but regionally as well, depending on various local factors. Thus, the marine curve must be applied together with the local or regional reservoir offset ($\Delta R$) of the time period under study.

**Statistical treatment and modelling**

*Why modelling?*

As discussed, the concentration of $^{14}C$ in the different primary reservoirs varies over time and for this reason, all $^{14}C$ measurements must go through the process of calibration. The outcome of the calibration process is always given by a probability density function for the age of the sample (fig. 3.5) which should be handled with appropriate statistical methods in order to overcome the uncertainties introduced by the calibration process and improve the calendar precision of each $^{14}C$ date (Bronk Ramsey 2008).
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Figure 3.5. Example of a probability density function. Calculated by OxCal 4.2 (Bronk Ramsey 2009) using IntCal13 curve (Reimer et al. 2013) for the calibration of a fictitious $^{14}$C age of 7000 ± 50 BP.

The visual inspection of probability distributions is a common method for the interpretation of $^{14}$C dates. It consists of the informal interpretation of graphs or tables of calibrated $^{14}$C dates by taking their widest limits for the start and end of the dated activity (Bayliss et al. 2007). However, calibrated $^{14}$C dates are probabilistic and the visual method does not take into account the normal statistical scatter on the $^{14}$C dates. As emphasized by A. Bayliss and colleagues (2007, 5), in any set of dates of an archaeological phase part of the “probability distributions of the calibrated radiocarbon dates will lie outside – earlier or later than – the actual calendar span of that phase. If this scatter is not taken into account, then it will appear that the archaeological activity started earlier, finished later and continued for longer than was actually the case”. The visual approach can be significantly misleading because it overestimates the spread of the events, particularly when looking at a series of calibrated $^{14}$C dates (Bayliss et al. 2007, 9; Bayliss 2009, 131; Bronk Ramsey 2009, 339).

Bayesian analysis is a statistical method increasingly applied to the analysis and interpretation of calibrated $^{14}$C dates and its application has been demonstrated to be very effective in archaeological research (Bronk Ramsey 2008, 265). Bayesian statistics allows us to combine the calibrated $^{14}$C ages with the appropriate archaeological (prior) information with greater precision and to find the most probable solution (Bayliss et al. 2007). This approach, known as Bayesian chronological modelling or Bayesian statistical modelling, accounts for the inevitable statistical scatter of the $^{14}$C dates around the actual values, and establishes a statistical distribution of the group of $^{14}$C dates giving the best range of possible fits and likelihoods with probabilities
Chapter 3

Bayesian statistical modelling is a significant step towards a more exact absolute chronology because it can improve the chronological resolution of a given set of $^{14}$C dates.

The Bayesian approach

Bayesian statistics were introduced to archaeology by a series of papers published in the early 1990s (Buck et al. 1991, 1992, 1994a–b) and have been successfully implemented for the treatment of $^{14}$C data in archaeological contexts (Bayliss 2009; Bayliss and Bronk Ramsey 2004; Bayliss et al. 2007, 2011; Bronk Ramsey 2009). The strength of any statistical method for the interpretation of archaeological problems comes from a combined approach of statistical methods with the explicit use of archaeological data. Without this explicit correlation models may bias data in ways that were not intended (Bronk Ramsey 2000; Steiner and Rom 2000).

The Bayesian approach to the interpretation of calibrated $^{14}$C dates is a statistical process and it requires clear and unequivocal choices, based on contextual archaeological data, about how to model every single $^{14}$C date in the study (Bayliss et al. 2011, 38) (fig. 3.6).

![Bayes's theorem applied to archaeology](https://example.com/bayes-theorem.png)

**Figure 3.6.** Bayes’s theorem applied to archaeology. (After Bayliss 2009, 127, fig. 3).

The dates (or, the standardised likelihoods) must be contextualized in previous archaeological knowledge, here referred to as prior beliefs (Bayliss et al. 2007; Bronk Ramsey 2009). The prior beliefs (or, the archaeology) can be expressed by relative dating evidence, such as the stratigraphic sequence of the dated samples. The stratigraphic data are based on archaeological evidence, known as informative prior beliefs, and affect the output of the Bayesian chronological model strongly (Bayliss...
et al. 2007, 5, 14) (fig. 3.7). The archaeological information (or, the informative prior beliefs) must be correct or the resulting chronological estimates suggested by the model will be wrong. The validity of any chronological modelling will always depend on the archaeological interpretation of the excavated evidence. In any model, the informative prior beliefs must be explicitly defined; their reliability must be critically evaluated and alternative readings of excavation records may be discussed as well (Bayliss et al. 2007, 14, 22).

![Diagram](image)

*Figure 3.7. Example of informative prior beliefs (or, the archaeology) incorporated in a Bayesian chronological model. The stratigraphic relationships between samples are shown with the earliest at the bottom. Solid lines indicate relationships determined by excavation; dashed lines indicate relationships inferred on the basis of the $^{14}$C results. (After Meadows et al. 2007)*

The mathematical distribution for the age of the samples is also a prior belief included in the model and is known as *uninformative prior belief* (Bayliss et al. 2007, 5). In contrast to the informative prior beliefs, the mathematical assumptions about the distributions of dated events (or, the uninformative prior beliefs) “have to be grossly wrong before they are problematic for the estimation of accurate chronologies” (Bayliss et al. 2007, 22).
The posterior beliefs (or, an answer) are the outcome of the Bayesian chronological modelling. These are quantitative estimates of the dates of events based on both archaeological and statistical data. These dates are expressed as probability distributions known as posterior density estimates. The outcome of the chronological modelling may change as new data become available or as the data are modelled from different perspectives, which must always be strongly rooted in archaeological evidence. Because the posterior beliefs are interpretative estimates, and are not absolute, the posterior density estimates should be given in italics (Bayliss et al. 2007).

**OxCal**

The calibration of $^{14}$C measurements is normally done with specific developed software. There is a range of user friendly freeware available, such as BCal (Buck et al. 1999), CALIB (Stuiver and Reimer 1993), CalPal (Weninger and Jöris 2008), and OxCal (Bronk Ramsey 2009), among others.

OxCal is one of the most widely used calibration programs. It is versatile, continuously updated and is available in both online and downloadable versions. OxCal can be used as a simple calibration program or to build rigorous chronological models of all kinds, from simple to very complex (Bronk Ramsey 1995, 425–6; 1998, 461). The Bayesian statistics for the analysis of $^{14}$C dates (Buck et al. 1992) have been incorporated in OxCal since its first release (Bronk Ramsey 1995). OxCal (Bronk Ramsey 1995, 2009) is the software used for the calibration, statistical treatment and modelling of all $^{14}$C measurements used in this dissertation. In this section, I highlight some of the most relevant functions for the data set under analysis. For a complete set of analysis operations, models and other options consult OxCal 4.2 Manual (Bronk Ramsey 2015).

In OxCal, one of the most useful and simplest ways to deal with a set of dates is to group them in a phase model. This is also the most common way of grouping dates in OxCal and should not be confused with the archaeological sense of the term phase. In OxCal, a phase means a group of elements for which there are no fixed relations (Bronk Ramsey 1995, 426) which imposes no internal constraints (Bronk Ramsey 1998, 463). The phase model is useful when the relative chronology of the dated elements is unknown. In OxCal, a phase model can be expressed in code view (Bronk Ramsey 2015) as the following:

```plaintext
Sequence()
{
  Boundary(“Start”);
  Phase()
  {
    R_Date(“A”,8050,25);
    R_Date(“B”,7980,30);
    R_Date(“C”,8020,25);
    R_Date(“D”,8000,25);
  };
  Boundary(“End”);
};
```
The *sequence model* should be used if the relative chronology of the group of dated elements is known. This is the second most useful grouping in OxCal and differs from the phase model because it constrains the group of dated elements within it, to be in a given chronological order (Bronk Ramsey 1995, 426, 1998, 463), which must be based on explicit archaeological evidence. In the sequence model it is assumed that A is older than B which is older than C which is older than D; and it can be expressed in code view (Bronk Ramsey 2015) as the following:

```c
Sequence()
{
    Boundary("Start");
    {
    R_Date("A",8050,25);
    R_Date("B",7980,30);
    R_Date("C",8020,25);
    R_Date("D",8000,25);
    }
    Boundary("End");
}
```

In both phase and sequence models, the $^{14}$C dates under analysis are framed by two undated events: a start event and an end event. In OxCal these events are termed *boundaries* (Bronk Ramsey 2000, 199). Boundaries are date estimates which have not been dated directly by $^{14}$C measurements and are calculated by OxCal from the dated events of the series. Boundaries do not depend on any particular $^{14}$C date, but on the whole assemblage of considered dates. Boundary events should be always included when modelling a discrete group of events. This is important because, in practice, archaeological events are not truly independent but related in some way over a limited time span, rather than in an infinite timescale. The introduction of boundaries in a model is a way to make the events relate statistically to each other. C. Bronk Ramsey (2001, 357) has made this point very clear when stating that “models without boundaries will tend to bias to spans which are too long and so, although for small numbers of events it usually makes little difference, they should really be included in almost any model”. Often, however, the use of boundaries in the analysis will have little effect in the outcome of the model, because the dates are often well resolved and not very high in number (Bronk Ramsey 2000, 201).

The OxCal program is flexible and each of these phase or sequence groups can admit many other possibilities, containing other sequences or phases (Bronk Ramsey 1995, 426, 1998, 463), and more or less complex Bayesian chronological models can be explicitly defined this way (Bronk Ramsey 2009, 2015).

Once the model is defined in OxCal, the program calculates the probability distributions of the individual calibrated $^{14}$C results (Stuiver and Reimer 1993), after which it relates the distributions with the prior information (i.e., our prior archaeological information). This process produces posterior density estimates for
the calendar age of each sample, which typically occupies part of the calibrated probability distribution (Bayliss et al. 2007, 6) (fig. 3.8).

Figure 3.8. Example of a posterior density estimate which occupies part of the calibrated probability distribution. Calculated by OxCal 4.2 (Bronk Ramsey 2009) using IntCal13 curve (Reimer et al. 2013) for the calibration of a fictitious 14C age of 7000 ± 50 BP in a fictitious phase model.

OxCal allows the analysis of phases and sequences, and of more complex relations such as the definition of time boundaries and limits, such as the probability distribution for the dates of the earliest (terminus post quem) and last events (terminus ante quem) (Bronk Ramsey 1995, 426). The program can also generate a probability distribution for the time difference between any two events (Bronk Ramsey 1995, 426, 2015). With OxCal it is also possible to combine a number of 14C dates available for one same entity into one probability distribution (Bronk Ramsey 1995, 426). The graphical output is another advantage of OxCal, as it shows the details imposed in the model allowing the reproducibility of the results by others (Bronk Ramsey 1995, 430).

Reliability and stability of the models
While the complexity of a society cannot be represented by any model, these are tremendously useful to make sense of reality. For this reason, and for the power of interpretation they may have, we must make sure that we are not imposing a model which is inconsistent with the dating evidence. Every model must be checked for reliability and stability.
Statistical criteria

Two main statistical criteria produced by OxCal can be used for reliability and consistency testing both on the model as a whole and on individual elements: the index of agreement ($A$) and convergence (Bronk Ramsey 1995). These criteria allow the user to test and select the most appropriate and reliable chronological model (Bayliss et al. 2007, 6; Bronk Ramsey 1995, 428). These agreement indices of OxCal will highlight cases where the prior model is inconsistent with the data (Bronk Ramsey 2000, 201).

The index of agreement ($A$) is related to the standardised likelihoods (the dates) and it expresses how well any posterior distribution (the modelled dates) agrees with the prior distribution (Bronk Ramsey 1995, 429). Always, for each dated element, an agreement index $A$ is calculated, which has a value of ≥ 100% but can be sometimes higher or fall as low as 60% (Bronk Ramsey 1995, 427). The index of agreement is high (≥ 60%) when the posterior distribution is situated in a high-probability region of the prior distribution. If the index of agreement is low (< 60%) it means that the posterior distribution falls in a low-probability region and the result is regarded problematic (Bronk Ramsey 1995, 429). This may indicate the presence of a statistical outlier, although a very low index of agreement may suggest that a sample is residual or intrusive.

The overall index of agreement ($A_{overall}$) is calculated for the model as a whole from the individual agreement indices (Bronk Ramsey 1995, 429) and provides a measure of the consistency between the prior information and the $^{14}$C results. The overall index of agreement is typically ≥ 100% with a threshold value of 60%, and models which produce values lower than this should be subject to critical re-examination (Bayliss et al. 2007, 6; Bronk Ramsey 1995, 429).

The index of convergence is the second criterion that must be checked. The convergence index indicates how quickly the sampler algorithm (Markov chain Monte Carlo, MCMC) is able to produce a representative and stable solution to the model (see Bronk Ramsey 1995, 429). In practice, a model is unstable when the convergence is poor (< 95%) and the results should not be used (Bronk Ramsey 1995, 429). In such case the sampling procedure can be examined in more detail to determine whether particular parts of the model are unstable.

Sensitivity analysis: prior beliefs and standardised likelihoods

Always when the data allows, it is advantageous to suggest and provide alternative chronological models. These comparisons of alternative models are known as sensitivity analyses because they measure the sensitivity of our estimates to different models (Bayliss et al. 2007, 7). Sensitivity analyses are useful because they allow us to argue for the reliability of the preferred model (Bayliss 2009, 134; Bayliss and Whittle 2007) and identify which elements of the model are vulnerable to incorrect information (Bayliss et al. 2007, 22).
In a sensitivity analysis, alternative models may explore different readings of the archaeological data (prior beliefs) and/or examine the robustness of the $^{14}$C measurements and any calibration data required (standardised likelihoods).

Archaeological evidence (prior beliefs) can be used to analyse and compare a range of statistically plausible models by incorporating different archaeological interpretations (different priors), to determine whether they provide similar estimates or not; if the results of the different models are similar it demonstrates that the conclusions are insensitive to the priors (Bayliss et al. 2007; Bronk Ramsey 2000, 201).

The standardised likelihoods (i.e., $^{14}$C measurements, calibration data) may also be assessed to test the validity of a model. In this case we may want to examine the effect of varying the calibration data (e.g., reservoir offsets) on the outcome of the chronological model (Bayliss et al. 2007, 17–8).

**Calibration and modelling in this study**

In this study, all chronological models are defined by a Bayesian approach to the analysis and interpretation of $^{14}$C measurements in archaeological contexts (fig. 3.6).

The standardised likelihoods (the dates) consist of 46 $^{14}$C dates on human bone: 30 from new measurements and 16 previously published (45 individuals). The atmospheric calibration curve used is IntCal13 (Reimer et al. 2013). The proportion of aquatic protein intake was estimated from the measured $\delta^{13}$C value of each sample by the application of two methods explicitly indicated in each case as marine 1 (Ambrose 1993) and marine 2 (Arneborg et al. 1999; Richards and Hedges 1999). The adopted endpoint values for marine (100%) and terrestrial (100%) diets are $-12\%$ to $-20\%$ respectively. Samples with mixed diet were calibrated using Marine13 curve (Reimer et al. 2013) and regional $\Delta R$ accordingly; $\Delta R = 140 \pm 40$ $^{14}$C yrs BP for the Tagus valley and $\Delta R = -100 \pm 155$ $^{14}$C yrs BP for the Sado valley (table 3.3).

The prior beliefs (the archaeology) are based on a critical review of the archaeological data in archive documentation and published literature. Stratigraphic relations of the dated material were retrieved from field notes, graphic documentation such as drawings and site plans, and published data. The archaeological priors from the historical excavations are limited and the modelling is therefore constrained to the available evidence. Because of this limitation, the Bayesian model is defined by simply incorporating the information that the dates derive from a coherent archaeological activity. Despite the limitations, the application of the method allows the estimate of posterior densities of the radiocarbon measurements, which are more precise than the date estimates (see Bayliss 2009, 127, 131).

The models are outlined in OxCal 4.2 (Bronk Ramsey 2009) which provides the posterior beliefs for each model and event.

For this study, the most suitable kind of model is the site-based model. These are robust models, potentially providing good chronological resolution enabling regional comparisons as well (Bronk Ramsey 2013, 34). In this study, all models are
defined as phase models with two boundaries for the start and end of activity. As discussed, this is a useful approach when we do not have explicit archaeological data indicating a clear order of a group of elements (Bronk Ramsey 1995). The phase model simply assumes that the start boundary event occurs before the dated events, and that these occur before the end boundary event. With a phase grouping of elements such as this, it is assumed that the dated events belong to the burial activity in the site, but no particular constraints or fixed relations are assumed or imposed. The reliability of this approach comes from the fact that each sample corresponds to a burial event which is part of the burial activity at the site. Following C. Bronk Ramsey (1998, 462, 2015) “failure to do this will mean that the events are assumed to be entirely independent apart from the constraint applied. To use no model at all is in fact to assume that all of the events are truly independent; this is in effort a model in itself, and in many cases a very unreasonable one”. Each model is presented in detail in chapter 4.

**Limits of current standardised likelihoods**

Calibration and modelling in this study relies on a set of informed assumptions. These are the estimated aquatic protein intake values, the adopted endpoint values for marine (100%) and terrestrial (100%) diets, and the regional ΔR.

**Estimated aquatic protein intake**

The marine (i.e., non-atmospheric) fraction of each sample was calculated by the application of two methods (see above, *Sources of protein component in human bone collagen: calculation estimate*). The values are slightly different in some cases but show agreement on the overall impression of the main source of protein in the diet of each individual. To determine if these differences would have an impact in the outcome of the chronological interpretation, the models were run independently with the values calculated with methods marine 1 and 2. In every case, the results were similar, demonstrating the robustness of the estimates.

**Endpoint values**

The knowledge of the regional endpoint values for marine (100%) and terrestrial (100%) diet requires an in-depth study of the local ecosystem of food chains at the time the shell middens were in use. In the absence of such studies, the adopted endpoint values are –12‰ to –20‰ (see section, *Stable isotope analysis of carbon and nitrogen*). These values may change slightly with further comprehensive studies of the regional ecosystems. Nevertheless, this should have little impact on the chronological interpretation of the sites. While R. Hedges (2004) pointed out that 1‰ change in the terrestrial endpoint corresponds to c 10% change in the estimate of marine protein, experimental work has shown that the exact choice of endpoints should not appreciably change the calibrated ages (Arneborg et al. 1999, 159).
In this study, the human remains were calibrated according to the ΔR of the region where they were buried. This approach assumes that the place of burial and the location(s) where the aquatic foods were collected were in the same region, within the same ΔR. However, this may not be the case. Aquatic foods, such as fish, could have been captured in other locations, such as by the coast, carrying a different reservoir offset (table 3.3). Thus, some individuals may have consumed foods from various aquatic offsets, marine (ΔRCoast = 95 ± 15) and estuarine (ΔRTagus = 140 ± 40; ΔRSado = -100 ± 155). However, the ΔR values are not significantly different and few individuals derive their isotopes from the intake of 50% or more of marine-estuarine foods (see chapter 4).

Sensitivity analysis of regional reservoir offsets
To examine the impact of the different regional ΔR values in the outcome of the chronological models I tested the calibration of a fictitious 14C date of 7000 ± 50 BP with an assumed marine/estuarine diet of 50 ± 10%. The calibrated date ranges are identical (fig. 3.9). When calibrated with the coastal ΔR the range is 5990–5761 cal BCE (95% confidence), which is identical when calibrated with any of the estuarine ΔR values, 5990–5762 cal BCE (95% confidence).

The sensitivity analysis shows that varying the relevant reservoir offsets (marine, estuarine) does not affect the outcome of the calibrated dates and posterior density estimates. The analysis shows that we can be confident about the calibration of human bone collagen from the Tagus and Sado valleys, even when the aquatic reservoirs may be unclear.
Figure 3.9. Sensitivity analysis of reservoir offsets. A fictitious $^{14}$C age of 7000 ± 50 BP was calibrated with three reservoir offsets ($\Delta R_{\text{Coast}} = 95 \pm 15$; $\Delta R_{\text{Tagus}} = 140 \pm 40$; $\Delta R_{\text{Sado}} = -100 \pm 155$) but presents identical calibrated date ranges. Sensitivity analysis of the reservoir offsets shows no significant effect on the outcome of the calibrated date ranges. Calculated by OxCal 4.2 (Bronk Ramsey 2009) using IntCal13 curve (Reimer et al. 2013).
Selection and screening of samples in this study

Nature and context
Articulated bones in archaeological contexts are among the most reliable category of samples for $^{14}$C dating (Bayliss et al. 2011, 38). In this dissertation, the articulated human skeleton was the targeted sample which dates the event that is of interest in this research: the practice of burying human remains. In this dissertation, only samples of \textit{Homo sapiens} bone in recorded archaeological context were selected and considered for the construction of chronological models of burial activity. The selection of samples of this nature ensures a direct relationship between the sample and the human activity of interest, otherwise difficult to establish, particularly when studying archaeological material from historical excavations. The selection follows the single-entity sampling approach (Ashmore 1999) and each $^{14}$C date comes from a bone sample from a single individual. This approach ensures that each $^{14}$C date estimates the time of death of the individual and dates the burial event within the period of burial activity at the site (Bayliss et al. 2011).

Contamination
Contamination of the sample is another important factor to take into consideration when choosing a sample for $^{14}$C dating because contamination of a sample may result in an erroneous date (Bayliss et al. 2011, 38; Brock and Dec 2013, 45). This is a significant issue in the archaeological material under study in the scope of this dissertation. Several human burials excavated from the nineteenth century to the 1960s in the shell middens of the Tagus and Sado valleys were covered with paraffin wax in order to maintain their original position or have been treated with a binding product to avoid the collapse of fragile bone elements. These substances cover not only the surface of the bones but often penetrate through the bone. Despite the rigorous selection to avoid contamination, 14 out of 52 samples selected in the scope of the radiocarbon dating programme were rejected after pre-treatment while 7 out of 52 samples did not yield enough collagen for reliable measurements (see below, Reliability of the isotopic measurements; chapter 4).

In the laboratory: pre-treatment and measurement of samples in this study
All samples selected in the course of this dissertation’s radiocarbon dating programme were processed by the Tandem Laboratory at the Department of Physics and Astronomy, Uppsala University, in 2013 and 2014, and are identified as Ua–number. $^{14}$C measurements were done using accelerator mass spectrometry (AMS) and the stable isotopes $^{13}$C and $^{15}$N were measured by EA-CF-IRMS (Elemental Analyzer Continuous Flow IRMS). The samples were pre-treated following the HCl method as reported by the laboratory:

1. The surface is mechanically cleaned (scraping, in some cases sand blasting).
2. The sample is ultrasonically cleaned in boiled distilled water, pH=3.
4. 0.8M HCl is added, stirring at 10°C for 30 minutes (apatite removed). Soluble fraction is named fraction A.
5. Distilled water kept at pH=3 is added to the insoluble fraction, which is stirred for 6–8 hours at 90°C. Insoluble part is named fraction C and soluble part is named fraction D. Fraction D should give the most relevant age, since it contains most of the organic parts (the “collagen”) of the original bone. However, information on the influence of contaminants could be obtained from the other fractions. In critical cases they should preferably be dated as well. The quality of the bone (and the reliability of the age) could be judged by the chemical yields in the different stages of preparation. The fraction to be $^{14}$C-dated is combusted to CO$_2$ and then converted to graphite using a Fe-catalyst reaction. The age of fraction D has been measured in the present investigation.
6. Fourteen samples were pre-treated with boiling in acetone, ultrasonification first with ether and then with ethanol, and finally filtrated; after that, processed as usual (5.).

Reliability of the isotopic measurements

Quality parameters
Collagen can be extremely resistant to post-mortem alterations (Ambrose 1993, 72), thus reflecting the isotopic signal that would have been measured in vivo. However, the preservation of collagen in human bone is dependent on factors such as temperature, extremes of pH, the presence of organic acids, and so forth (Pollard et al. 2007, 21), and can vary greatly within archaeological sites. Degradation (diagenetic alteration) and contamination (presence of exogenous substances) of the bone can significantly compromise the validity of the $^{14}$C measurements and other chemical analysis. A set of parameters can be considered to evaluate the sample quality and reliability of the measurements: chemical indicators, elemental data and stable isotopic ratios of nitrogen and carbon (van Klinken 1999). However, a single quality parameter may be insufficient on its own to clearly indicate contamination or degradation of the sample and should be used in combination with other quality parameter checks (van Klinken 1999). The screening of sample quality is normally done in the $^{14}$C laboratory. Nonetheless, the archaeologist should have a basic knowledge of the acceptance ranges for each of the indicators, for each type of sample, in order to critically assess the data received from the laboratory and evaluate the validity of the results.

Chemical indicators: one of the chemical indicators for bone collagen extracts is the collagen yield (expressed as weight percentage, wt %). Modern fresh bone has c 22 wt % collagen but it drops steadily after burial (van Klinken 1999). Well-preserved prehistoric bone should have more than 1 wt % collagen (Ambrose 1993, 75; van Klinken 1999, 689). Samples with values ranging between 0.5 to
and 2 wt % should be checked with other parameter to confirm the integrity of the sample (van Klinken 1999).

**Elemental data:** The degree of preservation of collagen is indicated by the atomic carbon and nitrogen ratios (C:N) measured for each sample (DeNiro 1985; Ambrose 1993). Experimental work has shown that collagen C:N ratios between 2.9 and 3.6 indicate minor post-mortem alterations (DeNiro 1985), and this indicator can be used as one of the parameters to assess the quality of the chemical measurements of a sample (van Klinken 1999). C:N ratios between the 3.4 and 3.6 range may indicate some contamination, by lipids, carbonates, humic acids or other carbon-rich substances (Ambrose 1993). Van Klinken (1999) recommended that the C:N parameter should be used with other indicators because in some cases it may be insufficient on its own, and proposed a slightly different range between 2.7 and 3.3 (van Klinken et al. 2000).

**Stable isotopic ratios of nitrogen and carbon:** $\delta^{13}C$ and $\delta^{15}N$ values can be used for quality checks. Out of range values are of concern and should be evaluated in combination with other quality parameters before accepting or discarding the sample. Values between $-22$ to and over $-24\%$ for $\delta^{13}C$ may indicate degradation and/or contamination of the sample. $\delta^{15}N$ values for quality checks are more limited and only meaningful when combined with the local trophic level values (van Klinken 1999; van Klinken et al. 2000).

Following this, contaminated or low-collagen samples are expected to have:
- variable, but mostly higher C:N ratios;
- variable, but mostly more negative $\delta^{13}C$;
- mostly, more positive $\delta^{15}N$ values, in the case of low-collagen samples (Ambrose 1990; DeNiro and Hastorf 1985; van Klinken 1999).

The usefulness of some of these parameters will vary with the laboratory procedures which the archaeologist should be aware of. In the case of the samples measured in the scope of this study (Ua–number) the parameter collagen yield was not provided by the laboratory because this indicator is not used as a measure of bone quality. In this case, the atomic carbon and nitrogen ratios (C:N), and $\delta^{13}C$ and $\delta^{15}N$ values can be used for quality checks.

$\delta^{13}C$ values: AMS or IRSM

It is important to be clear whether the $\delta^{13}C$ values were obtained by accelerator mass spectrometry (AMS) during the process of $^{14}C$ measurement or independently by isotope-ratio mass spectrometry (IRMS). In the case of previously published measurements, if the method is not explicit, it is prudent to confirm with the correspondent author or with the laboratory.

The $\delta^{13}C$ values associated with the dating process are normally offset from the values obtained by an IRMS instrument (Schulting and Richards 2001, 320; Taylor and Bar-Yosef 2014, 117). The offset is variable and although the AMS- and IRMS-based values may be highly correlated (Schulting and Richards 2001, 320) with an average offset lower than 2\%, it can be as high as 10\% (Taylor and Bar-
Methods: Radiocarbon dating and Bayesian analysis

Yosef 2014, 117). For this reason, only IRMS-based $\delta^{13}C$ values can be used for dietary reconstructions or other isotopic-based environmental analysis such as reservoir corrections (Millard 2014, 557; Taylor and Bar-Yosef 2014, 117).

Screening of samples in this study

Each measurement was screened based on the acceptance ranges of the atomic ratio of carbon and nitrogen (C:N) in combination with the stable isotopic ratios of nitrogen and carbon ($\delta^{13}C$, $\delta^{15}N$). Samples with C:N ratios outside the 2.9–3.6 range have been discarded as well as samples within the 3.4–3.6 range combined with an out of range $\delta^{13}C$ and/or $\delta^{15}N$ value (table A1).

Each $\delta^{13}C$ value was checked and in every case it is indicated whether the values were obtained by AMS or IRMS. Most $\delta^{13}C$ values measured from human bone collagen were obtained by IRMS, however, in some cases, the $\delta^{13}C$ values reported and published alongside the $^{14}C$ ages were obtained on an AMS instrument (table 3.4), and this can be outlined as follows:

- All $\delta^{13}C$ values obtained for the radiocarbon programme in the course of this study (Ua–number) were measured by EA-CF-IRMS (Elemental Analyzer Continuous Flow IRMS).
- All $\delta^{13}C$ values published by Jackes et al. 2014; Lubell and Jackes 1985, 1988; Meiklejohn et al. 1986; Roksandic 2006; , are IRMS-based values obtained independently from the dating process (Mary Jackes, pers. comm.; Lubell et al. 1994).
- All $\delta^{13}C$ values obtained for dietary studies (Fontanals-Coll et al. 2014; Guiry et al. 2015; Umbelino 2006) are IRMS-based values.
- All $\delta^{13}C$ values published by Cunha and Cardoso 2002–03; Cunha and Umbelino 2001; Cunha et al. 2003, are AMS-based values associated with the dating process (Cláudia Umbelino, pers. comm.) which cannot be used for dietary studies or reservoir corrections. When possible, these $^{14}C$ measurements were corrected with recent IRMS-based $\delta^{13}C$ values obtained for the same individual (table 3.4). The calibration of $^{14}C$ ages for which there are no IRMS-based $\delta^{13}C$ values is problematic and may be significantly misleading, particularly in the case of complex estuarine environments such as the sites under study. Thus, all $^{14}C$ measurements from individuals without IRMS-based $\delta^{13}C$ values are excluded until these values are obtained.
- The excluded measurements and corresponding AMS-based $\delta^{13}C$ values are discussed in chapter 5 in comparison with the isotopic series available for each site.

Following the selection criteria for retaining or rejecting determinations, the $^{14}C$ data set of this study comprises 46 $^{14}C$ dates on human bone: 30 from new measurements and 16 previously published (45 individuals). This data set comprises all reliable $^{14}C$ dates on human bone collagen for the sites of Moita do Sebastião and
Chapter 3

Cabeço da Arruda at the Tagus valley, and Arapouco, Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez and Várzea da Mó at the Sado valley.
Table 3.4. Measurements of problematic calibration from samples on human bone collagen. $\delta^{13}C$ values reported and published alongside the $^{14}C$ ages were obtained on an AMS instrument.

<table>
<thead>
<tr>
<th>Valley</th>
<th>Site</th>
<th>Identification of the human remains</th>
<th>Measurements $^{14}C$ and $\delta^{13}C$ by AMS</th>
<th>Reference</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tagus</td>
<td>Mota do Sebastião</td>
<td>16 1952–54 MHNUP</td>
<td>Beta–127499 7120±40 −16.8</td>
<td>Cunha and Cardoso 2002–03; Cunha et al. 2003</td>
<td>Excluded until IRMS values are available.</td>
</tr>
<tr>
<td>Tagus</td>
<td>Cabeço da Arruda</td>
<td>6 1937 MHNUP</td>
<td>Beta–127451 7550±100 −19.0</td>
<td>Cunha and Cardoso 2002–03; Cunha et al. 2003</td>
<td>Combined (OxCal, R_Combine) with new AMS $^{14}C$ date (Jackes and Lubell 2014) and respective IRMS–based $\delta^{13}C$ value.</td>
</tr>
<tr>
<td>Sado</td>
<td>Arapouco</td>
<td>2A 1962 MNA</td>
<td>Sac–1560 7200±130 −16.9</td>
<td>Cunha and Umbelino 2001; Umbelino 2006</td>
<td>Calibrated with recent IRMS–based $\delta^{13}C$ value (−17.2) obtained by Guiry et al. 2015.</td>
</tr>
<tr>
<td>Sado</td>
<td>Cabeço das Amoreiras</td>
<td>5 1958 MNA</td>
<td>Beta–125110 7230±40 −20.8</td>
<td>Cunha and Umbelino 2001</td>
<td>Calibrated with recent IRMS–based $\delta^{13}C$ value (−19.0) obtained by Fontanals-Coll et al. 2014.</td>
</tr>
<tr>
<td>Sado</td>
<td>Cabeço do Pez</td>
<td>4 1956 MNA</td>
<td>Beta–125109 6760±40 −22.6</td>
<td>Cunha and Umbelino 2001</td>
<td>Excluded until IRMS values are available.</td>
</tr>
<tr>
<td>Sado</td>
<td>Cabeço do Pez</td>
<td>4 1956 MNA</td>
<td>Sac–1558 6740±110 −19.3</td>
<td>Cunha and Umbelino 2001</td>
<td>Excluded until IRMS values are available.</td>
</tr>
</tbody>
</table>
Stable isotope analysis of carbon and nitrogen

Introduction

Burial analysis and past human diets

Human food choices are culturally defined in an environmental framework, with dietary patterns being highly dependent on ecological constraints, particularly in the case of past populations. In this sense, ethnographic data is revealing by showing a systematic relation between hunter-gatherer diets and their environment (Kelly 2013). Subsistence studies have been a central subject in the anthropology of hunter-gatherers, however the ethnographic methods used to estimate the foods consumed are often vague and inconsistent, and in many cases stereotyped (Kelly 2013, 40–44). Direct analysis of human remains is a reliable approach to overcome these biases. Stable isotope analysis of human remains in archaeological context is a scientific method widely used for assessing past dietary patterns (see Makarewicz and Sealy 2015). The method of dietary analysis works from the observation that the isotopic composition of human tissue, such as bone collagen or tooth enamel, largely reflects that of dietary protein (Ambrose and Norr 1993; DeNiro 1985). Additionally, the method recognizes that classes of dietary resources (i.e., plants, omnivores and carnivores) have characteristically different isotopic ratios (Ambrose 1993; DeNiro 1985), and present a systematic difference between the isotopic composition of the consumer and the ingested food resource (i.e., fractionation factor) (Ambrose 1993).

The comparative analysis of dietary patterns can reveal social aspects of the lifeways of hunter-gatherers. This is highly relevant for archaeological research because it offers a tool to discuss past relations to food at various levels, such as gender and age, group identity, and differential access to food resources. In the scope of this dissertation, centred on the mortuary practices of the last hunter-gatherers of the Tagus and Sado valleys, the analysis of dietary patterns is aimed at identifying and comparing intra- and inter-site variation at the isotopic scale of each individual in each burial place. In this framework, the method of dietary analysis is applied to identify broad patterns in terms of the main sources of protein intake which can be outlined as follows:

• to identify trends in terms of sources of protein in the diet, in each valley in general and in each site in particular;
• to identify synchronic and diachronic dietary patterns;
• to discuss homogeneity and/or heterogeneity of the isotopic signatures of each burial ground and each valley.
In this dissertation, I aim to discuss some aspects on which isotopic data can be particularly informative in terms of mortuary practices. Individual isotopic signatures may clarify whether the burial grounds are places of funerary activity for one or various dietary groups; bearing in mind that a group may comprise several sub-dietary groups defined by gender, age, or status. The following hypotheses are possible:

1. One dietary group uses these sites to bury their dead.
2. More than one dietary group uses these sites to bury their dead.
   a. Each group uses one main burial place (i.e., one group per site).
   b. Each group uses various burial places (i.e., more than one group at each site).

Also, in the light of the funerary activity and based on the isotopic data, I will discuss briefly whether the isotopic signatures reflect the ecology of the burial places, or rather the ecology from elsewhere, taking into account the current state of research and insufficient environmental data. How local are the deceased buried in these sites?

The first study applying isotopic evidence from the human remains recovered in the Portuguese shell middens was centred on the Mesolithic-Neolithic transition (Lubell et al. 1994). D. Lubell and colleagues (1994) compared the isotopic profiles from the Muge Mesolithic with those obtained from Neolithic sites in Portugal. This pioneering study indicated a decrease of marine foods in the diet as well as a decrease in diversity of food choices through time, suggesting a significant shift in dietary patterns from the Mesolithic to the Neolithic, characterized by the intensification of terrestrial sources and increased homogeneity of food choices towards the Neolithic (Lubell et al. 1994). A more in-depth study on Mesolithic and Neolithic palaeodiet from Portuguese sites, based on the analysis of trace elements and stable isotopes, confirmed the pattern of Mesolithic heterogeneity based on a mixed diet obtained from marine and terrestrial sources (Umbelino 2006; Umbelino et al. 2007). Latest studies centred in the Sado valley assemblages once again confirmed the regional heterogeneity already known for the Mesolithic. With a larger data set and greater resolution, these studies were able to show significant inter-site variability, indicating that the heterogeneity found in Mesolithic diets may derive from the differences found between different groups (Fontanals-Coll et al. 2014; Guiry et al. 2015). This suggestion, already hypothesised by J. Martins and colleagues (2008, 83), contradicts the seasonal model for the settlement pattern proposed for the Sado valley (Arnaud 1989), which suggested that most of the population living in the valley moved seasonally between large basecamps while making short incursions to smaller temporary camps for specialized activities. While the seasonal scenario may admit heterogeneity at the individual level, which could be explained by differential access to food sources depending on gender, age or status; it does not account for significant inter-site variability, because in such model the sites were presumably seasonally used by the same people.
New stable isotope data of carbon and nitrogen were obtained in the course of this dissertation in order to further test these scenarios along with higher chronological resolution. The selection of human bone collagen samples was fully dependent on the goals of the radiocarbon dating programme which are described in detail for each archaeological site in chapter 4.

**This section**

The section *Stable isotope analysis of carbon and nitrogen* presents a brief overview of the main principles of dietary analysis and interpretation of isotopic measurements of carbon and nitrogen, making explicit the set of informed assumptions used in this dissertation in the interpretation of human bone collagen measurements of $\delta^{13}C$ and $\delta^{15}N$.

Like the previous section *Radiocarbon dating method and Bayesian analysis*, this methodological review is written from the perspective of the analysis of unburnt prehistoric human bone in Holocene archaeological contexts in the temperate zone of the northern hemisphere, concerning south-western Europe in particular, and for this reason, issues relevant to other archaeological contexts may not have been addressed. This is the case, for example, for contexts in environments of C$_4$ pathway plants (e.g., maize, millet) which were not available in Mesolithic Europe. Other stable isotopes of elements such as hydrogen, oxygen, sulphur, or strontium, are also of interest for palaeodietary and palaeoenvironmental reconstruction, but are not discussed in the scope of this study.

The results of the isotope measurements of carbon and nitrogen are presented by archaeological site in chapter 4 and plotted with previously published data. In chapter 5 the isotopic data is analysed and contextualized from the perspective of funerary practices.

**Terminology and conventions**

Carbon–12 ($^{12}$C), carbon–13 ($^{13}$C), nitrogen–14 ($^{14}$N), and nitrogen–15 ($^{15}$N) are the natural isotopic variants of carbon and nitrogen, and can be used as tracers in biological systems because they do not decay over time (Pollard et al. 2007). The variation of stable isotopes in the environment and food chains is usually very small. For this reason, the measurement of their abundances involves measurement of the ratio of the heavier to the lighter isotope, with references to the ratio of a standard reference material: Vienna Pee Dee Belemnite (VPDB) for $^{13}$C, and atmospheric N$_2$ (AIR) for $^{15}$N ratios (see e.g., Mays 2010, 266; Tykot 2006, 132). Thus, the measured isotope ratios of a given sample are expressed as delta ($\delta$) units in parts per thousand (permil: ‰) (Ambrose 1993, 65; Mays 2010, 266). The $\delta^{13}$C values are always negative numbers, because they represent less $^{13}$C than in the reference standard while the $\delta^{15}$N values are always positive numbers because most food resources have more $^{15}$N than the standard (Ambrose 1993, 65). In this dissertation, the isotopic measurements are presented rounded to one decimal place.

In this study, the analysis of intra- and inter-site variability of isotopic signatures is based on the measure of standard deviation (SD) which quantifies the dispersion
Methods: Stable isotope analysis of carbon and nitrogen

of a set of data values (VanPool and Leonard 2011). Variation is considered small when SD is equal or lower than 0.5‰, moderately high when it is equal or higher than 1.0‰, and high when equal or higher than 1.5‰ (chapters 4 and 5).

Principles of dietary reconstruction based on the isotopes of carbon and nitrogen

The method is based on the principle that carbon and nitrogen ratios (\(^{13}\text{C}/^{12}\text{C}\) and \(^{15}\text{N}/^{14}\text{N}\)) will reflect those of the food resources, adjusted for the fractionation factor related to the relationship between trophic level and isotopic value of foods and consumers (Ambrose 1993; Pollard et al. 2007, 182). Since the range of stable isotope values in a variety of food resources is known, the measurements of \(\delta^{13}\text{C}\) and \(\delta^{15}\text{N}\) in human bone collagen will reflect which foods were consumed by the individual (Schulting and Richards 2002, 153). Overall, the \(\delta^{13}\text{C}\) values measured from human bone collagen samples will give an indication of the proportion of protein derived from terrestrial and/or marine food sources, while the \(\delta^{15}\text{N}\) values varying according to the trophic level will indicate the position in the food chain of the protein foods consumed (Ambrose 1993; Ambrose and Norr 1993).

Knowledge of the past environment

For an accurate assessment and interpretation of the isotopic values obtained from the human samples it is important to establish the stable isotope ecology of the region (see Eriksson et al. 2008), because environmental factors can influence isotopic variations (Hedges et al. 2004; van Klinken et al. 1994, 2000). This can be achieved through the robust sampling and analysis of contemporary assemblages of archaeological fauna species in order to characterize the extent of the isotopic variation in the region and in the foods consumed (Eriksson et al. 2008; Hedges and Reynard 2007; Makarewicz and Sealy 2015). This type of analysis is yet to be done in the Tagus and Sado valleys and without specific isotopic faunal data from these regions we have to rely on studies done for other regions in Europe.

Variation of \(\delta^{13}\text{C}\)

The endpoint value normally assumed for archaeological human bone collagen \(\delta^{13}\text{C}\) values from the European Holocene are about \(-21/20\)‰ for individuals deriving their protein from terrestrial C\(_3\) pathway plants, or from animals subsisting on those plants. The \(\delta^{13}\text{C}\) in human bone collagen is elevated with the consumption of foods grown in aquatic environments. The endpoint \(\delta^{13}\text{C}\) value of about \(-12 \pm 1\)‰ indicates that the protein portion of the diet was obtained from marine/aquatic food sources (Chisholm et al. 1982; Richards and Hedges 1999; Schoeninger et al. 1983; Schulting and Richards 2001, 2002).

Observations made on large data sets of \(\delta^{13}\text{C}\) measurements from across Europe show a geographic trend suggesting that isotopic data may vary with latitude presenting a strong correlation to a complex of climatic factors (van
Klinken et al. 1994, 2000). The data suggest that throughout the Holocene the terrestrial endpoint $\delta^{13}C$ values are on average consistently elevated by 1–2‰ in southern compared with northern Europe (Pollard et al. 2007, 178, 180; van Klinken et al. 1994, 2000). Following this, and without specific stable isotope values for Mesolithic terrestrial fauna from the Tagus and Sado valleys, the terrestrial endpoint $\delta^{13}C$ value assumed in this dissertation is –20‰.

Variation of $\delta^{15}N$

It is well attested that $\delta^{15}N$ values increase at successive trophic levels in the food chain. However, recent studies have shown that there are several difficulties in assessing the trophic level in human palaeodiet (Hedges and Reynard 2007; van Klinken et al. 2000). The $^{15}N$ enrichment value in humans is unclear, and although it is normally assumed to be about 2 to 4‰ for mammals (DeNiro and Epstein 1981; Schoeninger and DeNiro 1984) higher values up to 6‰ have been suggested. This discrepancy results from the assumption that the $\delta^{15}N$ values of plants consumed by humans and fauna are identical (Styring et al. 2015), but also from the fact that nitrogen values are specific to regions and ecosystems, which once again emphasizes the importance of defining the past environment under study (Ambrose 1993).

Experimental work has shown that breastfeeding infants will present higher $\delta^{15}N$ values than the mother due to bioenrichment from breast milk consumption (Fogel et al. 1989). In this case, the child will present $\delta^{15}N$ values 1 to 3‰ greater than the adult females in the sample, depending on whether they were breastfeeding exclusively (Katzenberg et al. 1996).

Overall, the $\delta^{15}N$ values estimated for archaeological human bone collagen from the European Holocene range from 4 to 10‰ for individuals deriving their protein from terrestrial sources, depending on the trophic level of the foods consumed. Because the food chains in aquatic systems are typically longer than terrestrial ones, the values are enriched, and range from 10 to 22‰ for protein derived mainly from marine/aquatic sources (Richards and Hedges 1999).

Freshwater reservoirs

The consumption of freshwater fish is an additional complication for the reconstruction of palaeodiets (Hedges and Reynard 2007; Keaveney and Reimer 2012). G. Cook and colleagues (2001) have demonstrated that foods from freshwater sources may induce a reservoir age in human bone collagen, in a similar way to marine foods. While the consumption of marine protein can be attested through elevated $\delta^{13}C$ values, freshwater sources of protein are more difficult to detect (Hedges and Reynard 2007). The $\delta^{15}N$ values derived from both marine and freshwater foods are generally higher than those of terrestrial origin (Schoeninger and DeNiro 1984), however, these high values are dependent on the productivity of the aquatic system.

The consumption of freshwater fish may be indicated by the enriched $\delta^{15}N$ values along with low $\delta^{13}C$ values (Bonsall et al. 2002; Cook et al. 2001). In these
cases, additional archaeological lines of evidence can support the isotopic interpretation, such as fish bones recovered from the site and the proximity to a riverine biome (Hedges and Reynard 2007). Freshwater systems are complex and without knowing the ecology of the region all interpretations must be taken with caution (Keaveney and Reimer 2012).

Assumptions in this study

Despite the sources of variation and uncertainties we can still benefit from stable isotope analysis of human remains, even if the past environment is not perfectly known. The present analysis and interpretation of human bone collagen measurements of $\delta^{13}C$ and $\delta^{15}N$ relies on several assumptions and published values for European Early Holocene. These can be listed as follows:

- The human bone collagen of an adult individual reflects the diet averaged over the 10 years prior to death (Hedges et al. 2007).
- The human bone collagen from a diet based on terrestrial C$_3$ pathway plants, and/or from animals subsisting on those plants, has a $\delta^{13}C$ value of $-20\%o$. This is the assumed terrestrial endpoint for a diet derived from protein sources of terrestrial origin (Richards and Hedges 1999; Schulting and Richards 2001, 2002).
- The human bone collagen from a diet based on marine/aquatic resources has a $\delta^{13}C$ value of $-12\%o$. This is the assumed marine endpoint for a diet derived from protein sources of marine/aquatic origin (Richards and Hedges 1999; Schulting and Richards 2001, 2002).
- The human bone collagen $\delta^{15}N$ values range from 4 to 10$\%o$ for a diet based on terrestrial sources of protein and 10 to 22$\%o$ for protein sources of marine/aquatic origin (Richards and Hedges 1999).

Based on these premises it is possible to compare objectively the isotopic data sets available for these sites and gain insights into broad dietary patterns in terms of the main sources of protein intake, which may be useful to clarify elements of intra- and inter-site variation at the isotopic scale of each individual in each burial ground.

Recent methodological developments are introducing a Bayesian approach to quantitative diet reconstruction estimates. These are powerful tools which can handle the different sources of uncertainty associated with past human diets, including the basis for necessary corrections to collagen $^{14}C$ dates that have a reservoir effect (Fernandes 2015; Fernandes et al. 2014). One example of this type of modelling was introduced by FRUITS (Food Reconstruction Using Isotopic Transferred Signals) (Fernandes et al. 2014) presenting the way forward in terms of dietary reconstruction of the past and associated reservoirs, which will be of great interest to apply to the assemblages of the Tagus and Sado valleys in future research.
Archaeothanatology: *chaîne opératoire* of mortuary practices

**Introduction**

**Enquiry-dependent taphonomies: the archaeothanatological approach**

The method of disposal of a cadaver has different taphonomic consequences. The complete skeletons of vertebrates can be preserved if quickly buried in areas of rapid sedimentation, or if they become buried in a slower manner in places sheltered from transportation forces (Lyman 1994, 137). Some animals, and humans in particular, are important agents behind the covering with sediments (i.e., burial) of faunal or human remains, contributing to the preservation of relatively complete and articulated skeletonized bodies.

In archaeology, the objectives of a taphonomic analysis are varied but the ultimate goal is identical: to identify and separate the taphonomic processes, and lead to conclusions regarding the human behaviour behind the archaeological context (Lyman 1994, 5). Taphonomic methods depend largely on the nature of the assemblage, but most importantly, on the nature of the enquiry. Archaeothanatology is a taphonomic approach to the study of human remains in archaeological context. The method is dependent on an enquiry, firmly rooted in the physicality of the body, documenting and explaining differences between the living appearance of the human skeleton and the human remains found in the archaeological context. This type of analysis provides the tools to distinguish natural processes from those that are the result of human action. Often, the evidence is insufficient to unequivocally determine the nature of the processes, however, this method is one of the most useful and reliable approaches for the study of the human remains when the objective is to identify and describe the *chaîne opératoire* of intentional gestures behind the deposit of the human cadaver in a grave feature (see Duday 2009; Nilsson Stutz 2003a).

This dissertation examines the archaeological features with human remains excavated in the shell midden sites in the Tagus and Sado valleys. Despite the unusual number of human burials, there was never a systematic study centred on the mortuary contexts of these valleys. Recent studies have applied the archaeothanatological approach to part of the assemblages of Moita do Sebastião and Cabeço da Amoreira in the Tagus valley (Jackes et al. 2014; Roksandic and Jackes 2014), while the material from the Sado sites remained unexplored.

The archaeological material (documentation and human remains) selected for this dissertation was carefully evaluated in order to determine which contexts contained high enough resolution for an archaeothanatological analysis (see below, *Source material: the challenges*). The quality of the source material varies largely from
site to site and their potential and limitations are described in detail for each site in chapter 4.

In this study, the objectives of the archaeothanatological analysis were to reconstruct central aspects of the mortuary practices in each context in particular, which can be outlined as follows:

- to identify the nature of the deposit (primary, secondary);
- to describe the space of decomposition of the cadaver (filled, empty, mixed);
- to reconstruct the initial position of the cadaver in the feature;
- to reconstruct the grave features, such as size and shape;
- to detect the initial presence of perishable materials deposited along with the cadaver that in different ways affected the body during the process of decomposition, such as structures placed behind the bodies (e.g., headrest, cushions, platforms), or wrappings of the body at the time of the burial;
- to clearly define the deposits containing more than one individual;
- to identify post-depositional manipulations of the cadaver.

The general aim is to reconstruct the mortuary programme in each valley in general and in each site in particular by defining typical practices as well as the atypical.

**This section**

**Structure**

The section *Archaeothanatology: chaîne opératoire of mortuary practices* concentrates on methodological issues related to the main principles of the method of archaeothanatology. This methodological review is written from the perspective of the analysis of articulated and semi-articulated skeletonized human remains, and for this reason, issues relevant to other archaeological contexts may not have been addressed. For a complete overview of the method consult *The archaeology of the dead: lectures in archaeothanatology* (Duday 2009), as well as reference texts presented by H. Duday (2006), H. Duday and M. Guillon (2006), and L. Nilsson Stutz (2003).

First, I present a brief history of the method and its impact in archaeology. Then, I outline the main principles of archaeothanatology, describing the principles and central aspects of the analysis. In this section I focus on the reconstruction of the initial position of the cadaver and present in detail some basic observations at the level of each bone element. Lastly, I discuss the application of archaeothanatology in this study by examining the possibilities and limitations of the method in the analysis of the historical source material used in this dissertation. Before the methodological review, I present the terminological choices and conventions used throughout this study.

The results of the archaeothanatological analysis are presented by archaeological site in chapter 4. The presentation of the results for each site adopts in general the
structure presented by L. Nilsson Stutz (2003a). The results are analysed and discussed in chapters 5 and 6.

Terminology and conventions

The lack of unequivocal terminology is a frequent problem in funerary archaeology (see Boulestin and Duday 2006; Knüsel 2014). Often, the nomenclature used in different studies varies, making it difficult to interpret and compare sites and contexts. Frequently, while one term may be used to describe different practices, one phenomenon may be described by using several different terms. To further complicate the problem, different research traditions use terminology in different ways, and in some cases the translations may not reflect the original meaning of the term, thus it may be good practice to use the original expression along with the translated term.

Overall, the terminological problem is well known in archaeology, not only in the field of funerary archaeology. The use of clear and explicit terminology is fundamental, and its adoption must be well understood. The description of human remains in archaeological context must be carried out by using specific and well-defined terminology, and by centring the descriptions around the cardinal points of the body applying anatomical nomenclature. The advantages of following these procedures are that they allow the replication of results and ensure that the published data can be used unambiguously by other researchers. Below, I provide the references used throughout this study for the anatomical terminology in general, and for the mortuary terminology in particular.

Anatomical terminology

Archaeothanatology uses the international anatomical nomenclature for the human skeleton (Duday 2009, 16), and in this dissertation I follow the standard reference as presented by T. D. White and P. A. Folkens (2005). Anatomical terms of bones are used for the description of the human remains in the feature while anatomical terms for the parts of the human body are preferred in the interpretation of the contexts.

The human remains are described in relation to the Anatomical Position of the human body, also referred to as Standard Erect Position (Bass 2005; White and Folkens 2005). In this standard, the body is standing and looking forward, with all limbs in extension, and the palms of the hands are facing forwards with the thumbs pointing away from the body (White and Folkens 2005, 67, 70).

Directional terms

The description of the human remains in the archaeological feature takes the body as the point of reference (Duday 2009, 16). Terms of location are always referred from the perspective of the body and never from that of the observer. For example, when describing a location on the right it refers to the right side of the body.
In archaeothanatology, it is essential to describe the lateralization of the bones as they are found in the archaeological feature. This is done by indicating the side of appearance of the bone elements in a plan view and in reference to anatomical terms of direction, such as anterior, posterior, lateral, medial, proximal, distal, or a composite view, such as anterior with a lateral component (Courtaud 1996; Duday et al. 1990; Nilsson Stutz 2003a, 205).

Motions of the body
The motions of the body occur as a function of the movement of the joints, thus all terms related to motion are described as a function of the joints, following the standard anatomical terms of motion, such as flexion, extension, abduction, adduction and rotation (Schwartz 2007; White and Folkens 2005). Additionally, following D. H. Ubelaker (1989), I use the terms semi-flexed (angle between 90 to 180 degrees), flexed (angle inferior to 90 degrees), and contracted (angle close to zero degrees), also referred to as hyperflexed. For example, when describing the upper limb the appropriate expression of motion is flexed elbow rather than flexed upper limb.

Other terms
For terminological clarity the position of the body in the feature is expressed as lying on the back, lying on the front, lying on the lateral right/ left side.

In this dissertation the expressions body, corpse, cadaver, and deceased are used interchangeably to refer to a dead human body.

Burial refer to the covering of human remains with sediment soon after disposal (Lyman 1999, 406), but also to the context where the human remains have been placed and covered (i.e., burial feature), which may also be referred to as grave feature. See further discussion below in The nature of the deposits.

Mortuary terminology
The clear use of an explicit terminology is essential for the accurate description and interpretation of archaeological contexts. This can be particularly problematic in the field of mortuary studies because terminology can also express human intention (see Boulestin and Duday 2006; Knüsel 2014). Thus, inconsistencies in the use of appropriate terminology may be an obstacle to a clear understanding of the mortuary context.

In this dissertation, I follow the guidelines for the mortuary archaeology in Portugal (Duarte 2003), adapted to the terminology and concepts used by archaeothanatology (Duday 2009; Duday et al. 1990; Nilsson Stutz 2003a) which are further explained along with the principles of archaeothanatology.
Archaeothanatology and archaeology

Brief history of the method and impact in archaeology
The methodological principles of archaeothanatology emerged in France in the late 1970s and early 1980s in the context of the exponential growth of rescue archaeology accompanied by an increase of excavation of cemeteries in urban areas. The method, initially termed anthropologie de terrain (Duday et al. 1990), was developed to overcome field difficulties when excavating and documenting human remains in archaeological contexts. This was done by applying basic knowledge of biology – regarding human anatomy and the decomposition process – to archaeological questions, in order to correctly identify and argue for the cultural phenomena behind the archaeological context (fig. 3.10).

![Figure 3.10. Archaeological contexts with human remains. Identification and interpretation of cultural phenomena with the methods of archaeothanatology.](image)

Simultaneously, in the UK and particularly in North America, other approaches were developed on the basis of forensic research, but were of great interest and applicability to archaeological contexts, notably by the syntheses and publication of data related to the taphonomic behaviour of the human cadaver (Haglund and Sorg 1997).

The lack of specific archaeological methodology capable of responding to the particular questions related to funerary contexts motivated a group of researchers
to formalize a set of tools and practical procedures for the fieldwork done in France (Duday and Guillon 2006, 118). The methodology evolved from a practical need, and it is today integrated in the discipline of archaeothanatology (Duday 2009). Its relevance comes from the urgency to resolve various taphonomic problems in archaeological deposits with human remains, while providing an understanding of the gestures associated with the funerary practice.

During the first decades of its development, the approach was known as l’anthropologie du terrain, a term still in use today by some authors. However, the term carries some conceptual problems. First, because there are different approaches to the discipline of anthropology: in the countries of Romance languages in Europe, such as France, Spain or Portugal, anthropology is the discipline that studies the human being in its biological dimension, while in the Anglo-Saxon countries as well as in Northern Europe, the discipline has a greater focus on the cultural dimension of human behaviour (see Roberts 2009, 2–6). Second, because the term terrain related to the fieldwork and directly associated with the context of excavation in archaeology, does not have the same meaning in anthropology. In this sense, B. Boulestin and H. Duday (2006) suggest the use of the term archaeothanatology. This expression is better framed for the goals and area of expertise of the method, since it is the discipline of thanatology that deals with the biological and social aspects of death. This new terminology was established by H. Duday (2009), one of the main proponents of the method, in the first methodological synthesis of the discipline The archaeology of the dead: lectures in archaeothanatology, emphasizing that the expression l’anthropologie du terrain must be abandoned in order to prevent terminological confusion with other disciplines (Duday 2009, 3).

Despite the relatively short expansion of archaeothanatology outside the francophone world, the method reached its maturity. The approach has been defined through more than three decades of research and it follows a strategy of continuous accumulation of data and archaeological references, with numerous contexts being described, supplying the tools of analysis that allow the comparison of archaeological observations with the reconstruction of intentional practices. To the researcher following this method, the collection and publication of references is taken as a duty always when excavating and studying human remains in archaeological contexts (Nilsson Stutz 2003a, 150). In recent years, some methodological texts were published in English (Duday 2006, 2009; Duday and Guillon 2006), allowing the expansion of the method to a wider audience, and exposing it to important methodological debates.

In Portugal, archaeothanatology has a recent history and few professionals apply it in the context of archaeological excavations. However, one of the first references to the method in Portugal, about the methodological potential of the French approach anthropologie de terrain was published in the late 1980s, Antropologia de campo e arqueologia funerária (Moura 1989). This short article seems to have gone almost completely unnoticed and it is rarely cited, but it remains one of the most detailed and complete reference on the terminology and methodological principles.
of *anthropologie de terrain*, published in Portuguese. Almost ten years later, a new article was published on the same theme, with a very similar title *Ler os ossos: antropologia de campo e arqueologia funerária* (Silva 1997), however, less detailed in terms of method, but presenting a case study in Portugal of the excavation of a collective megalithic tomb at Alcalar, the *tholos* of Monte Canelas I. In the past ten years, important steps were taken in order to implement the methods of archaeothanatology to fieldwork, in particular to the contexts of rescue archaeology (Neves et al., n.d.). Since 2006, there has been a series of practical courses, organized by a private company of archaeology, Dryas/Styx in collaboration with the University of Coimbra. These sessions have a strong interdisciplinary approach and involve the disciplines of archaeology, physical anthropology, and medicine, with the goal of bridging the gap between archaeologists and physical anthropologists, by teaching the methodological principles of archaeothanatology (Ferreira et al. 2008). The method has been successfully applied to various prehistoric contexts, such as the recent interventions at the Late Neolithic funerary complex of Monte Canelas in Alcalar, south of Portugal (Neves and Silva 2010), as well as to the recently excavated burials at the shell middens of Cabeço da Arruda and Cabeço da Amoreira in the Tagus valley (Roksandic 2006), and Poças de S. Bento in the Sado valley (Diniz et al. 2014).

**Archaeothanatology: main principles**

* Aims of the method

Traditionally, research developed in the context of the archaeology of death is focused on architectonic aspects of the graves and on detailed analysis of grave goods (see chapter 1), though the death of the individual is the reason for all funerary actions, and the human body the central element of funerary practices. The aim of archaeothanatology is to reconstruct past ritual actions in response to death, by the identification and reconstruction of funerary treatments, having as point of departure the material remains of the dead. In contrast to traditional approaches, in archaeothanatology human remains are the central question, with which all methodological processes are concerned (Duday 2006, 2009).

In this approach, the knowledge of what happens to the human body after the biological death of the individual is essential for the argumentation and taphonomic interpretation of the various aspects represented in the funerary context. In archaeology, it is universally accepted that the knowledge of site formation processes is essential for a proper archaeological excavation and its interpretation. Following this, it should be implicit why understanding the taphonomic processes related to the decomposition of the human body are fundamental for the excavation and interpretation of funerary contexts. This detailed knowledge about the physical aspects of death is the basis of the taphonomic theory developed by archaeothanatology, contributing in this way with unparalleled insights about past mortuary practices.
Taphonomy of mortuary practices

Taphonomic history begins with death (Lyman 1994) and the identification of its processes affecting archaeological human remains is one of the pillars of archaeothanatology. Taphonomy is an independent discipline with its roots in disciplines such as palaeontology, geology, chemistry and biology, which studies the natural and non-natural processes involved in the formation of geological and archaeological contexts. By identifying patterns with origins in different agents, the taphonomic analysis allows the identification of post-depositional phenomena affecting the archaeological assemblages during the period these have been buried to their recovery during archaeological excavations.

The goal of archaeothanatology is to identify taphonomic patterns caused by human agents in order to reconstruct the context created by the actions that constitute the mortuary practices. Departing from taphonomy, as theoretical foundation, archaeothanatology has been responsible for the development of a taphonomy of mortuary practices, particularly focused on the handling of the human body, equipping the archaeologist with an important set of tools and establishing a new confidence and new possibilities for a modern archaeology of death (Nilsson 1998; Nilsson Stutz 2003a, 2008).

Archaeothanatology is thus an interdisciplinary archaeological method, which applies knowledge of biology about human anatomy and decomposition processes of the human body, to the interpretation of human remains in archaeological context, supporting every observation on taphonomic theory, with the objective of identifying the chaîne opératoire of intentional gestures involved in the funerary practices of past populations.

Basic principles

In archaeothanatology, the source of information is the human skeleton, more or less complete, which must be documented rigorously. All elements must be taken into consideration and their relations carefully evaluated (Nilsson Stutz 2003a, 156). The basic principle of the method is the analysis of the spatial distribution and orientation of the bones. During excavation, it is important to record in detail all skeletal elements in order to identify their spatial distribution within the excavated feature, along with a rigorous documentation of the orientation of the bone and its face of appearance (Courtaud 1996; Duday et al. 1990; Nilsson Stutz 2003a, 205). Archaeothanatology is based on the identification of the post-depositional dynamics of the movements of the bones, and it is important to understand that there will always be a difference, more or less pronounced, between the initial position of the cadaver and its situation that the archaeologist will find in the context of excavation.

In the framework of the study of mortuary practices, it is fundamental to take a critical and dynamic stand point, and in every situation evaluate the intentionality of the actions represented in the archaeological context. The presence of human bones in the archaeological site is not evidence of intentionality of the deposit.
Likewise, a deposit with human remains, even if intentional, is not by itself evidence of funerary ritual. In the study of funerary practices it is necessary to prove first the intentionality of the deposit, which then may be followed by the identification of the evidence of the funerary practice (Duday 2009).

The most frequent kind of human remains found in archaeological context consist of hard tissue, that is, skeletal elements, such as bone and teeth, which are the most durable tissues of the body. The skeletonization of the body consists of the removal of all soft tissue from the bone and is one of the last chronological stages of decomposition (Lyman 1994; Pinheiro 2006). The decomposition of the body starts immediately after death. It is a complex process, subject to many variables and intervenients influencing the transformation, faster or slower, of the corpse into a skeleton (Pinheiro 2006). It is also an active process, and one of significant taphonomic consequences, the impact of which in the archaeological context is commonly neglected. The way the body decomposes may have important outcomes in the way the human remains are found in the archaeological feature. The process of decomposition is predictable, and when understood, may provide clear understanding of the non-natural and intentional processes involved in the mortuary practice. The first and second basic principles of archaeothanatology, observation of the joints and observation of the internal and external environments of the cadaver respectively, are based on the understanding of these processes.

First basic principle: observation of the joints

During decomposition, as the soft tissues dissolve, the skeletal elements begin to collapse, losing their anatomical integrity. Experimental fieldwork (Hill 1979a–b; Hill and Behrensmeyer 1984, 1985) has shown that the different types of joints have different resistance levels during the process of decomposition, suggesting that the anatomical characteristics of the joint will influence the chronological order of its disarticulation. Thus, the chronological order of joint disarticulation in a skeleton will largely depend on the anatomy of the joint and its associated soft tissue (Lyman 1994, 160).

A joint is a region of contact of two or more skeletal elements and is defined by its range of motion and according to the type of tissue holding it together (Schwartz 2007). The basic relative chronology for the decomposition and breakdown of the joints can be used to establish the relative chronology of the various events of the taphonomic history of the archaeological deposit with human remains (Nilsson Stutz 2003a, 152). These observations are of extreme importance for the application of archaeothanatology, and constitute a tool of great utility to identify central aspects related to the observed practice.

In archaeothanatology, the joints are classified into labile joints if they break down early in the process of decomposition, and persistent joints, if they resist decomposition for longer time (Duday et al. 1990) (fig. 3.11).
Persistent joints

Labile joints

Figure 3.11. Classification of joints in archaeoThanatology. Joints are classified as persistent or labile according to their relative resistance during the process of decomposition.
Labile joints can remain intact for a variable length of time, between some weeks to a few months. These are the temporomandibular (TM) joints, the joints of the cervical vertebrae (CV) (in particularly C2–C3 and C3–C4), the sternocostal joints, the scapulothoracic joints, the joints of the hands, the hip joints, and the distal joints of the feet (Duday 2009). The persistent joints can retain their function for several months or years, retaining the anatomical integrity of the skeletal elements involved. These are the atlanto-occipital joint, the joints of the lumbar vertebrae (LV), the lumbosacral joint, the sacroiliac joints, the knee joints, the ankle joints, and the tarsal joints (Duday 2009). The disarticulation of the bones held by these joints can happen due to the effects of gravity on the initial position of the cadaver in the feature (Duday 2006, 35). This is the case of the lumbar portion of the vertical column or the sacroiliac joints. Despite being some of the most persistent structures of the body, decaying very late in the process, these elements are commonly found disarticulated due to the phenomenon of gravity (Duday 2006, 35). For this reason, the sacroiliac joints have been referred to as relatively labile which in this case could be explained by the natural oblique position of the os coxae in relation to the sacrum, rather than to the relative resistance of the joint (Nilsson Stutz 2003a).

Second basic principle: observation of the internal and external environments of the cadaver

The process of decomposition depends on the internal (endogenous) and external (exogenous) environment of the cadaver. While decomposition in the endogenous environment is predictable, the processes in the exogenous surroundings can occur at different paces and levels of activity within the same cadaver, depending on the different micro-environments created around the corpse (Pinheiro 2006, 87). The dynamics between these two spaces will influence the distribution pattern of the bone elements in the archaeological context.

To reconstruct the taphonomic history of the deposit it is necessary to consider: first, the initial volume of the cadaver and the decomposition of soft tissue in its internal environment, and second, the external environment of the cadaver, the space of decomposition. In both internal and external environments, the decomposition of organic matter will result in empty spaces, which in the case of a buried cadaver, will be filled by sediment. The observation of these dynamics constitutes one of the basic principles of the archaeothanatological method (Nilsson Stutz 2003a, 151). This analysis is important because all empty spaces created during the process of decomposition in the space of disposal can potentially contribute to the instability of the bones and influence their spatial distribution pattern in the archaeological feature (fig. 3.12).

The dissolution of soft tissue will create empty spaces inside the initial volume of the cadaver. These new empty spaces will not only destabilize the initial position of the bone elements but will constitute pockets where the bones can collapse and gain new stability. The disarticulated bones will find a new balance when their movement is blocked by the filling of sediment or by the presence of some other
The new equilibrium will be achieved also in relation to the external environment. This equilibrium is disrupted during archaeological excavation, when the sediment is removed while lifting the bones (Duday and Guillon 2006, 130; Duday 2009, 17).

***

The processes described here are complex to observe and need a dynamic and critical approach. However, their effects are predictable and distinguishable from other post-depositional taphonomic processes, such as disturbances from the activity of a rodent, or geological movements of the soil. The observations, based on the two basic principles of archaeothanatology, provide the argumentative support for the identification and reconstruction of cultural phenomena associated with the mortuary practices, such as the nature of the deposits, the space of decomposition of the cadaver, the initial position of the cadaver in the feature, the grave features, deposits containing more than one individual and post-depositional manipulations of the cadavers (fig. 3.13).

Figure 3.12. Place of disposal of the cadaver. The external and internal environments will influence the distribution pattern of the bone elements during decomposition of soft tissue and other organic material in the feature.
Figure 3.13. The two basic principles of archaeothanatology and the reconstruction of aspects of the funerary practices.

The nature of the deposits

The variability of the cultural responses to death carries an assortment of ways of dealing and manipulating the human remains. Archaeothanatology distinguishes between two types of archaeological contexts where human remains can be found: the primary deposit and the secondary deposit, also termed primary or secondary burial (Duday 2009, 14; Nilsson Stutz 2003a, 206).

Primary deposit

The archaeological context with human remains is a primary deposit when the archaeothanatological analysis indicates the direct deposition of a fresh cadaver in the feature while it still retains its anatomical integrity (Duday and Guillon 2006, 125; Duday 2009). The primary deposit is where the breakdown of the organic matter takes place, being through decomposition, in the case of burial, or through fire, in the case of cremation, for example.

The positive identification of a primary deposit is easily argued when the bones articulated by labile joints retain their anatomical position. However, preservation conditions do not always allow such clear identification, and in the case of the rare cremations in primary deposits it becomes more complicated (see Duday 2009, 152–53). In fact, the anatomical preservation of all labile joints is rare (Duday and Guillon 2006, 131) but the observation of some of the labile joints in anatomical position demonstrates the integrity of the cadaver at the time of disposal, indicating the primary nature of the deposit. It is important to emphasize that the non-preservation of the labile joints is not sufficient to exclude the interpretation of a deposit in primary position (Duday and Guillon 2006, 128). The disorder of the
skeletal elements is a weak argument supporting the intentional manipulation of the bones and it is necessary to take into account other factors that may have disturbed the deposit.

The general topography of the body can demonstrate the primary nature of the deposit if the overall anatomical order of the skeletal elements has been maintained, even if few or none of the other diagnostic criteria (i.e., labile joints) has been preserved (Duday 2009, 27).

The primary nature of the deposit may be attested by the observation of fluids of decomposition altering the colour of the sediment involved, as well as by the identification of remains of organisms associated with the process of decomposition (Duday and Guillon 2006, 131).

The primary nature of a deposit can be demonstrated if one of or all these criteria are identified in the archaeological feature (table 3.5).

Table 3.5. Arguments supporting the nature of a deposit in primary position.

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<th>Arguments</th>
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<tr>
<td>Maintenance of labile articulations</td>
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<tr>
<td>Maintenance of general anatomical integrity of the body</td>
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<tr>
<td>Observation of products of decomposition</td>
</tr>
</tbody>
</table>

Secondary deposit

The secondary deposit, more expressively termed as funeral in multiple episodes (funérailes en plusieurs temps, or funérailles decallées) emphasizing the dynamics involved in this type of practice (Nilsson Stutz 2003a, 206), contains the manipulated remains of the deceased and is the result of the treatment of the remains in multiple episodes. This practice is characterized by the occurrence of one or more distinct and successive phases, between the moment of death and the final deposit. In the archaeological context we may find the last stage of manipulation, or rather an intermediate phase of a complex process (see Gray Jones 2011).

This process results in the disarticulation of the skeleton, total or partial, and the bones articulated by labile joints are more dispersed or even missing. It is almost common place in archaeology to consider that the absence of the bones of the hands and/or feet indicates the secondary nature of the deposit. This is however a weak argument because the absence of these bones may be explained in many cases by taphonomic agents and/or poor excavation methods (Duday 2009, 89).

The secondary deposit is easily identified when the context consists of a selection of skeletonized or cremated bones placed in a container much smaller than the human body. In most cases the clear identification of secondary deposits is difficult and requires a multiple set of observations which cannot be explained by
excavation bias or taphonomic agents such as bones in disarticulation, or absence of small bones.

Other observations, such as the retention of specific skeletal elements, such as crania or long bones (Andrew and Bello 2006, 17), or a particular spatial organization of the bones in the archaeological feature, may constitute strong arguments supporting the identification of a secondary deposit.

The space of decomposition of the cadaver

Empty and filled spaces of decomposition

The decomposition process starts soon after death, with the process taking place in an empty space or in a filled space (Duday 2009, 32; Nilsson Stutz 2003a, 252) (fig. 3.12). The relevance of the identification of the environment (i.e., space) of decomposition is twofold: first, it represents a relevant aspect of the mortuary practice, and second, it presents significant taphonomic consequences in the spatial distribution and orientation of the human remains in the archaeological feature.

The space of decomposition is empty if the cadaver is in an open air space, or if the body is placed in a hard container, such as a coffin or a crypt chamber. The space of decomposition is filled if the cadaver is covered with sediment soon after death, either intentionally, or by accidental or natural causes. Within these two possibilities, empty or filled space, other empty spaces can be created by the decomposition of organic elements external to the cadaver. These are secondary empty spaces and may be detected by their eventual effect on the spatial distribution and orientation of the skeletal elements in the feature. The identification of these secondary spaces is of great interest to the study of mortuary practices, because it allows the identification of perishable materials deposited along with the cadaver, which do not leave any trace, besides the taphonomic impact on the feature. Even if the cadaver is initially located in an empty environment, it will eventually be covered with sediment, unless the remains are placed in a durable and hermetic container such as a stone sarcophagus. This taphonomic process occurs at different speeds during the process of decomposition, depending on different factors.

The chronology of the filling of the different spaces can be progressive and immediate (colmatage progressif) or delayed (colmatage différé) (Duday 2009, 52; Nilsson Stutz 2003a, 254). The filling of the internal volume of the cadaver is dependent on the characteristics of the space of decomposition and the properties of the sediment. If the cadaver is buried in direct contact with the soil, in a filled space sufficiently porous and fluid, while the soft tissues dissolve, their original space is immediately and progressively substituted by sediment without the formation of an empty space. In the case of immediate filling, the movement of the bones will be minor even in the regions of contact of labile joints, since the penetration of sediment will allow the maintenance of the original equilibrium of the skeletal elements (Duday 2009, 38) (table 3.6). The term hourglass effect is used by archaeo-thanatology to describe situations when the infilling is particularly fluid. This effect occurs in the presence of very fine sediment, such as small grained sand or
powdery ash, and is a diagnostic criterion for the placement of the cadaver in direct contact with the soil (Duday 2006, 41).

Table 3.6. Arguments supporting the space of decomposition in a sediment-filled environment.

<table>
<thead>
<tr>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance of bones in original unbalanced position</td>
</tr>
<tr>
<td>No movement outside the initial volume of the cadaver</td>
</tr>
</tbody>
</table>

When the cadaver is not in immediate contact with sediment, separated either by a more resistant kind of wrapping creating an empty space around the corpse, or by the deposition of the corpse in an empty space such as a hard container, the filling will be delayed and may not be fluid and progressive. In this case, the movements of the bones will be more pronounced, depending on the forces of gravity towards the initial position of the cadaver (Duday 2009, 35). Basically, if the body decomposes in an open space, at least some bones will have the tendency to fall outside the initial volume of the body during decomposition. The most relevant diagnostic criteria are given by the position of the os coxae and the lower limbs, in which the documentation of the patellae is one of the key diagnostic elements (Duday 2009, 36) (see below, Patellae).

Wall-effect (effet de parois)

The balanced position of skeletal elements is determined not only by the filling pattern of sediment, but also by the relation between the bones and the limits of the feature, and between other elements in the space of decomposition. Archaeothanatology recognizes the presence of non-sedimentary supports, responsible by the maintenance of the bones in equilibrium. This phenomenon is known as wall-effect (effet de parois) (Duday 2006, 41; 2009, 40 Nilsson Stutz 2003a, 256). The wall-effect consists of any obstacle that constrains the movement of the bones while providing support and preventing their collapse. This effect may be produced by the physical limits of the feature or by the presence of elements with slower decomposition rate placed close to the body. Elements covering or involving the body, or even clothing can restrict the movement of the bones.

The initial position of the cadaver in the feature

If the methods of excavation and documentation are sufficiently detailed and rigorous, it is generally possible to reconstruct the initial position of the cadaver in the feature. This analysis must take into account the natural movements of the skeleton and the various phenomena occurring during decomposition. The post-depositional movements follow simple and logical rules, dictated by the relative chronology of decomposition of the joints and by a key taphonomic principle, the law of universal gravitation (Duday and Guillon 2006, 128). This principle affects
all movements but its impact depends largely on the initial position of the cadaver in the feature and on the topography of the grave feature (Duday 2006, 34).

Here, I present several key observations at the level of single bone elements that have been described in the literature, which are relevant to the current study. It is important to emphasize that I chose this format to facilitate the presentation. Archaeothanatology is a dynamic analysis and the skeletal elements, influencing one another, must be taken as a whole. The interpretation should not be carried out from the observation of one single element but of a composite observation of various elements in a dynamic process.

**Cranium and mandible**

Observations at the level of cranium and mandible may indicate the initial position of the cadaver in the feature, and the space of decomposition to a certain extent.

The identification of the original position of the head may be an important aspect for the study of mortuary practices. It is important to understand if the movement of rotation of the head is natural, that is, the result of taphonomic processes, or if it is intentional, and potentially related to a mortuary practice. The key observations are at the level of the temporomandibular (TM) joint and mandible, and at the level of the cervical vertebrae (C1–C7), the latter described in a separate section below.

**Observation of the mandible**

The TM joint is one of the first joints to decay during the process of decomposition (Hill 1979a–b).

In the archaeological feature, if the TM joint is detached, it indicates a taphonomic rotation. If the body is laid on its back, after dissociation at the level of the TM joint, the mandible tends to fall forwards while the cranium rolls in the reverse way.

If the TM is not detached and the cranium and mandible are well articulated, it indicates either a taphonomic or an intentional rotation. The relative position of the mandible is an important element in the analysis, but not determinant, because the maintenance of this element in anatomical articulation is not sufficient to argue for the initial position of the head (Duday 2009, 19).

The analysis of the rotation of the head must be done with caution and based on a multiple set of observations (see below, Observation of the cervical vertebrae).

**Hyoid**

The hyoid bone is particularly poorly represented in archaeological assemblages (Mays 2010, 31). Observations of the hyoid when possible, offer relevant information about the space of decomposition of the cadaver. The hyoid bone tends to collapse during decomposition. However, if its anatomical position is maintained, it suggests an hourglass effect, indicating that the sediment could penetrate imme-
Archeothanatology

Methods: Archeothanatology

Vertebral column

The most relevant observations are at the level of the cervical vertebrae, and lumbar vertebrae to a certain extent. The rotation observed at the level of the thoracic vertebrae may offer significant information about the initial position of the upper body.

Observation of the cervical vertebrae (C1–C7)

Observations at the level of the cervical vertebrae (CV) may indicate the nature of the deposit, the space of decomposition, and the initial position of the cadaver in the feature.

The atlanto-occipital joint is a persistent joint and articulates the occipital bone in the cranium with the first CV (C1, atlas). The remaining joints are labile: the atlanto-axial joint (C1, atlas–C2, axis), and the intervertebral joints, in particular at the level of C2–C3 and C3–C4 (Duday 2006, 35). Thus, the maintenance of the CV in articulation is a strong indicator of the primary position of the remains in a filled space of decomposition.

The rotation of the head usually involves all CV. In archaeothanatology it is particularly important to document the position of the superior portion of the cervical vertebrae (Duday 2009, 18; Duday and Guillon 2003, 132). If these are in continuity and in anatomical connection while presenting a degree of rotation in conformity with the rotation of the head, the intentionality of the rotation is confirmed.

In some cases, observations of the formation of an arc with the CV well articulated (Nilsson Stutz 2003a, 272) indicate that the neck was initially flexed forwards and downwards bringing the head towards the body in the feature. This movement can occur if the head is placed in an elevated position, such as in a sitting or semi-sitting position, but even a moderate downslope may have an impact on this movement. In cases like this, the maintenance of the CV in articulation can be explained by the progressive and immediate infilling of sediment preventing the collapse of the bone elements.

Observation of the lumbar vertebrae (LV)

The intervertebral joints at the level of the lumbar vertebrae (L1–L5) are persistent joints, as well as the lumbosacral joint (L5–sacrum). Despite the late decomposition of these joints, they are commonly found disarticulated due to the effects of gravity in relation to the initial position of the cadaver in the feature (Duday 2006, 35).

Observations at the level of the lumbosacral joint may reveal important aspects of the initial position of the cadaver. In some cases an angle can be observed between the L5 and the sacrum indicating the movement forwards of the sacrum followed by the lumbar vertebrae. Some case studies have shown that the migra-
tion forwards of the sacrum appears to be associated with the descent and movement downwards of the vertebral column, which could be explained by the decomposition of a cadaver in a sitting or semi-sitting position where the upper body is in a more or less vertical position (Nilsson Stutz 2003a, 269).

Thoracic cage: sternum and ribs

Often, very little is preserved from the thoracic cage (TC). This skeletal region is particularly vulnerable to decay in the soil because of the relatively low density of the ribs and due to the intense activity in this area during the decomposition process promoting the dissolution of the hard tissues. Observations at the level of the TC may reveal important aspects about the feature, such as the space of decomposition, the initial position of the cadaver, and other aspects related to the grave feature.

One of the most frequent disarticulations observed during decomposition are the collapse of the TC. The dissolution of the organs in the thoracic and abdominal cavities during decomposition leaves significant empty spaces resulting in the collapse of the bones. Commonly, the initial volume of the TC is not maintained, and can be outlined as follows:

- If the body is laid on its back, the ribs of both right and left hemithorax will fall symmetrically towards the bottom of the feature. This displacement is known in archaeothanatology as the flattening of the rib cage (Duday 2006, 34, 2009, 16).
- The hemithoraces may fall vertically if the body lies on a downslope or in a sitting position. In a filled space, the ribs collapse downwards or neatly vertically (Nilsson Stutz 2003a, 271).
- If the body is laid on one side, the ribs of the side on which the body lies will remain in the same position, while the ribs of the opposed side will collapse inside the thoracic void (Duday 2006, 34).
- Notably, the collapse of the TC may affect the movement of other bones, such as the bones of the hands, or objects, or clothing elements placed in front of the thorax or abdomen.
- In a few cases, the initial volume of the TC can be maintained (Duday 2006, 44). If the anatomical position of the ribs is maintained it indicates one of the following cases:
  - The sediment could penetrate immediately, and progressively fill the empty spaces created as soft tissue decayed (Duday 2009, 56). This is a rare occurrence because the TC is rich in soft tissue and a very active region of the body during the process of decomposition; thus disarticulations at this level are very common, even in filled environments. The maintenance of the thoracic volume is in this case explained by an hourglass effect.
  - Or, it may suggest the decomposition of the body in a narrow central pit. This particular form of pit is elevated on the lateral sides where the
upper limbs lie in a raised position relative to the thoracic cage. Thus, the usual displacement of the thoracic cage is prevented by the bilateral wall-effect supporting and keeping the ribs in equilibrium (Duday 2006, 44).

**Bones of the shoulder girdle and upper limbs**

Bones of the shoulder girdle
Observations at the level of the bones of the shoulder girdle (clavicles and scapulae) may offer relevant information about the grave feature. The key observations involve three bone elements: the clavicle and scapula, and the humerus at the level of the upper limb.

During the decomposition process the clavicles may become vertical or adopt a steeply oblique position, with the acromial ends directed upwards and the sternal ends rotated downwards. In archaeothanatology, this movement is termed the *verticalization of the clavicles* (Duday 2006, 43; 2009, 45). This movement presents strong evidence for constraint effects, indicated by a bilateral pressure at the level of the shoulder girdle. In some cases, the constraint effect may influence only one clavicle, indicating a particular pressure at that side of the feature. The transverse compression can happen when the cadaver lies on its back in a narrow space, such as a soft container (e.g., tight wrapping in a shroud) or a hard container (e.g., narrow coffin, anthropomorphic pit) (Duday 2006, 43; Duday and Guillon 2006, 144). A clear case may be indicated by the observation of the projection upwards and forwards of the shoulder girdle and the humeri. Typically, the clavicles are verticalized, the glenoid fossae are directed upwards and the axillary borders of the scapulae are vertical. Likewise, the humeri are projected upwards and forwards, rotated inwards and located very close to the TC.

A different pattern can be observed when the scapula is completely exposed presenting the anterior view. This phenomenon may indicate a combination of movements, such as the rotation of the scapula upwards (even if moderate) while the ribs slid towards the medial axis of the body exposing the anterior side of the scapula (Nilsson Stutz 2003b, 3). This movement pattern suggests a transfer of body weight towards the opposing side, which could indicate a sloping floor, even if moderate.

Bones of the hands
Observations at the level of the bones of the hands may indicate aspects related to the nature of the deposit, the space of decomposition and the initial position of the cadaver in the feature.

The joints of the hands are labile and the articulated state of the bones of the hands is a strong argument for the primary nature of the deposit, as well as for the filled space of decomposition. When found in situ, at least some bone elements, may aid in the reconstruction of the position of disturbed upper limbs (Nilsson Stutz 2003b, 5).
Bones of the pelvic girdle and lower limbs

Bones of the pelvic girdle

Observations at the level of the pelvic girdle may indicate the space of decomposition, the initial position of the cadaver and elements of the grave feature.

The joints at the level of the pelvic girdle, lumbosacral and sacroiliac joints are persistent and some of the last to decompose. However, a common movement during decomposition is the collapse of the bones of the pelvic girdle (Duday 2006, 34–35). Following the law of gravity, if the body is laid on its back, the os coxae tend to collapse towards the rear. If the body is laid on one side, the os coxae from the opposed side will collapse inside the pelvic cavity. These movements are common even in filled environments because of the instability caused by the decomposition of masses of soft tissues in the pelvic cavity and buttocks (Duday 2006, 35). If the body is laid on its back in a wide space, the collapse of the bones of the pelvic girdle may be more pronounced, with a progressive disarticulation at the level of the pubic symphysis until the os coxae lie towards the bottom of the feature (Duday 2006, 40).

The collapse of the pelvic girdle can be prevented, even in empty spaces, by bilateral pressure from a narrow container of soft or hard material (Duday 2006, 44, 2009, 41). The collapse of these bones can also be prevented, at least to some extent, by the rapid penetration of fluid sediment, such as by an hourglass effect.

Observations at the level of the sacrum may indicate particular aspects of the original position of the body. The rotation forwards and downwards of this bone and following disarticulation at the lumbosacral joint, with the formation of an angle between the L5 and the sacrum, may indicate a sloping floor and/or a body in a sitting position (see above, Observations of the lumbar vertebrae).

Bones of the lower limbs

Patellae

Observations at the level of the patellae may offer relevant information about the space of decomposition.

The position of the patellae is a diagnostic criterion for the space of decomposition and it is important to record their exact positions in the feature (Duday 2009, 35). During decomposition, as the os coxae become disarticulated, the femora tend to rotate outwards causing the patellae to fall and collapse in an empty space outside the knee joint (Duday 2009, 36). The movement of the patellae can be more moderate and slid in either direction, dragged by decomposition fluids constrained by the environment of the feature and by the initial position of the cadaver (Duday 2009, 34). The position of the patellae in anatomical position at the time of the excavation is a strong argument of a filled space of decomposition (Nilsson Stutz 2003a, 265).
**Bones of the feet**

Observations at the level of the bones of the feet may indicate aspects related to the nature of the deposit and the space of decomposition.

The bones of the feet are articulated by persistent joints at the level of the ankle and tarsal joints, and by labile joints on the distal portion of the feet. The maintenance in anatomical position of the distal portion of the feet is a diagnostic criterion for the primary nature of the deposit and indicative of decomposition in a filled environment (Duday 2009, 57).

**Initial position of the cadaver: additional observations about constraint effects**

Sediment and hypercontracted skeletons

The gradual penetration of sediment during the process of decomposition can accentuate the closure of the angles between the bones of the limbs enhancing the flexion of the joints (Duday 2006, 43, 47; 2009, 53–54). This constraint effect may occur if the body lies in direct contact with the sediment and affects the joints in flexion which become hypercontracted by the penetration of fine and fluid sediment. Explanations such as ties and/or tight wrappings must be based on arguments other than just the hyperflexion of the joints (Duday 2006, 43; 2009, 54).

Wrappings

Narrow grave features exert an obvious constraint effect on the cadaver. In some cases, the observed constraining effect cannot be explained by the narrowness of the feature, and may require alternative explanations such as the wrapping of the body (see Nilsson Stutz 2003a, 299). Wrapping of the body is difficult to confirm if direct elements such as the wrapping itself or items holding the wrapping are not preserved. Several indicators affecting the distribution of the bones must be addressed to confirm this hypothesis. The decomposition of a wrapped or tied body will present a general wall-effect, which is typically particularly visible at the level of the upper body, and can be outlined as follows (Nilsson Stutz 2006):

- the TC is compressed and presents a “narrow” appearance;
- the shoulder girdles are projected forwards and upwards and the clavicles are verticalized;
- the upper limbs are rotated inwards and possibly upwards, even if only slightly, and are placed in very close proximity to the TC.

While these indicators could be the effect of a narrow grave, the possibility of wrapping should be carefully considered, in particular if the limits of the grave are wider than the area occupied by the cadaver.

**The grave features**

This category consists of elements related to the physical appearance of the deposit where the human remains were found. It includes aspects related to the size (perimeter and depth), shape (e.g., oval, round, rectangle), and topography of the...
deposit, such as characteristics of the walls and the bottom of the feature. Aspects related to the surrounding sediment and filling of the deposit may also be included in this category.

One of the aims of the analysis of the grave features is the identification and description of the structure(s) that contained the human remains at the time of the deposit, i.e., the container. In archaeothanatology, the term container refers to any of the possible ways to contain a cadaver, such as a simple pit dug out of the ground, a shroud (see above, Wrappings), a wood roof, or a box such as a coffin or sarcophagus, or even a chamber. Thus, one deposit may accommodate several containers involving the cadaver. Archaeological observations, such remains of wood, nails or other architectonic elements, as well as by the identification of the limits of the grave pit, may allow the direct identification of the container(s). The archaeothanatological analysis enhances the identification of such structures, even without the direct observation of the remains, and also when the pit limits are difficult to recognize in the field.

The characteristics of the container, where the remains are deposited, will influence the taphonomic history of the deposit, as well as the position of the skeletal elements recovered in the archaeological context. In archaeothanatology, key observations used in the reconstruction of the grave features are indirect indicators showing the effect of the container on the organization of the skeleton (Duday 2006). This requires a multiple set of observations, in particular those related to constraint effects, such as wall-effects or fluid penetration of sediment causing hypercontraction. Likewise, indicators of collapse of bone elements are also valuable for the reconstruction of the grave features. Original empty spaces in the grave feature can promote the scattering of the bone elements. Other elements, such as structures placed behind the bodies (e.g., headrest, cushions, and wooden platforms) can also be responsible for disorder of the bones, and potentially can be identified through archaeothanatology.

Deposits containing more than one individual

Often, archaeological features with human remains contain more than one individual. Archaeothanatology is particularly useful in this kind of analysis because it allows reconstruction of the original context and recognition of whether the deposits are synchronous (simultaneous or successive/consecutive) or asynchronous (Duday 2009, 72).

The synchronous deposit of more than one individual is easily argued when the archaeothanatological analysis indicates that the corpses were in anatomical integrity when they came in contact with each other (Duday 2009, 76). It is normally difficult to determine if the deposits were made at the same time (simultaneous) or within a short period of time (successive/consecutive), because even the labile joints may remain intact for some days, or even weeks. The argument for a synchronous deposit (either simultaneous or successive/consecutive) becomes more difficult to support if the bodies are not intertwined, making it hard to determine the time gap between the depositions. Other observations, such as the common
arrangement of the bodies (e.g., facing each other) may support the main argument, but are not conclusive.

The asynchronous deposit of more than one individual in a feature is the common practice in collective burials (see definition below). The practice of reduction can be included in this category (Duday 2009, 72), and entails the removal of the remains of a previous deposit to give place to the deposit of a new individual (see below, Post-depositional manipulations of the cadavers). In all these cases, the deposit of a new individual is an independent episode from the previous deposition(s) in the feature.

Funerary contexts: one single structure
The synchronous or asynchronous deposit of human remains may take place in one single structure. Deposits in one single structure may indicate different mortuary practices and their description and definition should be explicit to avoid ambiguity in the interpretation. Funerary contexts in one single structure are distinguished by the number of individuals in the structure, one or more than one individual, and most significantly, by the chronology of disposal of the human remains, synchronous or asynchronous. Accordingly, funerary deposits in one single structure can be: individual, multiple, or collective deposits (table 3.7).

Table 3.7. Funerary contexts in one single structure.

<table>
<thead>
<tr>
<th>Individual deposit</th>
<th>Multiple deposit</th>
<th>Collective deposit</th>
</tr>
</thead>
<tbody>
<tr>
<td>one structure</td>
<td>one structure</td>
<td>one structure</td>
</tr>
<tr>
<td>one individual</td>
<td>two or more individuals</td>
<td>two or more individuals</td>
</tr>
<tr>
<td></td>
<td>synchronous deposit (successive/consecutive)</td>
<td>asynchronous deposit</td>
</tr>
<tr>
<td>e.g., one individual in a pit</td>
<td>e.g., two inds. buried synchronously in the same pit</td>
<td>e.g., family tomb</td>
</tr>
</tbody>
</table>

One single funerary structure defined for the mortuary remains of one individual is an individual deposit. This structure can be as simple as a pit dug in the soil, or as complex as a pyramid containing the remains of one individual. A container with the cremated remains of one individual also belongs in this category.

The distinction between multiple and collective deposits is based on the chronology of disposal. These terms are often used interchangeably. However, these expressions reflect specific cultural options that should be made clear by the use of appropriate terminology. A multiple deposit contains the synchronous disposal (successive or consecutive) of two or more individuals in one structure. In archaethanatology, a multiple deposit such as a double burial, can be demonstrated by showing that the cadavers “retained their anatomical integrity when they came in contact with each other” (Duday 2009, 75–6). If the labile joints of one individual were disturbed by the placement of a new cadaver in the feature, it indicates that the deposits were not synchronous. Multiple deposits can accommodate various individuals, deposited in a short time frame between each disposal, as in contexts of mortality crisis related to catastrophes, massacres or plagues, as long as it
can be demonstrated that the cadavers were in anatomical integrity at the time of the deposit, thus indicating a relatively short period between the disposals (Duday 2009, 98). Mortuary practices in a collective deposit follow a very different cadence. A collective funerary structure is used over a more or less long period of time where two or more individuals are deposited during separate events (Duday 2009, 105). Passage graves, dolmens, and family tombs are good examples of collective funerary deposits. These are single funerary structures successively re-opened for the deposit of new individuals over a period of time.

Funerary contexts: more than one structure

After considering the different types of disposal of human remains in one single structure, according to the number of individuals and time frame, we can focus on contexts with more than one funerary structure, i.e., cemeteries. Essentially, a cemetery accommodates a number of funerary structures regardless of the number of individuals and tempo of disposal. In its simplest definition, a cemetery can be defined as a funerary complex that accommodates more than one funerary structure, organized in a more or less complex manner (Duday 2009, 13). In modern cemeteries it is not uncommon to find the three types of funerary deposits described above: individual, multiple, and collective (fig. 3.14), but this seems to be less common in earlier periods. As a last observation on terminology, I have chosen to avoid the term necropolis and opted for the term cemetery instead, but more often I use the term burial ground. Necropolis is a common term used in archaeology and it has been used to cover a variety of categories where human remains are found in archaeological contexts, including cemeteries. Besides its vague definition, the term has an urban connotation derived from the Hellenistic Greek language, the city of the dead, which may not be the most suitable for deeper chronologies.

Figure 3.14. Terminology: a cemetery accommodates more than one funerary structure. A cemetery may contain one or all three categories of funerary structures.
Post-depositional manipulations of the cadavers

Post-depositional manipulations of the cadavers refer to the handling of human remains after deposit in the primary feature (Nilsson Stutz 2003a, 309). This deliberate action is part of the funerary process in multiple episodes and can be identified by the retrieval of selected bone elements from a primary deposit or by the identification of human remains in secondary position (see above, *The nature of the deposits*). In the analysis of post-depositional manipulations it is important to keep in mind the idea of intentionality of the practice (Duday 2009, 14, 89) which should not be interpreted in the same way as the taphonomic or accidental disturbance of the remains. Likewise, the practice of *reduction* should not be considered in this category because this gesture, while literally being a post-depositional manipulation, has a practical intention behind it, aimed at giving the necessary space to a new deposit (Duday 2009, 72). Nevertheless, it may be relevant to discuss the presence or absence of reductions when discussing mortuary practices as it may provide relevant information about the spatial organization of the mortuary areas and the space allocated for the dead.

Archaeothanatology in this study

Archaeothanatology emerged in the context of field archaeology and the application of the method requires detailed documentation of the human remains during the process of excavation. The method lays great emphasis on the field situation and it has been argued that assessment of the material may not be possible if key observations are not documented in situ (Duday 2006, 30). Depending on the quality of the field documentation the method of archaeothanatology may be applied in post-excision stages even when the archaeothanatological approach was not carried out in the field. A thorough excavation and documentation of the archaeological context with of the human remains, particularly when including key observations about the spatial distribution of the bones and their tridimensional registration, and high resolution graphic documentation showing diagnostic elements of analysis, may allow the application of the method with few restrictions (see e.g., Nilsson Stutz 2003a). Furthermore, recent studies (see e.g., Tõrv 2015), including the present dissertation, consistently show that archaeothanatology has great potential for the analysis of museum collections from old excavations that otherwise would remain unexplored, although with acknowledged restrictions (Tõrv and Peyroteo Stjerna 2014).

Source material: the challenges

The archaeological material selected for this study comes from historical excavations containing some of the most exceptional material from the European Mesolithic. Early excavations impose important limitations to the analysis of the material, not only because of the methods of excavation and registration but also due to curation problems (see chapter 2).
Chapter 3

In this dissertation, the archaeothanatological analysis relies on graphic documentation (drawings and field photographs), and on the human remains preserved in natural or artificial blocks. The written documentation (field notes, diaries, reports, letters, published articles, and one monograph) was used as supplementary documentation, except in the case of the analysis of the Moita do Sebastião where the main source of information is the written documentation published in a monograph. The completeness and detail of each analysis is dependent on the character and quality of the available source material, presented in detail for each site in chapter 4.

**Graphic documentation: drawings**

The field drawings available for the Sado valley are not only more abundant but of greater quality than the material available for the Tagus sites. This is because the National Museum of Archaeology (MNA), which was in charge of the excavations in the Sado valley, kept a professional artist on the staff, who very skilfully drew most of these shell middens. The material dated to 1956 was sketched by A. Paiva, and all documentation after 1958 by D. Sousa.

The few drawings available for the Tagus sites consist of very simple sketches of the human remains, site plans, and site profiles. Most of this documentation is published (Abrunhosa 2012; Cardoso and Rolão 1999–2000; Jackes and Alvim 2006; Roche 1965, 1967, 1972).

The human skeletons excavated in the Sado valley were individually drawn at a scale of 1:20. The skeletons were completely exposed and cleaned for the task of documentation, and if there were any other materials close to the skeleton, such as lithics or shell beads, these were removed before the drawing of the bones in situ (Dario de Sousa, pers. comm.). The drawings are in plan view and the measurements are accurate. In a few cases, the relative depth of some skeletal elements is documented. The skeletons are also documented in the site plans and in the site profiles, although in much less detail. The limitations of these drawings can be outlined as follows:

- in some cases the sketched view is somewhat distorted, presenting a mix of plan and profile views;
- there is a common lack of bone landmarks, possibly due to limited knowledge of human anatomy, making it difficult to identify the side of appearance of the bone elements;
- despite the realism and attention to detail presented in the drawings, it seems that in some cases the artist opted to represent the bone elements in articulation, when in fact they were not (e.g., articulations at the level of the pelvic girdle).

Other drawings available for the Sado sites include site plans and profiles with and without the human skeletons, and detailed drawings of concentrations of faunal remains.
Methods: Archaeothanatology

Graphic documentation: field photographs

Most of the few field photographs available for the Tagus sites are published (Abrunhosa 2012; Cardoso and Rolão 1999–2000; Cartailhac 1886; Ribeiro 1884; Jackes et al. 2014; Roche 1972). The material available for the Sado valley is in the archives of MNA and is in general poorly preserved. Overall, the field photographs are not abundant and are in general of poor quality, presenting several limitations:

- most photographs are not in plan view, resulting in distortion of depth and of the relative position of the skeletal elements;
- the photographs have no scale;
- the photographs present a general view of one or several individuals and the lack of close-up views restricts access to diagnostic skeletal elements; also in most cases it is unclear if the indistinctness of diagnostic elements is due to preservation, disturbance and/or exposure;
- bones that are underneath others, or covered by sediment, do not appear;
- the common size for the Sado valley photographs is c 12 x 8 cm presenting one whole skeleton, or several individuals;
- all photographs are in black and white making it difficult to distinguish colouration of the sediments.

These limitations introduce a significant uncertainty to the analysis. Nevertheless, the drawings and photographs when available are valuable documents and provide information that would not be available otherwise. The strategy of analysis is to combine and intersect the documentation, without relying on one single source.

Human remains

One particularity of these collections is the maintenance of the human remains in natural blocks of carbonate matrix or artificial preservation in blocks of paraffin wax. The material from the Tagus sites is normally heavily covered with a hard matrix of sediment and shells and in several cases, the human remains were kept within this cement, at least partially. Also, throughout the twentieth century, one of the most common procedures in recovering the skeletons was to cover them with paraffin wax and transport them in blocks to the museum. This procedure restricts a series of bioanthropological observations (Cunha and Umbelino 1995–97, 167), as well as chemical analysis, but it is very conducive to archaeothanatology, since it provides access to the remains as they were when excavated decades ago. Unfortunately, in the 1980s, an anthropologist with a different research agenda removed the wax from most of the blocks curated at MNA, and as a consequence most material is removed from its context.

The material maintained in blocks is extraordinary and should be preserved. However, this apparently perfect source material can be deceptive. The human remains preserved in blocks are not completely excavated and several bones and diagnostic elements, remain within the sediment, or underneath other bones, and
are also covered by wax. Another problem when working with material preserved in blocks, is that while the wax or sediment hides certain features, the block itself emphasizes other elements, and this distortion if not critically addressed can lead to misinterpretations. Here again, I would like to emphasize that when working with material from historical excavations, we should not rely on one source – even if that source is the block with the human remains as they were when originally excavated.

**Archaeothanatology in the lab: the strategies**

Archaeothanatological analysis from historical sources is challenging but possible (Tõrv and Peyroteo Stjerna 2014). The method has no cultural or chronological boundaries, and can be applied both in the field and in the laboratory.

One strategy is to cross-reference the different sources critically and to combine multiple observations in order to demonstrate the validity of the interpretation. When applying archaeothanatology to post-excavation documentation, the analysis should not rely on one kind of data, even if apparently very complete.

A second strategy is always to refer to comparative material and similar patterns published in the literature. This is a valuable way to compare and test observations with reference material fully excavated according to the principles of the method. Unfortunately, this is not always possible either because of the lack of case studies available, or due to the singularity of the patterns under investigation. Following this, in order to carry out more precise analyses, more comparative material is needed, ideally based on common protocols and terminology. Comparative data must be explicit, clear, and published. This is a fundamental strategic link between work in the field and future possibilities in the laboratory. It is based on a growing body of knowledge that *Archaeothanatology in the lab* can proceed as a strong and reliable method for the study of mortuary practices from the almost unlimited source material that has been stored for decades in our museums (Tõrv and Peyroteo Stjerna 2014).

A third strategy is to understand the context of data production, allowing the informed and necessary critical assessment of the documentation. Access to archives and original documentation is the closest we can get to the fieldwork situation. Knowledge about the general context of the excavation may be as important as the context of the human remains (see Tõrv 2015).

Archaeothanatology offers a step-by-step, observation-based argument to confirm or disprove hypotheses. When carrying out this type of analysis, all apparently small pieces of information can be revealing. Presumed good sources should not overshadow other sources that at first seem to be less informative. Archaeothanatology in the lab must be done through multiple filters while cross-referencing with published and well described reference material. This way, it is possible to achieve sufficient resolution for the archaeothanatological analysis of historical collections. Interpretations of the material may remain open, possibly to be resolved with new data or further developments of the method. In fact, this is not a limitation of the method, but an opportunity and a research challenge (Tõrv and Peyroteo Stjerna
2014). Despite the limitations, archaeothanatology is certainly one of strongest and most reliable methods to assess, study, and retrieve new valuable data from the extensive archaeological assemblages at our disposal in museums all over the world.
Chapter 4
Results

Introduction

This chapter is organized by archaeological site starting with Moita do Sebastião and Cabeço da Arruda in the Tagus valley, followed by Arapouco, Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó, in the Sado valley. The sites are introduced by the Site background: a short history of research containing a synthesis of basic elements about the site. This section is followed by the presentation of the results of this dissertation, which is organized in three parts, according to the three methodologies used in this study: radiocarbon dating and Bayesian analysis, stable isotope analysis of carbon and nitrogen, and archaeothanatology. The results are analysed, contextualized and synthesized in chapter 5.

In the section Chronology of the burial activity, I present the results of the $^{14}$C dating programme, calibration and statistical treatment of all $^{14}$C dates on human bone collagen available for each site. In this section, I present:

- Previous $^{14}$C measurements
- Objectives of the dating programme (macro-goals related to the general aims of this dissertation and micro-goals which are site-specific)
- Sampling strategy
- Results
- Calibration and chronological models

The chronological data is followed by the presentation of the results obtained for the stable isotopic analysis of carbon and nitrogen of human bone collagen, which can be outlined as follows:

- Previous measurements: $\delta^{13}$C and $\delta^{15}$N
- Sampling strategy
- Results

In the third section, I present the results of the archaeothanatological analysis. For each central aspect analysed I give the whole set of results summarized in a table. Several burial contexts are described in detail (e.g., burials at Arapouco, and at Vale de Romeiras in the Sado valley) as illustrative examples depending on the quality of the source material of each site. The presentation of the results is organized according to the following categories:
Chapter 4

- The nature of the deposits
- The space of decomposition of the cadaver
- The initial position of the cadaver in the feature
- The grave features
- Deposits containing more than one individual
- Post-depositional manipulations of the cadavers
- The mortuary programme
Tagus valley: Moita do Sebastião

Site background: a short history of research

Moita do Sebastião (also known as Fonte da Burra) is a shell midden site located on a low terrace on the left bank of the tributary Muge, c. 4 kilometres from the confluence with the Tagus River. The site has excellent access and visibility towards the river and towards Cabeço da Arruda on the opposite margin. The neighbouring site of Cabeço da Amoreira is just c. 700 metres east (fig. 2.2).

The site was first excavated in the nineteenth century by the Geological Commission: in 1880 (Ribeiro 1884), and in 1884–85 (Paula e Oliveira 1888–92). Dozens of human skeletons were excavated (table 4.1), and most of them, if not all, were found in the basal terrace sands (Jackes and Alvim 2006). This assemblage is curated at the Geological Museum in Lisbon (MG).

The next and last seasons of excavations were directed by J. Roche and O. V. Ferreira, between 1952 and 1954, after the destruction of the top layers, which were estimated to be at c. 2.5 metres from the bottom (Roche and Ferreira 1967). The 1950s excavation area was presumably contiguous to the areas excavated in the nineteenth century (Alvim 2009–10) (fig. 4.1). In these three years, 34 graves (sépultures, Roche 1972) were registered, and some of them contained the remains of more than one individual (Ferembach 1974; Roche 1972). The 1952–54 collection is curated at the Museum of Natural History, University of Porto (MHNUP).

Most human remains from Moita do Sebastião are preserved in disarticulated state. A few individuals are maintained in blocks of carbonate matrix, at least partially, including two individuals excavated in the nineteenth century.

Table 4.1. Estimated number of individuals excavated each year at Moita do Sebastião, Tagus valley.

<table>
<thead>
<tr>
<th>Year of excavation</th>
<th>Number of individuals</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1880</td>
<td>MS + CAR, MNI 120</td>
<td>Ribeiro 1884</td>
</tr>
<tr>
<td>1884</td>
<td>13</td>
<td>Paula e Oliveira 1888–92</td>
</tr>
<tr>
<td>1885</td>
<td>39</td>
<td>Paula e Oliveira 1888–92</td>
</tr>
<tr>
<td>1954</td>
<td>MNI 7 (sépultures 28–34)</td>
<td>Roche 1972</td>
</tr>
</tbody>
</table>

Total recovery, MNI = 86 + unknown number for 1880
Figure 4.1. Moita do Sebastião, Tagus valley: excavation areas with human skeletons. The human remains excavated in 1952–54 are identified in grey circles, A, B, and C. The areas excavated in the nineteenth century are identified by circle (1880) and ellipse (1884–85), but the exact location of the human burials is unknown. (Reproduced from Alvim 2009–10, 44, fig. 13).

The MNI calculated for the assemblages at both MG and MHNUP is 85 (Jackes and Meiklejohn 2008), which is lower than what was probably recovered in the field (table 4.1). Ferembach (1974) reported the analysis of 136 individuals: 96 individuals curated in Lisbon (MG) and 40 in Porto MHNUP (table 4.2). The number of individuals recovered at Moita do Sebastião was certainly higher than 85, and as previous authors have pointed out it is likely that some osteological material may not have survived in the current collections (Jackes and Alvim 2006).

Table 4.2. The various MNI estimates proposed for Moita do Sebastião, Tagus valley.

<table>
<thead>
<tr>
<th>Estimated MNI</th>
<th>Collections</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>136</td>
<td>MG and MHNUP</td>
<td>Ferembach 1974</td>
</tr>
<tr>
<td>79</td>
<td>MG and MHNUP</td>
<td>Jackes et al. 1997</td>
</tr>
<tr>
<td>85</td>
<td>MG and MHNUP</td>
<td>Jackes and Meiklejohn 2008</td>
</tr>
<tr>
<td>42</td>
<td>MHNUP</td>
<td>Cunha and Cardoso 2002–03</td>
</tr>
</tbody>
</table>
Most original written documentation available for Moita do Sebastião is from the excavations of 1952–54. These belong to a private collection but are published (Cardoso and Rolão 1999–2000), at least partially. This documentation consists of field notes in a diary format handwritten by O. V. Ferreira. The field notes that J. Roche certainly wrote are presumably destroyed (see chapter 3, *A note on the historical documentation*). The graphic documentation is also published (Cardoso and Rolão 1999–2000; Jackes et al. 2014; Roche 1972) and consists of site plans, a few field photographs, and simple sketches of the human remains. A few short notes from the nineteenth century have been identified and published (Jackes and Alvim 2006).

Among the middens of the Tagus and Sado valleys, Moita do Sebastião is the only site with a dedicated monograph, published in two volumes. The first volume is centred on the archaeological data (Roche 1972), and the second volume presents the anthropological analysis of all human remains excavated at the site (Ferembach 1974). These volumes contain detailed descriptions of the grave features, and a site plan with the location of the human remains.

Chronology of the burial activity

**Previous $^{14}$C measurements**

In 1954, J. Roche collected and submitted a sample of charcoal from Moita do Sebastião for $^{14}$C dating (Roche 1957). The charcoal was collected under the shell layers in the bottom level of the midden. This was the first $^{14}$C measurement (Sa–16, 7350 ± 350 BP) obtained from any site in Portugal, and was analysed in 1957 at the Laboratoire d'Electronique Physique du Centre d'Études Nucléaires de Saclay in France (Roche 1957, 1965, 160). Some years later, a second sample on charcoal (H–2119/1546), from the same excavations was submitted for $^{14}$C dating (Delibrias and Roche 1965) (table A3).

The first $^{14}$C measurements on human bone from Moita do Sebastião (TO–131, TO–132, TO–133, TO–134, and TO–135) were carried out in the 1980s (Lubell and Jackes 1985; Lubell et al. 1994; Meiklejohn et al. 1986), collected from material excavated in the nineteenth century, and selected according to the different enveloping sediments. The results were consistent, with the exception of TO–135 (individual CT), which revealed a more recent date in comparison with the other samples (Lubell and Jackes 1985). The measurements were done by AMS at the Isotrace Laboratory of the University of Toronto, Canada, and independently measured for stable isotopes. The individual results for the C:N ratio were not published but were reported to be within the accepted quality range of 2.9–3.6 (Lubell et al. 1994, 204).

The human remains recovered during J. Roche’s excavations in 1952–54 remained undated until individual 16 was submitted for dating in the early 2000s (Beta–127499, Cunha and Cardoso 2002–03; Cunha et al. 2003). Unfortunately, the only $\delta^{13}$C value available for this skeleton was obtained by AMS (Cláudia
Umbelino, pers. comm.) which cannot be used for dietary reconstructions or reservoir corrections (Millard 2014, 557; Taylor and Bar-Yosef 2014, 117). For this reason, this sample is excluded from the ¹⁴C data set until IRMS-based δ⁰³C values are available (see chapter 3, Reliability of the isotopic measurements).

Objectives of the dating programme

Most ¹⁴C measurements available from the historical collections of the Tagus middens are from samples from Moita do Sebastião. Before this radiocarbon dating programme, six human skeletons were directly dated: five from the nineteenth century material and one from 1952–54, the latter, as discussed, with a problematic calibration.

The general aims of the dating programme for Moita do Sebastião followed the macro-goals of the radiocarbon programme of this dissertation outlined in chapter 3, and were:

- to determine the duration of use of this site for burial activity;
- to determine when the burial activity started and when it ended;
- to estimate the frequency of the burial activity in the site.

The site-specific aims of the dating programme for Moita do Sebastião were:

- to date the three main burial areas identified in 1952–54;
- to establish their chronological relationship to each other and to the nineteenth century collections.

Sampling strategy

Fourteen samples of human bone were selected for ¹⁴C analysis (table 4.3). The sampling strategy was focused on the material excavated in 1952–54 which, contrary to the nineteenth century collection, is plotted (fig. 4.2) and well described. These human remains were excavated from one layer at the bottom of the shell midden and were found clustered in three main areas (A, B, and C) (Roche 1972).

Sample pre-selection was based on the analysis of J. Roche’s site plan, and was targeted towards burials in the three main clusters, as well as individuals found in relatively isolated positions. The sampling was constrained for the preservation of the collection. One sample only was obtained from area B (MS1952–54, Sk18), and just two samples from area C (MS1952–54, Sks 22, 25), one of which was outside the main cluster (Sk22). Nevertheless, it was possible to get a good spatial coverage of the whole burial area, in particular of the largest concentration of burials located in area A, where only one skeleton was previously dated (Beta–127499, MS1952–54, Sk16).
Table 4.3. Moita do Sebastião, Tagus valley: samples of human bone (14) collected and submitted for $^{14}C$ measurement in the course of this study. All samples are from contexts excavated in 1952–54 in the bottom layer. This material is curated at MHNUP. Age and sex estimation by *C. Umbelino (2006), otherwise by D. Ferembach (1974).

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Site plan</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ua–46263</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia–L</td>
<td>Area A</td>
<td>The feature with ind. 1 had the remains of two adults: one male and one female (Ferembach 1974; Roche 1972). Ind. 3 was the first choice because of its central position in the burial area, but was not possible to sample.</td>
</tr>
<tr>
<td>5</td>
<td>Ua–47977</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone–R</td>
<td>Area A</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>Ua–46264</td>
<td>Adult</td>
<td>♂</td>
<td>Tibia–L</td>
<td>Area A</td>
<td>–</td>
</tr>
<tr>
<td>10*</td>
<td>Ua–47978</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Tibia–L</td>
<td>Area A</td>
<td>Previous stable isotope analysis of the same bone (Umbelino 2006).</td>
</tr>
<tr>
<td>14</td>
<td>Ua–47979</td>
<td>Adult</td>
<td>♂</td>
<td>Tibia–L</td>
<td>Area A</td>
<td>Doubtful quality.</td>
</tr>
<tr>
<td>17</td>
<td>Ua–47980</td>
<td>Adult</td>
<td>♂</td>
<td>Femur–R</td>
<td>Area A</td>
<td>–</td>
</tr>
<tr>
<td>18</td>
<td>Ua–46266</td>
<td>Adult</td>
<td>♂</td>
<td>Tibia–R</td>
<td>Area B</td>
<td>Ind. 19 was the first choice but was not possible to sample because it is on display. Ind. 20 was not sampled because it is well preserved in a block.</td>
</tr>
<tr>
<td>22</td>
<td>Ua–46267</td>
<td>Non-adult, c 2 yrs</td>
<td>n/d</td>
<td>Femur–R</td>
<td>Area C, outside cluster</td>
<td>–</td>
</tr>
<tr>
<td>25</td>
<td>Ua–46268</td>
<td>Non-adult, c 1 yr</td>
<td>n/d</td>
<td>Tibia</td>
<td>Area C</td>
<td>–</td>
</tr>
<tr>
<td>30</td>
<td>Ua–47981</td>
<td>Adult</td>
<td>♂</td>
<td>Humerus–R</td>
<td>Area A</td>
<td>–</td>
</tr>
<tr>
<td>31</td>
<td>Ua–46269</td>
<td>Adult</td>
<td>♀</td>
<td>Tibia–R</td>
<td>Isolated</td>
<td>Previous stable isotope analysis of same bone (Umbelino 2006).</td>
</tr>
<tr>
<td>33</td>
<td>Ua–46270</td>
<td>Adult</td>
<td>♀</td>
<td>Tibia–R</td>
<td>Area A, outside cluster</td>
<td>–</td>
</tr>
<tr>
<td>34</td>
<td>Ua–46271</td>
<td>Adult, old</td>
<td>♂</td>
<td>Tibia–R</td>
<td>Area A</td>
<td>–</td>
</tr>
</tbody>
</table>
Figure 4.2. Moita do Sebastião, Tagus valley, 1952–54: excavated area with human remains and individuals selected for $^{14}$C measurements. Burial features were numbered from 1 to 34 (Roche 1972, 116, fig. 29). Samples selected for $^{14}$C measurements are indicated by *rounded rectangles*. Individual 14 was selected for dating but the results were of doubtful quality.

**Results**

Nineteen $^{14}$C measurements on human bone collagen samples from Moita do Sebastião are available now, one of which (Beta–127499, MS1952–54, Sk16), as discussed, has a problematic calibration and was excluded from the present study. Five samples belong to human remains excavated in the nineteenth century and 14 samples, including Beta–127499, belong to human remains excavated in 1952–54 (table 4.4). One of the 14 samples (Ua–47979, individual 14) submitted as part of this study revealed poor quality during laboratory analysis and was rejected (table A1).
Table 4.4. Human bone collagen samples (19) from Moita do Sebastião, Tagus valley: $^{14}$C measurements and estimation of non-terrestrial carbon intake (% marine). Samples are sorted so that the lowest marine percentage is on the top of the table. Marine percentage was estimated from the measured $\delta^{13}$C value of each sample by the application of method marine 1 and method marine 2, based on adopted endpoint values of $-12\%$ and $-20\%$ for marine (100%) and terrestrial (100%) diets respectively.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements $^{14}$C by AMS; $\delta^{13}$C and $\delta^{15}$N by IRMS</th>
<th>% marine (±10)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind.</td>
<td>Excav. Museum</td>
<td>Lab no.</td>
<td>$^{14}$C Age BP</td>
</tr>
<tr>
<td>33</td>
<td>1952–54 MHNUP</td>
<td>Ua–46270</td>
<td>6743±44</td>
</tr>
<tr>
<td>10</td>
<td>1952–54 MHNUP</td>
<td>Ua–47978</td>
<td>6753±46</td>
</tr>
<tr>
<td>15</td>
<td>1952–54 MHNUP</td>
<td>Ua–46265</td>
<td>6986±40</td>
</tr>
<tr>
<td>30</td>
<td>1952–54 MHNUP</td>
<td>Ua–47981</td>
<td>7058±44</td>
</tr>
<tr>
<td>31</td>
<td>1952–54 MHNUP</td>
<td>Ua–46269</td>
<td>7141±40</td>
</tr>
<tr>
<td>1</td>
<td>1952–54 MHNUP</td>
<td>Ua–46263</td>
<td>7483±48</td>
</tr>
<tr>
<td>9</td>
<td>1952–54 MHNUP</td>
<td>Ua–46264</td>
<td>7621±50</td>
</tr>
<tr>
<td>18</td>
<td>1952–54 MHNUP</td>
<td>Ua–46266</td>
<td>7095±45</td>
</tr>
<tr>
<td>22</td>
<td>1952–54 MHNUP</td>
<td>Ua–46267</td>
<td>7120±43</td>
</tr>
<tr>
<td>No</td>
<td>Date</td>
<td>Site</td>
<td>Code</td>
</tr>
<tr>
<td>----</td>
<td>------------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>5</td>
<td>1952–54</td>
<td>MHNUP</td>
<td>Ua–47977</td>
</tr>
<tr>
<td>29</td>
<td>19th c.</td>
<td>MG</td>
<td>TO–133</td>
</tr>
<tr>
<td>17</td>
<td>1952–54</td>
<td>MHNUP</td>
<td>Ua–47980</td>
</tr>
<tr>
<td>24</td>
<td>19th c.</td>
<td>MG</td>
<td>TO–132</td>
</tr>
<tr>
<td>41</td>
<td>19th c.</td>
<td>MG</td>
<td>TO–134</td>
</tr>
<tr>
<td>34</td>
<td>1952–54</td>
<td>MHNUP</td>
<td>Ua–46271</td>
</tr>
<tr>
<td>25</td>
<td>1952–54</td>
<td>MHNUP</td>
<td>Ua–46268</td>
</tr>
<tr>
<td>22</td>
<td>19th c.</td>
<td>MG</td>
<td>TO–131</td>
</tr>
<tr>
<td>CT</td>
<td>19th c.</td>
<td>MG</td>
<td>TO–135</td>
</tr>
<tr>
<td>16</td>
<td>1952–54</td>
<td>MHNUP</td>
<td>Beta-127499</td>
</tr>
</tbody>
</table>
Calibration and chronological models

The chronological model was built on 18 $^{14}$C dates, 13 of which are new dates obtained in the scope of this study, and five were previously published.

This is a phase model which groups all dated burial events in a phase of burial activity. As recommended (Bronk Ramsey 1998, 2000, 2001) and discussed in chapter 3, this grouping is constrained by a start of burial activity event, and an end of burial activity event (i.e., boundaries). This calibration approach imposes no internal constraints to the relative order of the dated events, which is particularly useful when these are from one stratigraphic set. All it assumes is that the start event occurs before the dated events, and that these all occur before the end event. For the command files defined for this model see appendix.

Internal consistency and reliability of the model

Agreement index (A) for each dated event is good (fig. 4.3), except for the sample Ua–46264 (individual 9) which is in poor agreement (Marine 1: A=38.3%; Marine 2: A=38.2%) but in good convergence (Marine 1: C=98.4%; Marine 2: C=97.9%). This sample, Ua–46264 (individual 9), is the earliest dated burial in the site and is not an outlier to the model, rather, its greater age may suggest an earlier event relatively older than the group of events in the considered phase. The most recent burial event dated in the site (TO–135, individual CT) shows a satisfactory agreement index (Marine 1: A=80%; Marine 2: A=75.1%) but which is lower than the remaining events in the group (A>100%). This sample is not in poor agreement, but its relatively lower index and recent age may suggest a more recent event, relatively later than the main grouping.

The model shows satisfactory overall agreement (Marine 1: $A_{overall}$=81.9%; Marine 2: $A_{overall}$=81.7%), indicating that the $^{14}$C dates are in accordance with the prior information incorporated in the model, which assumes one phase of burial activity and does not impose a relative order to the dated events.

The results obtained when running the model with the different marine values (M1, M2) are statistically insignificant (table 4.5). For this reason, all further observations and graphic presentation are based on the results obtained with the model run with the values of M1. The results obtained with M2 are presented in the tables.

The chronological model for Moita do Sebastião, calibrated with M1 values, estimates the start of the burial activity to have been in 6365–6051 cal BCE (95% probability; start of burial activity) and its end to have been in 5603–5351 cal BCE (95% probability; end of burial activity) (fig. 4.4; table 4.6). The burial activity is estimated to have continued for between 469 and 816 years (95% probability; site use for burial activity), or 523 and 696 years (68% probability) (fig. 4.5; table 4.6).
Figure 4.3. Chronological model for the burial activity at Moita do Sebastião, calibrated using marine 1 diet values. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, *Tagus valley, Moita do Sebastião, Model 1, Marine 1*. 
Results: Tagus valley, Moita do Sebastião

Figure 4.4. Start and End of burial activity at Moita do Sebastião derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is 6365–6051 cal BCE (95% probability) or 6246–6088 cal BCE (68% probability). Posterior density estimated for the end of the burial activity is 5603–5351 cal BCE (95% probability) or 5557–5437 cal BCE (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Figure 4.5. Duration of burial activity at Moita do Sebastião derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the duration of the burial activity is between 469 and 816 years (95% probability), or 523 and 696 years (68% probability). Calibrated ranges of 95% and 68% are given by the lower and higher square brackets respectively.
Table 4.5. Human bone collagen samples (18) from Moita do Sebastião, Tagus valley: calibrated date ranges according to two different approaches for the calculation of the marine percentage (M1, M2). Results are presented in both (a) cal BCE and (b) cal BP in 95.4% confidence range. The calibrated date ranges are probability distributions derived from scientific dating alone. The posterior density estimates (in italic) are derived from Bayesian modelling. Samples are sorted so that the most recent dates are at the top of the column.

### (a) Cal BCE

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<tr>
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<th>Posterior density estimate (95% probability)</th>
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<td>5667–5487</td>
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<tr>
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<tr>
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### (b) Cal BP

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Table 4.5b. continued

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Table 4.6. Posterior density estimates for the dates of archaeological events (Start/End) and the duration of burial activity at Moita do Sebastião. Data derived from model described in fig. 4.3

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<td>End of burial activity</td>
<td>5557–5437</td>
<td>5580–5459</td>
<td>5603–5351</td>
<td>5613–5366</td>
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<td>Span of burial activity, duration</td>
<td>523–696 yrs</td>
<td>515–706 yrs</td>
<td>469–816 yrs</td>
<td>469–828 yrs</td>
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<tr>
<td>Overall model agreement (Aoverall)</td>
<td>81.9%</td>
<td>81.7%</td>
<td>87.9%</td>
<td>81.7%</td>
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Stable isotopes: carbon and nitrogen

**Previous measurements: $\delta^{13}C$ and $\delta^{15}N$**

The first measurements of stable isotopes ($\delta^{13}C$, $\delta^{15}N$) on human bone from Moita do Sebastião were carried out in the 1980s by H. Schwarcz at the McMaster University in Canada (TO–131, TO–132, TO–133, TO–134, and TO–135). The precision of analysis for $\delta^{13}C$ is $\pm 0.1\%$ and for $\delta^{15}N$ is $\pm 0.2\%$ (Lubell et al. 1994, 204). These five samples were also independently measured for $^{14}C$ dating (see above).

In the early 2000s, three samples from the 1950s excavations (Sks 10, 15, 31) were analysed in the scope of a palaeodiетary study (Umbelino 2006). Like the first measurements, these analyses were carried out at the McMaster University and the precision of the results are $\pm 0.1\%$ for $\delta^{13}C$ and $\pm 0.2\%$ for $\delta^{15}N$ (Umbelino 2006, 208–9). The C:N ratios were not provided but the laboratory confirmed the quality of the collagen and of the measurements (Umbelino 2006, 315). The $\delta^{13}C$ value published for MS1952–54, Sk16 (Beta–127499) along with its $^{14}C$ date (Cunha and Cardoso 2002–03; Cunha et al. 2003) was obtained via AMS and not by IRSM (Cláudia Umbelino, pers. comm.). This sample was not included in
Chapter 4

Umbelino’s palaeodietary study (2006), and as previously discussed it should not be used for dietary reconstructions and/or reservoir corrections.

All previous measurements were included in this study (n=8), as long as they fell within the accepted quality ranges as discussed.

**Sampling strategy**

In this study, the selection of samples of human remains for $\delta^{13}C$ and $\delta^{15}N$ measurements was fully dependent on the goals of the radiocarbon dating programme (see above).

**Results**

Samples Ua–number (n=13) were measured by IRSM and the precision of the measurements for both $\delta^{13}C$ and $\delta^{15}N$ is $\pm 0.1\%o$.

MS1952–54, Sks 10, 15, and 31 have multiple measurements (this study; Umbelino 2006) and present different values even when the same bone was sampled (Sks 10, 31) (table 4.7).

At Moita do Sebastião, the human collagen $\delta^{13}C$ values (n=21/no. individuals=18) range from –18.4 to –15.3‰ with a mean value of –16.9 ± 0.7‰. The human collagen $\delta^{15}N$ values (n=20/no. individuals=18) range from +9.0 to +14.0‰ with a mean value of +11.1 ± 1.3‰ (fig. 4.6; table 4.7). Measurement of $\delta^{15}N$ was not possible for the sample of MS1952–54, Sk15 (Umbelino 2006).

![Figure 4.6](image_url)

*Figure 4.6. Moita do Sebastião, Tagus valley: correlation between the $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) values of 20 samples of human bone collagen from 18 individuals. Individuals 10 (triangle) and 31 (circle) have two sets of values.*
Table 4.7. Moita do Sebastião, Tagus valley: carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) measurements on human bone collagen samples. Samples from the nineteenth century assemblages were collected at MG and samples from the 1952–54 material were collected at MHNUP. Age and sex estimation by C. Umbelino (2006), Mary Jackes (pers. comm.), otherwise by D. Ferembach (1974). Samples are sorted so that the lowest $\delta^{13}C$ values are on the top of the table. Individuals with multiple measurements are sorted together.

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<td>This study</td>
</tr>
<tr>
<td>5</td>
<td>1952–54</td>
<td>♂</td>
<td>Adult</td>
<td>Long bone–R</td>
<td>Ua–47977</td>
<td>7138±42</td>
<td>–16.9</td>
<td>9.3</td>
<td>3.1</td>
<td>44</td>
<td>39</td>
<td>This study</td>
</tr>
<tr>
<td>18</td>
<td>1952–54</td>
<td>♂</td>
<td>Adult</td>
<td>Tibia–R</td>
<td>Ua–46266</td>
<td>7095±45</td>
<td>–16.9</td>
<td>10.8</td>
<td>3.1</td>
<td>44</td>
<td>39</td>
<td>This study</td>
</tr>
<tr>
<td>22</td>
<td>1952–54</td>
<td>n/d</td>
<td>Non–adult, c 2 yrs</td>
<td>Femur–R</td>
<td>Ua–46267</td>
<td>7120±43</td>
<td>–16.9</td>
<td>12.8</td>
<td>3.2</td>
<td>44</td>
<td>39</td>
<td>This study</td>
</tr>
<tr>
<td>29</td>
<td>19th c.</td>
<td>♀</td>
<td>Adult</td>
<td>n/p</td>
<td>TO–133</td>
<td>7200±70</td>
<td>–16.9</td>
<td>10.4</td>
<td>n/a</td>
<td>44</td>
<td>39</td>
<td>Lubell and Jackes 1985; Lubell et al. 1994; Meiklejohn et al. 1986</td>
</tr>
<tr>
<td>17</td>
<td>1952–54</td>
<td>♂</td>
<td>Adult</td>
<td>Femur–R</td>
<td>Ua–47980</td>
<td>7105±42</td>
<td>–16.8</td>
<td>9.5</td>
<td>3.1</td>
<td>45</td>
<td>40</td>
<td>This study</td>
</tr>
<tr>
<td>24</td>
<td>19th c.</td>
<td>♂</td>
<td>Adult</td>
<td>n/p</td>
<td>TO–132</td>
<td>7180±70</td>
<td>–16.8</td>
<td>11.9</td>
<td>n/a</td>
<td>45</td>
<td>40</td>
<td>Lubell and Jackes 1985; Lubell et al. 1994; Meiklejohn et al. 1986</td>
</tr>
<tr>
<td>41</td>
<td>19th c.</td>
<td>n/d</td>
<td>Adult</td>
<td>n/p</td>
<td>TO–134</td>
<td>7160±80</td>
<td>–16.7</td>
<td>11.2</td>
<td>n/a</td>
<td>46</td>
<td>41</td>
<td>Lubell and Jackes 1985; Lubell et al. 1994; Meiklejohn et al. 1986</td>
</tr>
<tr>
<td>34</td>
<td>1952–54</td>
<td>♂</td>
<td>Adult, old</td>
<td>Tibia–R</td>
<td>Ua–46271</td>
<td>7236±41</td>
<td>–16.3</td>
<td>11.9</td>
<td>3.2</td>
<td>50</td>
<td>46</td>
<td>This study</td>
</tr>
<tr>
<td>25</td>
<td>1952–54</td>
<td>n/d</td>
<td>Non-adult, c 1 yr.</td>
<td>Tibia</td>
<td>Ua–46268</td>
<td>7243±45</td>
<td>–16.2</td>
<td>14.0</td>
<td>3.2</td>
<td>51</td>
<td>48</td>
<td>This study</td>
</tr>
<tr>
<td>22</td>
<td>19th c.</td>
<td>♀</td>
<td>Adult</td>
<td>n/p</td>
<td>TO–131</td>
<td>7240±70</td>
<td>–16.1</td>
<td>12.2</td>
<td>n/a</td>
<td>51</td>
<td>49</td>
<td>Lubell and Jackes 1985; Lubell et al. 1994; Meiklejohn et al. 1986</td>
</tr>
<tr>
<td>CT</td>
<td>19th c.</td>
<td>♂</td>
<td>Adult</td>
<td>n/p</td>
<td>TO–135</td>
<td>6810±70</td>
<td>–15.3</td>
<td>13.4</td>
<td>n/a</td>
<td>59</td>
<td>59</td>
<td>Lubell and Jackes 1985; Lubell et al. 1994; Meiklejohn et al. 1986</td>
</tr>
</tbody>
</table>
Archaeothanatology

Source material and analysis strategy
Source material for Moita do Sebastião is restricted to the excavations by J. Roche in 1952–54. It comprises field photographs of variable quality (Cardoso and Rolão 1999–2000; Jackes et al. 2014; Roche 1972), simple sketches, written documentation from field notes (Cardoso and Rolão 1999–2000) and from the monograph Le Gisement Mésolithique de Moita do Sebastião I (Roche 1972) and II (Ferembach 1974). Few skeletons are preserved, or partially preserved, in blocks of concretion, including two individuals excavated in the nineteenth century (table 4.8). Unfortunately, most skeletal material is in disarticulated state, often in containers with more than one individual.

Overall, the archaeothanatological analysis is limited, and in several cases it relies on indirect observations only, such as the descriptions of the excavators. The analysis was carried out on a total of 18 individuals, two excavated in the nineteenth century and 16 individuals excavated in 1952–54 (c 40% MNI 1952–54). In several cases, the analysis is restricted to a few portions of the skeleton where diagnostic criteria can be observed. In some cases it was possible to obtain data supporting general observations regarding the treatment of the dead, even when detailed analysis was not possible. For the remaining individuals excavated in 1952–54 (18 burial features), and for most of the assemblage from the nineteenth century, there is not enough source material available, at least at the time of this study.

Results of the archaeothanatological analysis

The nature of the deposits
Analysis of the nature of the deposits at Moita do Sebastião suggests a pattern of primary burials (table 4.9), indicating that the cadavers were placed in the burial features before the degradation of the labile joints. In four cases the labile articulations are poorly preserved and/or unclear in the documentation (MS1952–54, Sks 20, 21, 27, 32), however, the overall position of the bones strongly indicates that the bodies were disposed while still retaining their general anatomical integrity, supporting the interpretation of burials in primary position.

J. Roche (1972) noted that some grave features contained the remains of more than one individual. The documentation does not allow detailed analysis of these cases, and the possibility of placement of skeletal elements in secondary position cannot be excluded. Deposits presumably containing more than one individual will be discussed further below.
Table 4.8. Moita do Sebastião, Tagus valley: source material used for the archaeothanatological analysis. Material from the nineteenth century is curated at MG and the assemblage from 1952–54 is located at MHNUP.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Source material</th>
<th>Block</th>
<th>Graphic documentation w/ human remains</th>
<th>Field photographs</th>
<th>Written documentation</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>10, 19th c.</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Lower body is not preserved in the block. MS19thc., Sk10 described by Ferembach (1974) seems to be a different skeleton as the one currently identified.</td>
</tr>
<tr>
<td>43, 19th c.</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>Archaeothanatology is limited and partially possible at the level of the lower limbs.</td>
</tr>
<tr>
<td>3, 1952–54</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td></td>
<td>–</td>
</tr>
<tr>
<td>5, 1952–54</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>–</td>
</tr>
<tr>
<td>9, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>–</td>
</tr>
<tr>
<td>10, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Upper body is poorly preserved. Archaeothanatology is limited and partially possible on the lower limbs.</td>
</tr>
<tr>
<td>12, 1952–54</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>–</td>
</tr>
<tr>
<td>14, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and unclear documentation. Limited analysis.</td>
</tr>
<tr>
<td>15, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and unclear documentation. Limited analysis.</td>
</tr>
<tr>
<td>17, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and unclear documentation. Limited analysis.</td>
</tr>
<tr>
<td>19, 1952–54</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and unclear documentation. Limited analysis.</td>
</tr>
<tr>
<td>20, 1952–54</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and unclear documentation. Limited analysis.</td>
</tr>
<tr>
<td>21, 1952–54</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>The block contains the remains of probably two individuals, possibly disturbed. The bones are heavily covered with concretion and the analysis is extremely limited.</td>
</tr>
<tr>
<td>27, 1952–54</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and unclear documentation. Limited analysis.</td>
</tr>
<tr>
<td>30, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and limited documentation. Limited analysis.</td>
</tr>
<tr>
<td>31, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and limited documentation. Limited analysis.</td>
</tr>
<tr>
<td>32, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and limited documentation. Limited analysis.</td>
</tr>
<tr>
<td>33, 1952–54</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>Poor preservation and limited documentation. Limited analysis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Nature of the deposit</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10, 19th c.</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Labile articulations are poorly preserved. The bones of the left hand are covered with concretion and although their articulation is not clear, these are concentrated in front of pelvic girdle. The skeleton is well articulated and the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>3, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right and left hand, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>5, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Labile articulations are unclear in the documentation, except for the bones of the hands which are partially disarticulated. The overall position of the bones indicates that the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>9, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of left foot; other labile articulations are unclear in the documentation. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>12, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right hand, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>14, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of left foot. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>17, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>19, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of left hand, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
</tbody>
</table>
Table 4.9. continued

<table>
<thead>
<tr>
<th>No.</th>
<th>Date</th>
<th>Gender</th>
<th>Age</th>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Probably primary</td>
<td>Maintenance of labile articulations: bones of right hand, metatarsals and phalanges of feet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The skeleton is well articulated and the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>21</td>
<td>1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right hand, some metatarsals and phalanges of right foot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The skeleton is well articulated and the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>27</td>
<td>1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of left hand, metatarsals and phalanges left foot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The skeleton is well articulated and the general anatomical integrity of the body has been maintained.</td>
</tr>
</tbody>
</table>
The space of decomposition of the cadaver

Analysis of the space of decomposition of the cadavers buried in Moita do Sebastião indicates a general pattern of filled spaces (table 4.10). The cadavers were covered with sediment immediately after their placement in the features. The decomposition of the bodies took place in this sediment-filled environment. In several cases the analysis is unclear due to the poor preservation of the remains. In every case, the movement of the bones is limited suggesting that the space of decomposition was filled and that the sediment could penetrate immediately.

The initial position of the cadaver in the feature

The dominant position at Moita do Sebastião consists of a cadaver lying on the back (n=15 to 17). In one case only (MS1952–54, Sk10), it is possible that the cadaver was lying on the right side (see Jackes et al. 2014), but the data is not conclusive (table 4.11).

The head of the cadaver was often raised in relation to the trunk as illustrated by the rotation of the crania forwards and downwards towards the body in the feature. In a few cases, the excavators noted a volume of sand behind the crania (e.g., MS1952–54, Sks 3, 5, 9) (Roche 1972). In at least one case (MS1952–54, Sk12), the head was not elevated and was placed at the same level as the trunk.

The position of the upper limbs varied considerably, but they were normally placed close to the body, symmetrically (n=6 to 8) or asymmetrically (n=6), in extension, semi-flexion (mostly), flexion or hyperflexion. In most cases, at least one of the hands was placed on the abdominal or pelvic region. MS1952–54, Sk15 presents the exception to this pattern and his arms were placed in abduction, however, the forearms were lying towards the body and the hands were placed on the pelvic region. Two burials (MS1952–54, Sks 9, 12) present a particular disposal of one of the forearms. In these cases, one of the elbows is in hyperflexion (9–left, 12–right), the forearm having been placed in front of the respective arm with the hand lying on the respective shoulder.

Typically, the lower limbs were in flexion at the hip and knee joints, and the feet were positioned towards the buttocks in a constrained position. According to J. Roche (1972), the feet were usually close to the pelvic region, and they were often crossed or placed one against the other (MS1952–54, Sks 5, 12, 14, 15, 16, 22, 30). Hyperflexion is noted at the level of the knees only, probably in just two to four cases (MS19th c., Sk43; MS1952–54, Sks 19, 21, 31–right). MS1952–54, Sk9 was the only individual buried with the lower limbs in full extension (fig. 4.7). MS1952–54, Sk15 presents a similar position but in this case the limbs were placed in slight semi-flexion. Often, the rotation of the lower limbs is unclear in the documentation, but it seems that in just a few cases the limbs were rotated to the right (MS1952–54, Sks 17, 19–tendency, 31) or to the left (MS1952–54, Sks 12–tendency, 14). Normally, the knees would be directed forwards or towards one side while the feet were brought up towards the buttocks. In a few cases, the lower
limbs were probably placed towards the trunk. This is documented for MS1952–54, Sk10, but the documentation is unclear in most cases.
Table 4.10. *Summary of the space of decomposition of the human remains in the grave features at Moita do Sebastião, Tagus valley.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Space of decomposition</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10, 19th c.</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of bones in original unbalanced position: bones of left hand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>in front of pelvic region.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>43, 19th c.</td>
<td>Adult</td>
<td>♂️</td>
<td>Probably filled</td>
<td>Analysis not possible at the level of the upper body.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of bones in original unbalanced position: phalanges of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>feet.</td>
</tr>
<tr>
<td>3, 1952–54.</td>
<td>Adult</td>
<td>♂️</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: perfect articulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of the bones of right hand rotated and flexed at the wrist; moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>collapse of the bones of the left hand lying in the lower abdominal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>region.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The left patella lies in articulation at the distal end of the femur.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>5, 1952–54.</td>
<td>Adult</td>
<td>♂️</td>
<td>Filled</td>
<td>Diagnostic criteria are only partially exposed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of bones in original unbalanced position: moderate collapse</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of bones of left hand which placed in front of abdominal region;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>metatarsals of foot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>9, 1952–54.</td>
<td>Adult</td>
<td>♂️</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of the hands of the femora; the patellae are suspended on the distal end</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of the femora.</td>
</tr>
<tr>
<td>10, 1952–54.</td>
<td>Adult, 35–50 yrs</td>
<td>♂️</td>
<td>Probably filled</td>
<td>Diagnostic criteria at the level of the upper body are not preserved.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of bones in original unbalanced position: phalanges of right</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>foot.</td>
</tr>
<tr>
<td>12, 1952–54.</td>
<td>Adult</td>
<td>♂️</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>of the bones of os coxae; the bones of the feet are well articulated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>while rotated and placed in front of each other (left in front of right).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>14, 1952–54.</td>
<td>Adult</td>
<td>♂️</td>
<td>Probably filled</td>
<td>Unclear documentation but no movement outside initial volume of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cadaver.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>feet are rotated and placed in front of each other.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
</tbody>
</table>

*continued...*
| 17, 1952–54 | Adult | ♂ | Filled | Poor preservation and unclear documentation. Maintenance of bones in original unbalanced position: bones of the hands lying in front of each other on the lower abdominal region. No movement outside initial volume of the cadaver. |
| 19, 1952–54 | Adult | ♀ | Filled | Poor preservation and unclear documentation. Maintenance of bones in original unbalanced position: bones of left hand are rotated and lie in front of left shoulder girdle; bones of left foot. No movement outside initial volume of the cadaver. |
| 20, 1952–54 | Adult | ♀ | Filled | Poor preservation and unclear documentation. Maintenance of bones in original unbalanced position: bones of right hand are rotated at the wrist. No movement outside initial volume of the cadaver. |
| 21, 1952–54 | Adult | n/d | Unknown | The feature is disturbed and contains the remains of possibly two individual. The bones are only partially exposed and covered with a hard matrix of concretion. |
| 27, 1952–54 | Non-adult | n/d | Probably filled | Poor preservation and no graphic documentation. No movement outside initial volume of the cadaver. |
| 30, 1952–54 | Adult | ♂ | Filled | Poor preservation and unclear documentation. Maintenance of bones in original unbalanced position: moderate collapse of TC; bones of right hand. No movement outside initial volume of the cadaver. |
| 31, 1952–54 | Adult | ♀ | Filled | Poor preservation and unclear documentation. Maintenance of bones in original unbalanced position: bones of right hand are rotated and placed in front of left forearm; a portion of the right foot seems to be well articulated while rotated outwards. According to J. Roche (1972, 127) the CV can be followed as an arc forwards. No movement outside initial volume of the cadaver. |
| 32, 1952–54 | Adult | ♀ | Probably filled | Poor preservation and unclear documentation. No movement outside initial volume of the cadaver. |
| 33, 1952–54 | Adult | ♀ | Filled | Maintenance of bones in original unbalanced position: bones of the left hand are rotated and lie in front of LV; bones of the feet are rotated and placed in front of each other (left in front of right). No movement outside initial volume of the cadaver. |
Table 4.11. *Summary of the reconstruction of the initial position of the cadaver in the grave features at Moita do Sebastião, Tagus valley.* The initial position of the limbs is indicated as −R or −L, and refers to the right or left limb, when their positions are different. Rotation −R or −L indicates the rotation of the skeletal element(s) towards the right or the left side.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Initial position of the cadaver in the feature</th>
<th>Trunk</th>
<th>Upper limbs</th>
<th>Lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Head</td>
<td>Trunk</td>
<td>Upper limbs</td>
<td>Lower limbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10, 19th c.</td>
<td>Adult</td>
<td>n/d</td>
<td>n/a</td>
<td>On the back</td>
<td>In semi-flexion−L</td>
<td>Hip joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Knee joints: n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hip and knee joints: n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>43, 19th c.</td>
<td>Adult</td>
<td>♂</td>
<td>n/a</td>
<td>Probably on the back</td>
<td>n/a</td>
<td>Hip joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Knee joints: prob. hyperflexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>3, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Raised Rotation downwards (neck flexed forwards) − tendency R</td>
<td>On the back</td>
<td>In flexion−R</td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In semi-flexion−L</td>
<td>Rotation−R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>5, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Raised Slight rotation downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In semi-flexion</td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>9, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Raised Slight rotation downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In flexion−R</td>
<td>Hip and knee joints: extension</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In hyperflexion−L</td>
<td></td>
</tr>
<tr>
<td>10, 1952–54</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>n/a</td>
<td>On the back, or on the right?</td>
<td>n/a</td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In adduction towards trunk</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>12, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Rotation−L</td>
<td>On the back</td>
<td>In hyperflexion−R</td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In extension−L</td>
<td>Rotation−tendency L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>14, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>n/a</td>
<td>On the back</td>
<td>In extension−R</td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In extension−L</td>
<td>Rotation−L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet crossed and towards buttocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet against one another</td>
</tr>
</tbody>
</table>

*continued...*
<table>
<thead>
<tr>
<th>Date</th>
<th>Gender</th>
<th>Age</th>
<th>Position</th>
<th>Flexion</th>
<th>Rotation</th>
<th>Joint Flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td>17, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Raised</td>
<td>On the back</td>
<td>In semi-flexion</td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)</td>
<td></td>
<td>Rotation–R</td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)</td>
<td></td>
<td>In hyperflexion–L</td>
<td>Knee joint–R: n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hip joint–L: flexion</td>
<td>Knee joint–L: hyperflexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Knee joint–L: flexion</td>
<td>Left foot towards buttocks–tendency R</td>
</tr>
<tr>
<td>20, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Raised</td>
<td>On the back</td>
<td>In flexion–R</td>
<td>Hip joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)</td>
<td></td>
<td>In semi-flexion–L</td>
<td>Knee joints: flexion?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet crossed</td>
<td>Feet crossed</td>
</tr>
<tr>
<td>21, 1952–54</td>
<td>Adult</td>
<td>n/d</td>
<td>Raised</td>
<td>Probably on the back</td>
<td>n/a</td>
<td>Hip joints: prob. flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)</td>
<td></td>
<td>Knee joints: prob. hyperflexion</td>
<td>Prob. feet towards buttocks</td>
</tr>
<tr>
<td>27, 1952–54</td>
<td>Non-adult</td>
<td>n/d</td>
<td>n/a</td>
<td>On the back</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>30, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>Raised</td>
<td>On the back</td>
<td>In extension</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)</td>
<td></td>
<td>Feet next to one another towards buttocks</td>
<td></td>
</tr>
<tr>
<td>31, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Raised</td>
<td>On the back</td>
<td>In semi-flexion (c 90°)–R</td>
<td>Hip joint–R: semi-flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotated–R and downwards (neck flexed forwards)</td>
<td></td>
<td>In semi-flexion–L</td>
<td>Knee joint–R: hyperflexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hip joint–L: semi-flexion (c 90°)</td>
<td>Knee joint–L: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rotation–R</td>
<td>Prob. feet towards buttocks</td>
</tr>
<tr>
<td>32, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Raised</td>
<td>On the back</td>
<td>In semi-flexion</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)</td>
<td></td>
<td>Feet towards buttocks</td>
<td></td>
</tr>
<tr>
<td>33, 1952–54</td>
<td>Adult</td>
<td>♀</td>
<td>Raised</td>
<td>On the back</td>
<td>In extension or semi-flexion–R</td>
<td>Hip joints: semi-flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation downwards (neck flexed forwards)–tendency L</td>
<td>In semi-flexion–L</td>
<td>Knee joints: flexion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rotation–R</td>
<td>Prob. feet towards buttocks</td>
</tr>
</tbody>
</table>
The grave features

J. Roche (1972) described the grave features as natural depressions, or as pits excavated in the sand, possibly not very deep. The limits of the graves were difficult to determine during excavation, but according to the archaeologists, the floor of the graves was prepared to accommodate the cadaver (MS1952–54, Sks 3, 5, 7, 14, 30).

Archaeothanatological analysis suggests that the lateral pressures and wall-effects observed on the skeleton in the feature indicate that the shape and size of the pit was just sufficient to contain the body in the planned burial position (table 4.12). In most cases the design of the grave had a significant impact on the final arrangement of the body in the feature, visible by the constrained positions of most skeletons, particularly at the level of the lower limbs. Often, the lower limbs were supported by the wall of the grave, keeping the feet towards the buttocks. While the pit imposed physical limits on the cadaver, by maintaining the lower limbs clumped together, it also provided lateral support preventing the collapse of the skeletal elements. At the level of the upper body, this is demonstrated by bilateral pressure exerted on the body, observed in most cases.

It is possible that in some cases there might have been an extra support offered by some kind of container such as a light wrapping. MS1952–54, Sk9 (fig. 4.7) presents one of these cases, where the strong bilateral pressures could suggest the existence of a soft wrapping at the time of the burial. This adult male (Ferembach 1974) was lying on the back, with the head slightly elevated in relation to the trunk. The upper limbs were flexed or hyperflexed at the elbows, the right hand was placed on the chest and the left hand lay on the left shoulder. The most striking element of this burial is the placement of the lower limbs in complete extension, which is unique at Moita do Sebastião.

Another striking feature of this burial is the compression towards the medial axis of the body. The analysis suggests an overall bilateral pressure exerted on the body. Some diagnostic elements are unclear in the documentation, but the available arguments are strong. The wall-effect and consequent pressure on the upper body is well illustrated by the alignment and inwards rotation of the right humerus, the verticalization of the left clavicle, the alignment of the bones of the upper left limb, and the medial compression and verticalization of the ribs. These pressures seem to suggest the possibility of the existence of a soft wrapping surrounding the cadaver at the time of the burial. At the lower body, the lateral support of the skeletal elements seems to suggest another possible scenario. The os coxae were maintained in anatomical position, even after the slight outwards rotation of the femora, suggesting significant lateral support at this level. While the femora rotated, the patellae remained in perfect anatomical position, indicating direct contact with sediment, preventing the collapse of these unstable elements, which seems to invalidate the hypothesis of soft wrapping, at least at this level. The two latter arguments suggest that the overall compression of the skeleton could be explained by the narrow characteristics of the pit. In this scenario, the walls of the grave would have exerted a significant supporting effect on the skeletal elements. This
hypothesis could be excluded if some element in the feature suggested that the pit was wider than the area occupied by the body, but that was not the case. Overall, the hypothesis of a narrow pit seems to explain most of the observations in the feature; however, the wrapping hypothesis is possible, at least around the upper body, and cannot be completely excluded.

Figure 4.7. MS1952–54, Sk9 was the only cadaver lying on the back with the lower limbs in complete extension. Bottom figure, shows MS1952–54, Sk9 (superior right) lying on a sloping floor, slightly more elevated at the level of the head. (Photographs after Cardoso and Rolão 1999–2000, 200, fig. 38; Roche 1972, Plate III–1)
Two other cases (MS19\textsuperscript{th} c., Sk10; MS1952–54, Sk30) present strong arguments supporting the hypothesis of extra support provided by a soft wrapping of the cadaver. In these burials, the skeletal elements of the upper body present strong medial tendency, which is particularly well illustrated by the compression of the TC and verticalization of the ribs. The bilateral pressures are further demonstrated by the verticalization of the clavicles, the projection forwards and upwards of the shoulder girdles, and the strong alignment of the upper limbs placed close to the upper body. The skeletal elements of the lower body of MS19\textsuperscript{th} c., Sk10 are not preserved in articulation and there is no graphic documentation for this feature. In the case of MS1952–54, Sk30 (fig. 4.8), the os coxae have collapsed outwards and do not present any particular support at this level. The lower limbs are not preserved, but the position of the bones of the feet, placed towards the buttocks, indicate that the limbs were flexed at the hips and knees. It is plausible, but not conclusive, that the upper bodies of these cadavers could have been contained in a soft wrapping at the time of the burial. The placement of the bodies in a narrow pit remains valid, and possibly the most likely hypothesis.

\textit{Figure 4.8.} The upper body of MS1952–54, Sk30 presents strong medial tendency. This is illustrated by the compression of the TC and verticalization of the ribs. Bilateral pressures are further demonstrated by the verticalization of the clavicles, the projection forwards and upwards of the shoulder girdles, and the strong alignment of the upper limbs placed close to the upper body. (Photograph after Jackes et al. 2014, 134, fig. 10.2)

In some cases, the grave pits were somewhat wider allowing a relatively expanded position of certain skeletal elements, particularly at the level of the upper body (MS1952–54, Sks 5, 12, 15, 31). This is visible by the position of the humeri in abduction and/or by the expansion and partial opening of the rib cage (figs. 4.9, 4.10). Apart from MS1952–54, Sk15 (fig. 4.11), whose lower limbs were in slight semi-flexion at the hips and knees, all other cadavers were constrained by a wall-effect at the lower end of the grave.
Chapter 4

Figure 4.9. MS1952–54, Sk5. The opening of the lower portion of the rib cage indicates that the grave pit was wide enough to allow the expansion of the skeletal elements. (Photograph after Cardoso and Rolão 1999–2000, 201, fig. 39)

Figure 4.10. MS1952–54, Sk12. The position of the upper right limb in abduction suggests that the grave pit was relatively wide at this level. This is in contrast with the wall-effect at the lower end of the grave keeping the lower limbs aligned, and the feet in forced position directed towards the buttocks. (Photograph after Cardoso and Rolão 1999–2000, 201, fig. 39)
The floor of the graves was often irregular and sloping, however, the documentation is not always clear. The moderate downslope is suggested by the rotation forwards and downwards of the head, towards the body in the feature, registered in several cases. At least in one case (MS1952–54, Sk31) this rotation was very pronounced and the neck was in hyperflexion, as indicated by the flexion of the cervical vertebrae which could be followed in an arc forwards (Roche 1972, 127). However, as noted by J. Roche, the elevation of the head was sometimes aided by the placement of a volume of sand functioning as a headrest. Further elements supporting the sloping nature of the floors are indicated by the displacement observed at the level of persistent joints of the vertebral column (MS1952–54, Sks 3, 5, 9), suggesting the effect of an irregular surface and the rearrangement of the bones during the process of decomposition.
Table 4.12. *Summary of the key observations used in the reconstruction of the grave features at Moita do Sebastião, Tagus valley. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Pressures</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10, 19th c.</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Strong bilateral compression and constraint effects on upper body. Lower body: n/a. Design of the grave feature and/or soft wrapping.</td>
<td>1. Alignment of upper limbs positioned close to TC. Projection forwards and upwards of shoulders and arms. Medial compression of TC.</td>
</tr>
<tr>
<td>10, 1952–54</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>n/a</td>
<td>1. Suggested by exposure of right scapula indicating movement of the body towards left side; 2. Alignment of upper left limb, involving shoulder and arm; 3. Lower limbs are constrained and clumped together. Feet are forced towards buttocks.</td>
</tr>
<tr>
<td>14, 1952–54</td>
<td>Adult</td>
<td>♂</td>
<td>1. Prob. wall-effect, bilateral, upper body; 2. Wall-effect, left lower end. Design of the grave feature.</td>
<td>1. Suggested by alignment of the upper limbs affecting shoulders and arms; 2. Feet are forced towards buttocks.</td>
</tr>
<tr>
<td>No.</td>
<td>Date</td>
<td>Age</td>
<td>Sex</td>
<td>Notes</td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>---------</td>
<td>-----</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>15</td>
<td>1952–54</td>
<td>Adult, 25–35 yrs</td>
<td>♂</td>
<td>No particular pressures.</td>
</tr>
</tbody>
</table>
| 17  | 1952–54 | Adult | ♂   | 1. Prob. bilateral compression;  
2. Prob. wall-effect, lower end.  
Prob. design of the grave feature.  
Unclear documentation.          |
|     |       |       |     | 1. Suggested by alignment of the upper limbs affecting shoulders and arms;  
2. Suggested by constrained position of lower limbs clumped together, visible by the placement of feet towards buttocks. |
| 19  | 1952–54 | Adult | ♀   | 1. Wall-effect, bilateral, upper body;  
2. Wall-effect, lower left end.  
Design of the grave feature.  |
|     |       |       |     | 1. Alignment and compression of shoulders and upper limbs;  
2. Left foot towards buttocks. |
| 20  | 1952–54 | Adult | ♀   | 1. Wall-effect, bilateral, upper body;  
2. Prob. wall-effect, lower end.  
Design of the grave feature.  |
|     |       |       |     | 1. Alignment and compression of shoulders and upper limbs;  
2. Suggested by constrained position of lower limbs clumped together. |
| 21  | 1952–54 | Adult | n/d | 1. Overall constraint effect.  
Design of the grave feature?  |
|     |       |       |     | 1. Suggested by constrained position of lower limbs clumped together. |
| 27  | 1952–54 | Non-adult | n/d | n/a                                            |
| 30  | 1952–54 | Adult | ♂   | 1. Weigh of sediment from above;  
2. Strong bilateral compression and constraint effects on upper body.  
3. Prob. wall-effect, lower end.  
Design of the grave feature and/or soft wrapping. |
|     |       |       |     | 1. Crushing of frontal of cranium and movement inwards towards the calvaria while the lack of the cranium is perfectly preserved;  
2. Alignment of upper limbs positioned close to TC. Projection forwards and upwards of shoulders and arms. Medial compression of TC;  
3. Suggested by constrained position of lower limbs clumped together, visible by the placement of feet towards buttocks. |
| 31  | 1952–54 | Adult | ♀   | 1. Weigh of sediment from above;  
2. Wall-effect, lower end.  
Design of the grave feature.  |
|     |       |       |     | 1. Crushed cranium; hyperflexion of neck;  
2. Possible wall-effect at the lower end of the feature keeping the lower limbs clumped together, visible by the feet placed towards the buttocks. |
Design of the grave feature.  |
|     |       |       |     | 1. Suggested by alignment of shoulders and arms. |
| 33  | 1952–54 | Adult | ♀   | 1. Weigh of sediment from above;  
2. Wall-effect, bilateral, upper body;  
3. Wall-effect, lower end.  
Design of the grave feature.  |
|     |       |       |     | 1. Crushed cranium;  
2. Alignment and compression of shoulers;  
3. Suggested by constrained position of lower limbs clumped together, visible by the placement of feet towards buttocks. |
Deposits containing more than one individual

J. Roche (1972) describes 34 grave features excavated between 1952 and 1954, some of which containing the remains of more than one individual. That is the case of the graves 1, 7, 13, and 18. MS19th c., Sk20 was also identified as containing the remains of two individuals (Ferembach 1974). In every case, the remains were found disturbed and fragmented and the temporal relation between the individuals is unclear (Roche 1972). The site plan from the 1952–54 shows only individual burials (n=34). Also, in the descriptions by both J. Roche and O. V. Ferreira (Cardoso and Rolão 1999–2000; Roche 1972) it is clear that in each of these features, one individual was always identified as the main skeleton in the grave, suggesting that the remains of the second or third individual were older and deposited separately over a period of time. It seems likely that new burials may have disturbed previous deposits, and the older elements were displaced to accommodate the new cadaver. Field notes from June 1880 describe the skeletons placed in very close proximity, often overlapping, at least partially (Jackes and Alvim 2006). This practice, known as reduction, was presumably common at Moita do Sebastião, indicating the continued preference for these areas of the site for the burial of the dead. Based on the current documentation, there is no evidence to support the interpretation of simultaneous deposits at the Moita do Sebastião, but this hypothesis cannot be rejected either.

Post-depositional manipulations of the cadavers

At Moita do Sebastião, the bodies are apparently complete and lie generally undisturbed in the grave feature. As discussed above, some deposits were possibly disturbed to give place to a new burial.

It is unknown if the practice of re-opening the grave for the removal or rearrangement of selected elements occurred at Moita do Sebastião. Some cases seem to indicate post-depositional manipulations of the cadavers but the data is not conclusive. MS1952–54, Sk14 was found without the cranium while a fragment of the mandible remained in situ (Roche 1972, 122). The remains of this individual were disturbed and poorly preserved, and it is unclear if the missing cranium could be explained by preservation, disturbance or deliberate action. Skeletons of children were normally found incomplete (Roche 1972, 125–6). This could be explained by the intrinsically low resistance to decay of the bones of infant and juvenile skeletons (Mays 2010, 28). Two cases, however, are suggestive of post-manipulation of selected skeletal elements. One case is MS1952–54, Sk23, which has been described as an isolated cranium of a child deposited in a pit (Roche 1972, 125). The second case (MS1952–54, Sk24), was found next to the latter deposit, and contained most skeletal elements of the upper body of a child, including the cranium, while the lower limbs were missing. Overall, the poor preservation of the material and unclear documentation does not allow reliable observations at this level, but the hypothesis of post-manipulations of the cadavers is plausible and cannot be excluded.
Other observations

In the 1952–54 excavations, J. Roche (1972) documented the presence of ochre and other pigments, objects of adornment, charcoal and ashes, as well as the concentration of selected shells placed in the grave features.

Ochre and other pigments were found in small quantities and in small fragments in at least five graves (MS1952–54, Sks 3, 5, 6, 11, 14) (Roche 1972, 132).

Objects of adornment were identified in several graves, most notably in MS1952–54, Sks 1, 5, 6, 8, 11, 25 (Roche 1959, 408). These consisted mostly of pierced shells, such as *Theodoxus fluviatilis* (also known as *Neritina fluviatilis*), and were sometimes stained with ochre.

The floor of some graves was covered with selected shells (Roche 1972, 132). A layer of unopened grooved carpet shells (*Ruditapes decussatus*) was placed in the grave before the placement of MS1952–54, Sk3. MS1952–54, Sk 12 had a great quantity of non-pierced land snails (*Helix pisana*) all around the deposit (Roche 1972, 121). MS1952–54, Sk 33 was buried with a great quantity of peppery furrow shells (*Scrobicularia plana*). The most striking floor preparation was found in a child burial (MS1952–54, Sk 25), with the body being laid on its back on a layer of *Theodoxus fluviatilis* shells.

Fragments of charcoal and ashes are commonly found mixed in the grave sediment. J. Roche (1972) noted that in some cases, the relation between fire activity and the graves is more evident. According to the archaeologist, two cases (MS1952–54, Sks 1, 3) indicated that a fire was lit close to the cadavers. A third case (MS1952–54, Sks 34) suggested an intense fire near the cadaver, the heat of which was sufficient to have an impact on the cranium, at least superficially (Roche 1972, 132).

The mortuary programme at Moita do Sebastião

Archaeothanatological analysis of the human remains excavated at Moita do Sebastião is limited. Most human remains are preserved in disarticulated state, and the graphic documentation is limited to a few individuals. Nevertheless, the analysis indicates a general similarity of burial practices observed at the site and the minor detected variations do not affect the overall pattern of the treatment of the dead.

In the sample analysed, the cadavers were placed in individual grave features while retaining their anatomical integrity (individual primary deposits). The feature was then immediately covered with sediment, providing a filled space of decomposition.

The bodies were typically lying on the back in pits somehow adjusted to the size of the cadaver in the planned burial position. The upper limbs were normally placed close to the body and the hands were placed in front of the upper body in variable positions. The lower limbs were normally in flexion at the hips and knees, but rarely placed in front of the trunk. Often, the lower limbs were in contraction, and the knees were directed forwards, or alternatively directed towards one side. In
these cases, the feet were placed in a forced position towards the buttocks. These
constrained positions, particularly at the level of the lower limbs, were maintained
by the physical limits of the grave which provided support and kept the limbs
clumped together.

Some cases provide clear indications of the preparation of the graves; notably
by the arrangement of headrests made of sand and the inclusion of shells before
the placement of the cadaver in the grave.

Few cases present deviant elements, but there are exceptional instances of fea-
tures with, for example, possible wrappings, unique initial positions in the grave,
and particular preparation of the feature. Despite the striking and unusual ele-
ments, all these cases follow the common core characteristics of burial practices
observed in the sample analysed from Moita do Sebastião.
Tagus valley: Cabeço da Arruda

Site background: a short history of research

Cabeço da Arruda is a shell midden site located on a small headland on the edge of the flood plain, on the right bank of the tributary Muge, about 5 kilometres from the confluence with the Tagus River. This position makes the site vulnerable to occasional floods, particularly during the winter (Roche 1967, 79, 80, 1974, 25). The site has excellent visibility towards the river and towards Moita do Sebastião and Cabeço da Amoreira on the opposite margin (fig. 2.2). Cabeço da Arruda is possibly the largest shell midden known reaching c 5 metres in depth in the central area (Roche 1967, 79).

The site was identified and test excavated in 1863 by C. Ribeiro of the Geological Commission, the same year the first middens were identified. The first systematic excavations were carried out in 1865 by F. A. Pereira da Costa, and continued in 1880 by C. Ribeiro who aimed at presenting the site at the 9th International Congress of Prehistoric Anthropology and Archaeology in Lisbon (Ribeiro 1884). In 1884–85, F. de Paula e Oliveira expanded the excavations. His work was presented in a posthumous publication in 1892, becoming the first volume on a prehistoric site in Portugal (Paula e Oliveira 1888–92).

In the 1930s, M. Corrêa and collaborators from the Institute of Anthropology Porto University, started a new period of excavations at Cabeço da Arruda (Cardoso and Rolão 1999–2000). The first season in the summer of 1933 was relatively short possibly due to the excavation of few human remains (MNI 1) (Cardoso and Rolão 1999–2000, 172). The second season, in 1937 was longer (August to November), and presumably with better results (MNI 10).

In 1964–65 the site was excavated by J. Roche and O. V. Ferreira, under the Geological Services of Portugal, and the fieldwork was focused on the analysis of the complex stratigraphy of the site (Roche 1967; 1974, 27).

The last field season was in 2000, directed by J. Rolão, aiming at assessing the state of preservation of the site while reinforcing and protecting the profiles (Roksandic 2006).

Written sources indicate that c 80 individuals were excavated in the nineteenth century, while the excavations of 1933, 1937 and 1964–65 recovered c 11 and 13 individuals, respectively (table 4.13). The currently accepted MNI is 110 based on the assemblages at both MG and MHNUP (Cunha and Cardoso 2002–03) and the two burials excavated in 2000 (Roksandic 2006).
Table 4.13. *Estimated number of individuals excavated each year at Cabeço da Arruda, Tagus valley.*

<table>
<thead>
<tr>
<th>Year of excavation</th>
<th>Number of individuals</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1863</td>
<td>45</td>
<td>Pereira da Costa 1865</td>
</tr>
<tr>
<td>1880</td>
<td>MS + CAR, MNI 120</td>
<td>Ribeiro 1880</td>
</tr>
<tr>
<td>1884</td>
<td>13</td>
<td>Paula e Oliveira 1888–92</td>
</tr>
<tr>
<td>1885</td>
<td>?</td>
<td>–</td>
</tr>
<tr>
<td>1933</td>
<td>1</td>
<td>Abrunhosa 2012; Cardoso and Rolão 1999–2000</td>
</tr>
<tr>
<td>1937</td>
<td>10</td>
<td>Abrunhosa 2012; Cardoso and Rolão 1999–2000</td>
</tr>
<tr>
<td>1964</td>
<td>9 (Sks 1–9)</td>
<td>Cardoso and Rolão 1999–2000; Roche 1974</td>
</tr>
<tr>
<td>2000</td>
<td>2 (CA–00–01, CA–00–02)</td>
<td>Roksandic 2006</td>
</tr>
</tbody>
</table>

Total recovery, MNI = 84 + unknown number for 1880

Like Moita do Sebastião, the current MNI is probably lower than the number excavated at the site. The number of individuals excavated at Cabeço da Arruda could presumably go up to 150, admitting that some of the osteological material may not have survived in the current collections (Jackes and Meiklejohn 2008, 238), or even up to 170, according to original nineteenth century labels at MG.

Most human remains excavated in the nineteenth century by the Geological Commission are curated at MG. A few individuals, represented by their crania, are maintained at the National Museum of Natural History and Science (MUNHAC), Lisbon. The collections from the 1930s are curated at the Museum of Natural History, University of Porto (MHNUP). The MG also holds the collections from 1964–65. Most human remains are preserved in disarticulated state, and just a few bone elements are still in articulation due to an enveloping heavy carbonate concretion.

Original written documentation known for Cabeço da Arruda is from the excavations in 1933, 1937 and 1964–65. Both archives are published (Abrunhosa 2012; Cardoso and Rolão 1999–2000), at least partially. The 1930s material consists of various short loose notes, as well as field diaries, handwritten by Santos Júnior and M. Corrêa (Abrunhosa 2012; Cardoso and Rolão 1999–2000). The 1964–65 documentation consists of a field diary handwritten mostly by O. V. Ferreira, but also by M. Andreata (Cardoso and Rolão 1999–2000). J. Roche’s field notes have not survived (see chapter 3, *A note on the historical documentation*). The graphic documentation is extremely limited and consists of site plans, profiles, a few field photographs and simple sketches of the human remains (Abrunhosa 2012; Cardoso and Rolão 1999–2000; Cartailhac 1886; Ribeiro 1884; Roche 1967).
Chronology of the burial activity

**Previous \(^{14}\)C measurements**

Five \(^{14}\)C measurements are available on non-human samples (table A4). Two of these measurements are from material from the nineteenth century (Beta–152956 and Beta–271927), one of which (Beta–152956) on bone of a domestic dog (*Canis familiaris*) (Detry and Cardoso 2010). The 1960s excavations were dated by J. Roche from two samples of charcoal (Sa–196 and Sa–197) from the upper and bottom layers respectively (Delibrias and Roche 1965; Roche 1965, 161). One sample on charcoal (TO–10215) from the 2000s excavations was also dated (Roksandic 2006).

The first measurements on human bone from Cabeço da Arruda (TO–354, TO–355, TO–356, TO–359, and TO–360) were carried out in the 1980s. The samples were collected from the nineteenth century material and selected randomly (Lubell and Jackes 1988; Lubell et al. 1994). The measurements were done by AMS at the Isotrace Laboratory of the University of Toronto, Canada, and independently measured for stable isotopes. The individual results for the C:N ratio were not published but were reported to be within the accepted quality range of 2.9–3.6 (Lubell et al. 1994, 204).

The excavations from 1937 were dated by one \(^{14}\)C measurement on individual 6 (Beta–127451, Cunha and Cardoso 2002–03; Cunha et al. 2003). This measurement has been questioned for being too old (Jackes and Meiklejohn 2004; Jackes and Lubell 2012), and CAR1937, Sk6 was recently re-dated (AA-101343, Jackes et al. 2014). M. Jackes and colleagues (2014) suggest that the original date (Beta–127451) is anomalous, although not statistically different from the new measurement (AA–101343). One of the problems with the first \(^{14}\)C date (Beta–127451) was that the \(\delta^{13}C\) value published along with the sample was obtained by AMS (Cláudia Umbelino, pers. comm.), which cannot be used for dietary reconstructions or reservoir corrections (Millard 2014, 557; Taylor and Bar-Yosef 2014, 117). Now, with the new measurements (AA–101343), which include an IRMS–based \(\delta^{13}C\) value, this problem can be overcome, and the Beta–127451 date can be corrected with the new \(\delta^{13}C\) value. Following this, instead of rejecting the first \(^{14}\)C date (Beta–127451), and because the dates are not statistically different, I opted to combine the two \(^{14}\)C measurements available for CAR1937, Sk6 (Beta–127451 and AA–101343). This was done by using the OxCal function \texttt{R.Combine} and the recent \(\delta^{13}C\) value (AA–101343) obtained by IRMS.

The two individuals (CA–00–01 and CA–00–02) excavated in 2000 are also dated (Roksandic 2006). The C:N ratios were not originally published but were reported recently (Jackes and Lubell 2015). These two samples were also independently measured for stable isotopes.

The human remains recovered during J. Roche’s excavations in 1964–65 were not previously dated.
Objectives of the dating programme

Cabeço da Arruda is a large site with a high number of human burials found in different levels of the shell midden.

The general aims of the dating programme for Cabeço da Arruda followed the macro-goals of the radiocarbon programme of this dissertation, outlined in chapter 3, and were

- to determine the duration of use of this site for burial activity;
- to determine when the burial activity started and when it ended;
- to estimate the frequency of the burial activity in the site.

The site-specific aims of the dating programme for Cabeço da Arruda were:

- to establish the chronology of the burial areas identified in 1964 (basal sand) and in 1965 (upper layers) (fig. 4.12), which were undated;
- to establish the chronology of the burial area excavated in 1937. At the time of this programme, only one skeleton was dated from this collection (Beta–127451, CAR1937, Sk6), which provided the oldest date known at the Tagus valley;
- to define the temporal relation between the burial areas identified in 1964–65, their relationship to each other and to the nineteenth century and 1937 collections.

Sampling strategy

Six samples of human bone were selected for $^{14}$C analysis (table 4.14). The sampling strategy was focused on the material excavated in 1937 and in 1964–65. Sampling of the 1937 collection was based on the stratigraphic position of each individual. Five samples were selected from different depths in the midden, including two from the lower levels. The sampling of the 1964–65 collection was severely constrained by the current state of preservation of the collection. The human remains are mixed and partially sorted by bone type. It was possible to identify one individual only, which was selected for sampling (CAR1964, Sk4). Unfortunately, it was not possible to identify the remains from the upper layers excavated in 1965.

Results

Fifteen $^{14}$C measurements on human bone collagen samples from 14 individuals from Cabeço da Arruda are available now. Five samples belong to human remains excavated in the nineteenth century. Seven samples belong to human remains excavated in 1937, two of which were sampled from the same skeleton (individual 6). One sample is from the material excavated in 1964 and two samples are from the burials excavated in 2000 (table 4.15).
Figure 4.12. Cabeço da Arruda, Tagus valley 1964–65: site plan with the location of the skeletons. The human remains excavated in 1964 were found in the lower levels (layers 5–7), while the material excavated in 1965 was recovered from the upper levels (layer 2) at c. 4 metres from the bottom (Roche 1974). Arrow indicates the southern edge where CA–00–01 and CA–00–02 were excavated in 2000 (Roksandic 2006, 44). (Site plan after Cardoso and Rolão 1999–2000, 227, fig. 57).
Table 4.14. Cabeço da Arruda, Tagus valley: samples of human bone (6) collected and submitted for \(^{14}\)C measurement in the course of this study. Samples from the 1937 assemblage were collected at MHNUP. The sample from the 1964 material (individual 4) was collected at MG. Age and sex estimation by *A. Ataide (1940) and **C. Umbelino 2006.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Stratigraphy</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1937**</td>
<td>Ua–46272</td>
<td>Adult</td>
<td>♀</td>
<td>Tibia–R</td>
<td>1.40 m from basal sand</td>
<td>Previous analysis of the same bone for stable isotope analysis (Umbelino 2006).</td>
</tr>
<tr>
<td>2, 1937*</td>
<td>Ua–47975</td>
<td>Adult</td>
<td>♀</td>
<td>Radius–R</td>
<td>0.85/0.95 m from basal sand</td>
<td>–</td>
</tr>
<tr>
<td>3, 1937*</td>
<td>Ua–46273</td>
<td>Adult</td>
<td>♂</td>
<td>Tibia–R</td>
<td>1.20 m from basal sand</td>
<td>–</td>
</tr>
<tr>
<td>9, 1937</td>
<td>Ua–46274</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia</td>
<td>0.30 m from basal sand</td>
<td>–</td>
</tr>
<tr>
<td>10, 1937**</td>
<td>Ua–46275</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Femur–L</td>
<td>0.25 m from basal sand</td>
<td>Previous analysis of the same bone for stable isotope analysis (Umbelino 2006).</td>
</tr>
<tr>
<td>4, 1964</td>
<td>Ua–47976</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia–R</td>
<td>Basal sand, layer 5–7</td>
<td>–</td>
</tr>
<tr>
<td>Identification of the human remains</td>
<td>Measurement ( \delta^{13}C ) by AMS; ( \delta^{15}N ) by IRMS</td>
<td>( \delta^{13}C ) (% marine)</td>
<td>( \delta^{15}N ) (% marine)</td>
<td>% marine (±10)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>--------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>----------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>M1</td>
<td>TO-354</td>
<td>670±10</td>
<td>19.0</td>
<td>122</td>
<td>n/a</td>
<td>24 13</td>
</tr>
<tr>
<td>M2</td>
<td>TO-355</td>
<td>670±10</td>
<td>18.9</td>
<td>10.3</td>
<td>n/a</td>
<td>25 14</td>
</tr>
<tr>
<td></td>
<td>CA-00-01</td>
<td>6620±60</td>
<td>18.1</td>
<td>10.5</td>
<td>3.4</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>CA-00-02</td>
<td>7040±60</td>
<td>17.9</td>
<td>10.6</td>
<td>3.2</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>6990±110</td>
<td>17.7</td>
<td>11.2</td>
<td>n/a</td>
<td>36 112</td>
</tr>
<tr>
<td></td>
<td>III 19th c.</td>
<td>6900±110</td>
<td>17.7</td>
<td>11.2</td>
<td>n/a</td>
<td>36 112</td>
</tr>
<tr>
<td></td>
<td>9 1937</td>
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<td>10.6</td>
<td>3.2</td>
<td>39</td>
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<tr>
<td></td>
<td>10 1937</td>
<td>7263±56</td>
<td>17.4</td>
<td>11.4</td>
<td>3.2</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>3 1937</td>
<td>7198±40</td>
<td>17.3</td>
<td>10.1</td>
<td>3.1</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>42 19th c.</td>
<td>6960±70</td>
<td>17.2</td>
<td>11.8</td>
<td>n/a</td>
<td>41 118</td>
</tr>
</tbody>
</table>
Table 4.15. continued

<table>
<thead>
<tr>
<th>#</th>
<th>Year</th>
<th>Location</th>
<th>Code</th>
<th>Age</th>
<th>Error</th>
<th>CR</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1964–65</td>
<td>MG</td>
<td>Ua–47976</td>
<td>7261±45</td>
<td>–17.1</td>
<td>9.7</td>
<td>3.1</td>
<td>42</td>
<td>36</td>
<td>This study</td>
</tr>
<tr>
<td>2</td>
<td>1937</td>
<td>MHNUP</td>
<td>Ua–47975</td>
<td>7116±44</td>
<td>–16.7</td>
<td>9.5</td>
<td>3.1</td>
<td>46</td>
<td>41</td>
<td>This study</td>
</tr>
<tr>
<td>1</td>
<td>1937</td>
<td>MHNUP</td>
<td>Ua–46272</td>
<td>7166±41</td>
<td>–16.6</td>
<td>11.2</td>
<td>3.1</td>
<td>47</td>
<td>43</td>
<td>This study</td>
</tr>
<tr>
<td>6</td>
<td>1937</td>
<td>MHNUP</td>
<td>AA–101343</td>
<td>7351±70</td>
<td>–16.6</td>
<td>10.9</td>
<td>3.3</td>
<td>47</td>
<td>43</td>
<td>Jackes et al. 2014</td>
</tr>
<tr>
<td>6</td>
<td>1937</td>
<td>MHNUP</td>
<td>Beta–127451</td>
<td>7550±100</td>
<td>AMS:</td>
<td>n/a</td>
<td>n/a</td>
<td>–</td>
<td>–</td>
<td>Cunha and Cardoso 2002–03; Cunha et al. 2003</td>
</tr>
<tr>
<td>N</td>
<td>19th c.</td>
<td>MG</td>
<td>TO–356</td>
<td>6360±80</td>
<td>–15.3</td>
<td>12.5</td>
<td>n/a</td>
<td>59</td>
<td>59</td>
<td>Lubell and Jackes 1988; Lubell et al. 1994</td>
</tr>
</tbody>
</table>
Results: Tagus valley, Cabeço da Arruda

Calibration and chronological models
The chronological model was built on 15 $^{14}$C dates, six of which are new dates obtained in the scope of this study, and nine were previously published.

The two $^{14}$C measurements available for CAR1937, Sk6 (Beta–127451 and AA–101343) were combined using the OxCal function $R_{\text{Combine}}$ and calibrated using the only $\delta^{13}$C value (AA–101343) obtained by IRMS. The combined result shows good agreement (A=90.8%) (fig. 4.13).

This is a phase model which groups all dated burial events in a phase of burial activity (Bronk Ramsey 1998, 2000, 2001). This grouping is constrained by a start of burial activity event, and an end of burial activity event (i.e., boundaries) which imposes no internal constraints to the relative order of the dated events. All it assumes is that the start event occurs before the dated events, and that these all occur before the end event. For the command files defined for this model see appendix.

![Figure 4.13. Probability density function for the calibration of two bone collagen samples (Beta–127451 and AA–101343) from CAR1937, Sk6. Calculated by OxCal 4.2 (Bronk Ramsey 2009) using function $R_{\text{Combine}}$ and IRMS–based $\delta^{13}$C value obtained for AA–101343. The posterior density estimated for the death of CAR1937, Sk6 is 6133–5852 cal BCE (95% probability), 6065–5969 cal BCE (54% probability), or 5050–5914 cal BCE (14% probability).](image)

Internal consistency and reliability of the model
Agreement index (A) for each dated event is high (A≥91%), except for the sample TO–356 (CAR19$^{\text{th}}$ c., SkN) which is in poor agreement (Marine 1: A=49%, Marine 2: A=51.5%) but in good convergence (Marine 1, 2: C=99.2%) (fig. 4.14). This sample, TO–356 (CAR19$^{\text{th}}$ c., SkN), is the most recent burial known in the site and is not an outlier to the model, rather, its younger age may suggest a later event, relatively more recent than the group of events in the considered phase.

The model shows satisfactory overall agreement (Marine 1: $A_{\text{overall}}$=85.8%; Marine 2: $A_{\text{overall}}$=87.7%), indicating that the $^{14}$C dates are in accordance with the
prior information incorporated in the model, which assumes one phase of burial activity and does not impose any relative order to the dated events.

The results obtained when running the model with the different marine values (M1, M2) are statistically insignificant (table 4.16). For this reason, all further observations and graphic presentation are based on the results obtained with the model run with M1. The results obtained with M2 are presented in the tables.

Figure 4.14. Chronological model for the burial activity at Cabeço da Arruda, calibrated using marine 1 diet values. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, Tagus valley, Cabeço da Arruda, Model 1, Marine 1.
The chronological model for Cabeço da Arruda, calibrated with M1 values, estimates the start of the burial activity to have been in 6270–5918 cal BCE (95% probability; start of burial activity), and its end to have been in 5424–4843 cal BCE (95% probability; end of burial activity) (fig. 4.15; table 4.17). The burial activity is estimated to have continued for between 557 and 1093 years (95% probability; site use for burial activity), or for 682 and 918 years (68% probability) (fig. 4.16; table 4.17).

Figure 4.15. Start and End of burial activity at Cabeço da Arruda derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is 6270–5918 cal BCE (95% probability) or 6127–5976 cal BCE (68% probability). Posterior density estimated for the end of the burial activity is 5424–4843 cal BCE (95% probability) or 5289–5046 cal BCE (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Figure 4.16. Duration of burial activity at Cabeço da Arruda derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the duration of the burial activity is between 557 and 1093 years (95% probability) or 682 and 918 years (68% probability). Calibrated ranges of 95% and 68% are given by the lower and higher square brackets respectively.
Table 4.16. Human bone collagen samples (14+1) from Cabeço da Arruda, Tagus valley: calibrated date ranges according to two different approaches for the calculation of the marine percentage (M1, M2). Results are presented in both (a) cal BCE and (b) cal BP in 95.4% confidence range. The calibrated date ranges are probability distributions derived from scientific dating alone. The posterior density estimates (in italic) are derived from Bayesian modelling. Samples are sorted so that the most recent dates are at the top of the column.

(a) Cal BCE

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>(^{14}C) Age BP</th>
<th>Unmodelled cal BCE, M1</th>
<th>Modeled cal BCE, M1</th>
<th>Modeled cal BCE, M2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Calibrated date range (95% confidence)</td>
<td>Posterior density estimate (95% probability)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>TO–356</td>
<td>6360±80</td>
<td>5217–4738</td>
<td>5464–4963</td>
<td>5466–4951</td>
</tr>
<tr>
<td>CA–00–01</td>
<td>TO–10217</td>
<td>6620±60</td>
<td>5604–5280</td>
<td>5602–5287</td>
<td>5613–5317</td>
</tr>
<tr>
<td>D</td>
<td>TO–355</td>
<td>6780±80</td>
<td>5735–5391</td>
<td>5734–5428</td>
<td>5754–5475</td>
</tr>
<tr>
<td>42</td>
<td>TO–359</td>
<td>6960±70</td>
<td>5831–5501</td>
<td>5827–5495</td>
<td>5866–5528</td>
</tr>
<tr>
<td>A</td>
<td>TO–354</td>
<td>6970±60</td>
<td>5907–5617</td>
<td>5902–5617</td>
<td>5973–5652</td>
</tr>
<tr>
<td>2</td>
<td>Ua–47975</td>
<td>7116±44</td>
<td>5913–5637</td>
<td>5905–5640</td>
<td>5970–5666</td>
</tr>
<tr>
<td>CA–00–02</td>
<td>TO–10216</td>
<td>7040±60</td>
<td>5965–5622</td>
<td>5914–5621</td>
<td>5976–5653</td>
</tr>
<tr>
<td>III</td>
<td>TO–360</td>
<td>6990±110</td>
<td>5975–5509</td>
<td>5972–5511</td>
<td>5982–5533</td>
</tr>
<tr>
<td>1</td>
<td>Ua–46272</td>
<td>7166±41</td>
<td>5977–5696</td>
<td>5975–5696</td>
<td>5980–5719</td>
</tr>
<tr>
<td>3</td>
<td>Ua–46273</td>
<td>7198±40</td>
<td>6000–5741</td>
<td>5993–5745</td>
<td>6017–5769</td>
</tr>
<tr>
<td>9</td>
<td>Ua–46274</td>
<td>7200±41</td>
<td>6005–5746</td>
<td>5998–5748</td>
<td>6021–5771</td>
</tr>
<tr>
<td>4</td>
<td>Ua–47976</td>
<td>7261±45</td>
<td>6033–5759</td>
<td>6021–5766</td>
<td>6061–5816</td>
</tr>
<tr>
<td>10</td>
<td>Ua–46275</td>
<td>7263±46</td>
<td>6065–5794</td>
<td>6049–5798</td>
<td>6072–5836</td>
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</tbody>
</table>

(b) Cal BP

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>(^{14}C) Age BP</th>
<th>Unmodelled cal BP, M1</th>
<th>Modeled cal BP, M1</th>
<th>Modeled cal BP, M2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Calibrated date range (95% confidence)</td>
<td>Posterior density estimate (95% probability)</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>TO–356</td>
<td>6360±80</td>
<td>7166–6687</td>
<td>7413–6912</td>
<td>7415–6900</td>
</tr>
<tr>
<td>CA–00–01</td>
<td>TO–10217</td>
<td>6620±60</td>
<td>7553–7229</td>
<td>7551–7236</td>
<td>7562–7266</td>
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<tr>
<td>D</td>
<td>TO–355</td>
<td>6780±80</td>
<td>7684–7340</td>
<td>7683–7377</td>
<td>7703–7424</td>
</tr>
<tr>
<td>42</td>
<td>TO–359</td>
<td>6960±70</td>
<td>7780–7450</td>
<td>7776–7444</td>
<td>7815–7477</td>
</tr>
<tr>
<td>A</td>
<td>TO–354</td>
<td>6970±60</td>
<td>7856–7566</td>
<td>7851–7566</td>
<td>7922–7601</td>
</tr>
<tr>
<td>2</td>
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<td>7116±44</td>
<td>7862–7586</td>
<td>7854–7589</td>
<td>7919–7615</td>
</tr>
<tr>
<td>CA–00–02</td>
<td>TO–10216</td>
<td>7040±60</td>
<td>7914–7571</td>
<td>7863–7570</td>
<td>7925–7602</td>
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<tr>
<td>III</td>
<td>TO–360</td>
<td>6990±110</td>
<td>7924–7458</td>
<td>7921–7460</td>
<td>7931–7502</td>
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<tr>
<td>1</td>
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<td>7166±41</td>
<td>7926–7645</td>
<td>7924–7645</td>
<td>7929–7668</td>
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<tr>
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<td>7942–7694</td>
<td>7966–7718</td>
</tr>
<tr>
<td>9</td>
<td>Ua–46274</td>
<td>7200±41</td>
<td>7954–7695</td>
<td>7947–7697</td>
<td>7970–7720</td>
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</table>

continued...
Table 4.17. Posterior density estimates for the dates of archaeological events (Start/End) and the duration of burial activity at Cabeço da Arruda. Data derived from model described in fig. 4.14

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Modelled cal BCE, M1</th>
<th>Modelled cal BCE, M2</th>
<th>Modelled cal BCE, M1</th>
<th>Modelled cal BCE, M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of burial activity</td>
<td>6127–5976</td>
<td>6154–6003</td>
<td>6270–5918</td>
<td>6311–5952</td>
</tr>
<tr>
<td>End of burial activity</td>
<td>5289–5046</td>
<td>5276–5026</td>
<td>5424–4843</td>
<td>5444–4823</td>
</tr>
<tr>
<td>Span of burial activity, duration</td>
<td>682–918 yrs</td>
<td>713–956 yrs</td>
<td>557–1093 yrs</td>
<td>582–1126 yrs</td>
</tr>
<tr>
<td>Overall model agreement (Aoverall)</td>
<td>85.8%</td>
<td>87.7%</td>
<td>85.8%</td>
<td>87.7%</td>
</tr>
</tbody>
</table>

Stable isotopes: carbon and nitrogen

**Previous measurements: Δ¹³C and Δ¹⁵N**

The first measurements of stable isotopes (Δ¹³C, Δ¹⁵N) on human bone from Cabeço da Arruda were carried out in the 1980s by H. Schwarz at the McMaster University in Canada (TO–354, TO–355, TO–356, TO–359, and TO–360). The precision of analysis for Δ¹³C is ± 0.1‰ and for Δ¹⁵N is ± 0.2‰ (Lubell et al. 1994, 204). These five samples were also independently measured for ¹⁴C dating (see above).

In the early 2000s, two samples from the 1937 excavations (individuals 1 and 10) were analysed in the scope of a palaeodietary study (Umbelino 2006). Like the first measurements, these analyses were done at the McMaster University and the precision of the results are ± 0.1‰ for Δ¹³C and ± 0.2‰ for Δ¹⁵N (Umbelino 2006, 208–9). The C:N ratios were not provided but the laboratory confirmed the quality of the collagen and of the measurements (Umbelino 2006, 315). The Δ¹³C value published for CAR1937, Sk6 (Beta–127451) along with its ¹⁴C date (Cunha and Cardoso 2002–03; Cunha et al. 2003) was obtained via AMS and not by IRSM (Cláudia Umbelino, pers. comm.). This sample was not included in Umbelino’s palaeodietary study (2006), and as previously discussed it should not be used for dietary reconstructions and/or reservoir corrections. This individual was recently re-dated (AA–101343, Jackes et al. 2014) and new stable isotope measurements were carried out by IRSM with a precision of analysis of ± 0.1‰ for Δ¹³C and ± 0.15‰ for Δ¹⁵N.
The latest human remains excavated at Cabeço da Arruda (CA–00–01 and CA–00–02) were analysed for stable isotopes (TO–10216 and TO–10217) (Roksandic 2006), independently from the $^{14}$C measurements. The C:N ratios were not originally published but were recently reported (Jackes and Lubell 2015).

All previous measurements were included in this study (n=10), as long as they fell within the accepted quality ranges as discussed.

**Sampling strategy**

In this study, the selection of samples of human remains for $\delta^{13}$C and $\delta^{15}$N measurements was fully dependent on the goals of the radiocarbon dating programme (see above).

**Results**

Samples Ua–number (n=6) were measured by IRMS and the precision of the measurements for both $\delta^{13}$C and $\delta^{15}$N is ± 0.1‰.

CAR1937, Sks 1, 10 have multiple measurements from the same bone element. In the case of individual 10, the results are similar, but different in the case of individual 1 (table 4.18).

At Cabeço da Arruda, the human collagen $\delta^{13}$C values (n=16/no. individuals=14) range from –19.0‰ to –15.3‰ with a mean value of –17.3 ± 1.0‰. The human collagen $\delta^{15}$N values (n=16/no. individuals=14) range from +9.5‰ to +12.‰ with a mean value of 11.0 ± 0.9‰ (fig. 4.17, table 4.18).

![Figure 4.17. Cabeço da Arruda, Tagus valley: correlation between the $\delta^{13}$C (‰) and $\delta^{15}$N (‰) values of 16 samples of human bone collagen from 14 individuals. Individuals 1 (triangle) and 10 (circle) have two sets of values.](image-url)
Table 4.18. Cabeço da Arruda, Tagus valley: carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) measurements on human bone collagen samples. Samples from the nineteenth century and 1964–65 assemblages were collected at MG. Samples from the 1937 material were collected at MHNUP. Samples are sorted so that the lowest $\delta^{13}\text{C}$ values are on the top of the table. Individuals with multiple measurements are sorted together.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements $^{14}\text{C}$ by AMS; $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ by IRMS</th>
<th>% marine (±10)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind.</td>
<td>Age</td>
<td>Sex</td>
<td>Bone</td>
</tr>
<tr>
<td>A 19th c.</td>
<td>Adult</td>
<td>♂</td>
<td>n/p</td>
</tr>
<tr>
<td>D 19th c.</td>
<td>Adult</td>
<td>♂</td>
<td>n/p</td>
</tr>
<tr>
<td>CA–00–01, 2000</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Rib</td>
</tr>
<tr>
<td>CA–00–02, 2000</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia</td>
</tr>
<tr>
<td>III 19th c.</td>
<td>Non-adult, 10–11 yrs</td>
<td>♂</td>
<td>n/p</td>
</tr>
<tr>
<td>9 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia</td>
</tr>
<tr>
<td>10 1937</td>
<td>Adult</td>
<td>♂</td>
<td>Femur–L</td>
</tr>
<tr>
<td>10 1937</td>
<td>Adult</td>
<td>♂</td>
<td>Femur–L</td>
</tr>
<tr>
<td>3 1937</td>
<td>Adult</td>
<td></td>
<td>Tibia–R</td>
</tr>
</tbody>
</table>

continued…
| No. | Date    | Age | Sex | Bone | Code   | Width | Thickness | Width | Thickness | Width | Thickness | Width | Thickness | Width | Thickness | Width | Thickness | Width | Thickness |
|-----|---------|-----|-----|------|--------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|-------|-----------|
| 42  | 19th c. | Adult, 20–24 yrs | ♀ | n/p | TO–359 | 6960±70 | −17.2 | 11.8 | n/p | 41 | 35 | Lubell and Jackes 1988; Lubell et al. 1994 |
| 4   | 1964–65 | Adult | n/d | Tibia–R | Ua–47976 | 7261±45 | −17.1 | 9.7 | 3.1 | 42 | 36 | This study |
| 2   | 1937    | Adult | n/d | Radius–R | Ua–47975 | 7116±44 | −16.7 | 9.5 | 3.1 | 46 | 41 | This study |
| 1   | 1937    | Adult | ♀ | Tibia–R | Ua–46272 | 7166±41 | −16.6 | 11.2 | 3.1 | 47 | 43 | This study |
| 1   | 1937    | Adult | ♀ | Tibia–R | n/p | analysis for isotopes | −15.7 | 12.0 | n/p | 55 | 54 | Umbelino 2006 |
| 6   | 1937    | Adult | ♀ | Fibula–R | AA–101343 | 7351±70 | −16.6 | 10.9 | 3.3 | 47 | 43 | Jackes et al. 2014 |
| N   | 19th c. | Adult, old | ♂ | n/p | TO–356 | 6360±80 | −15.3 | 12.5 | n/p | 59 | 59 | Lubell and Jackes 1988; Lubell et al. 1994 |
Archaeothanatology

Source material and analysis strategy

Source material for Cabeço da Arruda is restricted to the excavations by M. Corrêa in 1937 and by J. Roche in 1964–65, however, with great limitations (table 4.19).

The documentation is relatively more abundant for the assemblage from the 1930s (MNI 11). It comprises a few field photographs of low quality (Abrunhosa 2012), simple sketches, and written documentation from field notes (Cardoso and Rolão 1999–2000, 172–79) and one article (Aтаíde 1940). The skeletal material is mostly in disarticulated state, and just a few elements remain in small blocks of concretion.

The material from the 1960s (MNI 13) is poorly documented. The burials excavated in 1964 (n=9) were described briefly by O. Veiga Ferreira and M. Andreata (Cardoso and Rolão 1999–2000, 224–32), but the documentation for 1965 (n=4) is extremely limited. O. Veiga Ferreira was sick during this campaign (Cardoso and Rolão 1999–2000, 236–37) and he did not describe the burials, except for individual 13, which he mentions briefly. J. Roche (1974) made short descriptions of each burial and commented on their relative chronology. He published a short synthesis, comparing Cabeço da Arruda and Moita do Sebastião, regarding burial positions, orientation of the bodies, and grave goods (Roche 1974). J. Roche’s notes are not available (see chapter 2, A note on the historical documentation). The graphic documentation available is limited to a few photographs showing several individuals (Cardoso and Rolão 1999–2000; Roche 1974) (fig. 4.18), one sketch indicating the relative spatial position of the burials (1 to 9) (fig. 4.19), and one site plan with the human burials (fig. 4.12). The human remains are preserved in disarticulated state, and sorted by bone type. Archaeothanatological analysis is extremely limited and it relies strongly on a few descriptions by the excavators.

Most human burials were excavated in the nineteenth century (MNI 80). There are no field notes available for these excavations and the burials were not described. A few field photographs are published but it is impossible to observe the skeletal elements in any detail (Cartailhac 1886, 56; Ribeiro 1884) (fig. 4.20). Some of the material is preserved in small blocks of concretion but are of limited use for archaeothanatology.

Overall, archaeothanatological analysis is extremely constrained by the absence of appropriate graphic documentation and by the lack of human remains preserved in blocks. The analysis was carried out partially on a total of 15 individuals, 10 excavated in 1937 (possibly 100% MNI, 1937) and 5 excavated in 1964 (c 39% MNI, 1964–65). In most cases, the analysis is restricted to one line of evidence, such as one description, or one photograph. Despite the difficulties it was possible to obtain sufficient data supporting general observations regarding the treatment of the dead, even when detailed analysis was constrained.
Figure 4.18. Field photograph of the human burials excavated in 1964 at Cabeço da Arruda, Tagus valley. (Reproduced from Cardoso and Rolão 1999–2000, 235, fig. 61)

Figure 4.19. Field sketch by O. Veiga Ferreira showing the relative spatial position of the burials excavated in 1964 at Cabeço da Arruda, Tagus valley. (Reproduced from Cardoso and Rolão 1999–2000, 235, fig. 61)
Figure 4.20. Nineteenth century excavations at Cabeço da Arruda, Tagus valley. (Reproduced from Ribeiro 1884, Plates I, II)
Table 4.19. Cabeço da Arruda, Tagus valley: source material assessed for archaeothanatological analysis. Material from 1937 is curated at MHNUP and the assemblage from 1964–65 is located at MG.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Source material</th>
<th>Block</th>
<th>Graphic documentation w/human remains</th>
<th>Written documentation</th>
<th>Observations</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Field photographs</td>
<td>Drawings</td>
<td>Site plan</td>
<td></td>
</tr>
<tr>
<td>1, 1937 n/a</td>
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<td>sketch</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
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<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<td>4, 1937 n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>5, 1937 n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
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<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
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<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>8, 1937 n/a</td>
<td>yes</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>9, 1937 n/a</td>
<td>yes</td>
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<td>yes</td>
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<td>10, 1937 n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
<td>yes, ltd</td>
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<tr>
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<td>sketch w/ 1–9</td>
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<td>yes, ltd</td>
<td>yes, ltd</td>
</tr>
<tr>
<td>2, 1964 n/a</td>
<td>w/ other burials</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes</td>
<td>Limited documentation. Archaeothanatology is extremely limited.</td>
</tr>
<tr>
<td>3, 1964 n/a</td>
<td>n/a</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes, ltd</td>
<td>Limited documentation and very fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>4, 1964 n/a</td>
<td>n/a</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes, ltd</td>
<td>Limited documentation and very fragmented material. Archaeothanatology is extremely limited.</td>
</tr>
<tr>
<td>5, 1964 n/a</td>
<td>w/ other burials</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes</td>
<td>Limited documentation. Disturbed and fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>6, 1964 n/a</td>
<td>w/ other burials</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes</td>
<td>Limited documentation. Archaeothanatology is limited.</td>
</tr>
<tr>
<td>7, 1964 n/a</td>
<td>w/ other burials</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes</td>
<td>Limited documentation. Archaeothanatology is extremely limited.</td>
</tr>
<tr>
<td>8, 1964 n/a</td>
<td>w/ other burials</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes</td>
<td>Limited documentation. Disturbed and fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>9, 1964 n/a</td>
<td>w/ other burials</td>
<td>sketch w/ 1–9</td>
<td>yes</td>
<td>yes, ltd</td>
<td>Limited documentation and very fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>10, 1965 n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes, ltd</td>
<td>yes, ltd</td>
</tr>
<tr>
<td>11, 1965 n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes, ltd</td>
<td>Limited documentation and very fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>12, 1965 n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes, ltd</td>
<td>Limited documentation and very fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>13, 1965 n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>yes</td>
<td>yes, ltd</td>
<td>Limited documentation and very fragmented material. Archaeothanatology is not possible.</td>
</tr>
</tbody>
</table>
Results of the archaeothanatological analysis

The nature of the deposits
Analysis of the nature of the deposits at Cabeço da Arruda suggests a pattern of primary burials (table 4.20) indicating that the cadavers were placed in the burial features before the degradation of the labile joints. In most cases the labile articulations are unclear in the documentation, however, the overall position of the bones strongly indicates that the bodies were disposed while retaining their general anatomical integrity, supporting the interpretation of burials in primary position. In three cases (CAR1937, Sks 7, 8, 9) the analysis was not possible, and the nature of these deposits is unknown.

The space of decomposition of the cadaver
Analysis of the space of decomposition of the cadavers buried in Cabeço da Arruda suggests a pattern of filled spaces (table 4.21). The cadavers were covered with sediment immediately after their placement in the features. The decomposition of the bodies took place in this sediment-filled environment. In several cases (CAR1937, Sks 2, 3, 5, 6, 10; CAR1964, Sks 5, 8), the interpretation was based on the observation that the bones of the lower limbs were rotated and suspended, but in articulation. These are not the typical diagnostic criteria for the identification of the space of decomposition, but the maintenance of these skeletal elements in unbalanced position, indicates support during decomposition. In every case, the movement of the bones is limited suggesting that the space of decomposition was filled and that the sediment could penetrate immediately.

The low resolution of the source material does not allow the identification of original empty spaces in the grave feature and/or the formation of secondary empty spaces outside the volume of the cadaver within the overall filled environment. The hypothesis of mixed spaces of decomposition cannot be excluded.
Table 4.20. *Summary of the nature of the deposits with human remains at Cabeço da Arruda, Tagus valley. Age and sex estimation by *A. Ataíde (1940) and **C. Umbelino (2006).*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Nature of the deposit</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1937**</td>
<td>Adult</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: some bones of left hand; some bones of feet.</td>
</tr>
<tr>
<td>2, 1937*</td>
<td>Adult</td>
<td>♀</td>
<td>Probably primary</td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>3, 1937*</td>
<td>Adult</td>
<td>♂</td>
<td>Probably primary</td>
<td>Poor preservation and unclear documentation.</td>
</tr>
<tr>
<td>4, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Limited documentation.</td>
</tr>
<tr>
<td>5, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>6, 1937</td>
<td>Adult</td>
<td>♀?</td>
<td>Probably primary</td>
<td>Unclear documentation.</td>
</tr>
<tr>
<td>7, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>Unclear documentation.</td>
</tr>
<tr>
<td>8, 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>Unclear documentation.</td>
</tr>
<tr>
<td>9, 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>Unclear documentation.</td>
</tr>
<tr>
<td>10, 1937**</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Probably primary</td>
<td>Maintenance of the general anatomical integrity of the body (according to field description).</td>
</tr>
<tr>
<td>2, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Limited documentation and poor preservation.</td>
</tr>
<tr>
<td>4, 1964,</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Limited documentation.</td>
</tr>
<tr>
<td>5, 1964</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>7, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>8, 1964</td>
<td>Adult, young</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
</tbody>
</table>
Table 4.21. Summary of the space of decomposition of the human remains in the grave features at Cabeço da Arruda, Tagus valley.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Space of decomposition</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1937</td>
<td>Adult</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: some bones of the left hand are rotated and flexed at the wrist and lie on the lower abdominal region; several bones of the feet.</td>
</tr>
<tr>
<td>2, 1937</td>
<td>Adult</td>
<td>♀</td>
<td>Probably filled</td>
<td>Maintenance of bones in original unbalanced position: bones of lower limbs are rotated. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>3, 1937</td>
<td>Adult</td>
<td>♂</td>
<td>Probably filled</td>
<td>Maintenance of bones in original unbalanced position: bones of lower limbs are rotated and suspended. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>4, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Maintenance of bones in original unbalanced position: bones of feet are rotated.</td>
</tr>
<tr>
<td>5, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Maintenance of bones in original unbalanced position: lower limbs are rotated in front of the upper body. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>6, 1937</td>
<td>Adult</td>
<td>?</td>
<td>Probably filled</td>
<td>Maintenance of bones in original unbalanced position: bones of the lower limbs are rotated and suspended. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>7, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>–</td>
</tr>
<tr>
<td>8, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>–</td>
</tr>
<tr>
<td>9, 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>–</td>
</tr>
<tr>
<td>10, 1937</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Probably filled</td>
<td>Maintenance of bones in original unbalanced position: bones of lower limbs are rotated and suspended (according to field description).</td>
</tr>
<tr>
<td>2, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>Limited documentation.</td>
</tr>
<tr>
<td>4, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Unknown</td>
<td>Limited documentation.</td>
</tr>
<tr>
<td>5, 1964</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Limited documentation.</td>
</tr>
<tr>
<td>7, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of labile articulations: bones of hands in front of the os coxae.</td>
</tr>
<tr>
<td>8, 1964</td>
<td>Adult, young</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Limited documentation.</td>
</tr>
</tbody>
</table>
The initial position of the cadaver in the feature

The most common position at Cabeço da Arruda consists of a cadaver lying on the back (n=12) with the lower limbs in flexion or hyperflexion (table 4.22). In three cases (CAR1937, Sks 7, 8, 9), it was not possible to determine if the bodies were lying on the back or on the side.

The position of the upper limbs was varied, but they were always placed close to the body, in extension, semi-flexion, flexion or hyperflexion.

At Cabeço da Arruda, the bodies were placed in the feature with the lower limbs in semi-flexion, flexion or hyperflexion at the level of the hip and knee joints. In most cases the feet were forced towards the buttocks in a constrained position. In a few cases (i.e., CAR1937, Sks 1, 2) that was not the case. Often, the rotation of the lower limbs was unclear in the documentation. In some cases, the knees were directed forwards (CAR1964, Sk5), or towards the right or left side (CAR1934, Sks 1, 2, 10). In seven cases the hip and knee joints were in hyperflexion (CAR1937, Sks 4, 5, 7, 8, 9; CAR1964, Sks 2, 5), and the limbs were in adduction and rotated towards the trunk. Other burials (CAR1964, Sks 9, 13), without sufficient documentation for archaeothanatological analysis, have been described in a similar contracted position (Roche 1974). In a few cases (CAR1937, Sks 7, 8, 9), clumping of the body was enhanced during decomposition by the progressive closure of the angles between the bone segments and the skeletons became hypercontracted.

The grave features

The size and shape of the deposits with human remains were probably difficult to determine during excavation. J. Roche (1974) described the grave features as natural depressions, or as shallow pits excavated in the basal sand layers. CAR1965, Sks 10, 11, 12, 13 were excavated in the upper layers (layer 2), c 4 metres from the bottom of the shell midden, but these features were not described, except for short descriptions of the human remains (Roche 1974).

The archaeothanatological analysis suggests that the lateral pressures and wall-effects observed on the skeletons in the features indicate that the shape and size of the pit was just sufficient to contain the body (table 4.23). In several cases, the design of the grave had a significant impact on the final arrangement of the body in the feature, visible by the constrained position of several skeletons, particularly at the level of the lower limbs. Often, the lower limbs were supported by the wall of the grave, keeping the feet towards the buttocks. While the pit imposed a physical limit to the cadaver, by maintaining the lower limbs clumped together, it also provided lateral support preventing the collapse of the skeletal elements. In some cases (CAR1937, Sks 1, 2, 3, 6), the grave pits were somewhat wider allowing a relatively expanded position, at least at the level of the lower limbs.

Analysis of the upper body is limited and it is not possible to provide further descriptions at this level. Likewise, the low resolution of the source material does
not allow the analysis of the presence or absence of extra support offered by some kind of container, such as a light wrapping of the cadaver at the time of burial.

The floor of the graves was possibly uneven and sloping, but the documentation is in most cases unclear. The moderate downslope is suggested by the rotation forwards and downwards of the head, towards the body in the feature.

*Deposits containing more than one individual*

At Cabeço da Arruda, all deposits apparently contain the remains of one individual.

*Post-depositional manipulations of the cadavers*

J. Roche (1974) indicates that a few skeletons have been disturbed by more recent burials. That is the case in CAR1964, Sks 6, 9, which were disturbed by the burial of CAR1964, Sk7. Also, CAR1964, Sk3 was buried above the lower limbs of CAR1964, Sk2. All these cases indicate the removal and disturbance of previous burials to give place to a new cadaver. Despite this practice of reduction, the bodies at Cabeço da Arruda are apparently complete and lie generally undisturbed in the grave feature.

The low resolution of the source material does not allow further observations at this level. It is unknown if the practice of re-opening of the grave for the removal or rearrangement of selected elements occurred at Cabeço da Arruda.

*The mortuary programme at Cabeço da Arruda*

Archaeoanthropological analysis of the human remains excavated at Cabeço da Arruda is extremely constrained by the general lack of documentation. Despite the limitations, it is possible to observe some patterns in the mortuary practices at the site.

In the sample analysed, the cadavers were typically placed in individual grave features while retaining their anatomical integrity (individual primary deposits). The feature was then immediately covered with sediment, providing a filled space of decomposition.

Typically, the cadavers were lying on the back with the upper limbs positioned close to the body in various arrangements. Often, the lower limbs were placed in contraction, with the feet forced towards the buttocks.

In most cases, the pressures exerted on the bodies in the features can be explained as the result of the design of the grave. However, the data is not conclusive and the possibility of extra support provided by soft wrapping of the body at the time of burial cannot be completely excluded.

Overall, the mortuary programme at Cabeço da Arruda presents a consistent set of practices and all cases observed follow a common way of burying the dead.
Table 4.22. Summary of the reconstruction of the initial position of the cadaver in the grave features at Cabeço da Arruda, Tagus valley. The initial position of the limbs is indicated as –R or –L and refers to the right or left limb, when their positions are different. Rotation –R or –L indicates the rotation of the skeletal element(s) towards the right or the left side.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Initial position of the cadaver in the feature</th>
<th>Trunk</th>
<th>Upper limbs</th>
<th>Lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
<td>Sex</td>
<td>Head</td>
<td>Trunk</td>
</tr>
<tr>
<td>2, 1937</td>
<td>Adult</td>
<td>♂</td>
<td>n/d</td>
<td>On the back</td>
</tr>
<tr>
<td>4, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Rotation downwards (neck flexed forwards)</td>
<td>On the back</td>
</tr>
<tr>
<td>5, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>Slightly raised Rotated–L and downwards (neck flexed forwards)</td>
<td>On the back</td>
</tr>
<tr>
<td>6, 1937</td>
<td>Adult</td>
<td>♂♀</td>
<td>Prob. rotation–L</td>
<td>On the back</td>
</tr>
</tbody>
</table>

continued...
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Gender</th>
<th>Cranial Deviation</th>
<th>Maxilla and Mandible</th>
<th>Position</th>
<th>Modality</th>
<th>Other Movements</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>7, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>n/d</td>
<td>n/d</td>
<td>n/d</td>
<td>In hyperflexion</td>
<td>Feet towards buttocks, Clumping</td>
<td></td>
</tr>
<tr>
<td>8, 1937</td>
<td>Non-adult</td>
<td>n/d</td>
<td>n/d</td>
<td>n/d</td>
<td>n/d</td>
<td>In hyperflexion</td>
<td>Feet towards buttocks, Clumping</td>
<td></td>
</tr>
<tr>
<td>9, 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>n/d</td>
<td>n/d</td>
<td>n/d</td>
<td>In hyperflexion</td>
<td>Feet towards buttocks, Clumping</td>
<td></td>
</tr>
<tr>
<td>10, 1937</td>
<td>Adult, 20–35 yrs</td>
<td>♂️</td>
<td>Cranial: tendency–R Maxilla and mandible: rotation–L</td>
<td>On the back</td>
<td>In flexion–R n/a–L</td>
<td>Prob. in semi-flexion or flexion Rotation–tendency L n/a – L In adduction?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Rotation downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In extension or semi-flexion</td>
<td>In hyperflexion Rotation–tendency L Feet towards buttocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>n/d</td>
<td>On the back</td>
<td>In semi-flexion–R In extension or semi-flexion–L</td>
<td>Hip joints: semi-flexion or flexion Knee joints: hyperflexion Feet towards buttocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5, 1964</td>
<td>Non-adult</td>
<td>n/d</td>
<td>n/d</td>
<td>On the back</td>
<td>n/a</td>
<td>In hyperflexion Feet towards buttocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7, 1964</td>
<td>Adult</td>
<td>n/d</td>
<td>Rotation downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In semi-flexion</td>
<td>Hip joints: semi-flexion (c 90°) Knee joints: hyperflexion Feet towards buttocks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8, 1964</td>
<td>Adult, young</td>
<td>n/d</td>
<td>n/d</td>
<td>On the back</td>
<td>In extension or semi-flexion</td>
<td>Hip joints: semi-flexion (c 90°) Knee joints: hyperflexion Feet towards buttocks</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.23. Summary of the key observations used in the reconstruction of the grave features at Cabeço da Arruda, Tagus valley. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Pressures</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1937</td>
<td>Adult</td>
<td>♂️</td>
<td>1. Prob. wall-effect, upper right side. Unclear documentation.</td>
<td>1. Alignment of upper right limb and projection forwards and upwards of right shoulder and arm. Suggested by oblique position of left clavicle and alignment of upper right limb.</td>
</tr>
<tr>
<td>2, 1937</td>
<td>Adult</td>
<td>♂️</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>3, 1937</td>
<td>Adult</td>
<td>♂️</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>6, 1937</td>
<td>Adult</td>
<td>♂️</td>
<td>1. Sloping floor; 2. Prob. wall-effect, left side and lower end. Unclear documentation.</td>
<td>1. Transfer of body weight from the right to the left side. Suggested by LV and the os coxae which present a tendency towards the left side; 2. Alignment of lower left limb in constrained position. Left foot towards buttocks.</td>
</tr>
<tr>
<td>9, 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Overall strong bilateral compression and constraint effects. Limited documentation.</td>
<td>1. Hypercontracted skeleton.</td>
</tr>
</tbody>
</table>
Sado valley: Arapouco

Site background: a short history of research

Arapouco (also known as Ara Pouca) is the western-most shell midden site in the Sado valley (fig. 2.3). The site is located on the left margin of the Sado River at 47 m.a.s.l. (Diniz et al. 2012, 13), and has excellent visibility over the river valley.

Archaeological material and documentation available for Arapouco are curated at the National Museum of Archaeology in Lisbon (MNA). The year of its identification is unknown. The earliest reference to Arapouco comes from one letter (MNA, APMH, 5/1/654/50, Torrão, 25 Aug. 1960) written by J. Roldão to M. Heleno, where Roldão mentions his intentions of approaching the owner of the land (Santa Casa da Misericórdia) to request a fieldwork permit. At the time of this letter, J. Roldão was working in the region, at the sites of Barrada do Grilo and Vale de Romeiras, while planning the fieldwork for Poças de S. Bento.

Graphic documentation in the archives of MNA indicates that Arapouco was excavated by the museum staff in 1961 and 1962. Unfortunately, all written documentation for the years of 1961, 1962, and 1963 relative to the shell middens is missing from the museum archives. One site plan of Arapouco (MNA, 1961, D. Sousa, A120a) shows the areas excavated in the field season of 1961 (fig. 4.21). This is the only site plan available, thus, there is no information about site profiles or precise location of the human burials. According to Dario de Sousa who did the site drawings, all human burials were in the basal sandy layers of the site (Dario de Sousa, pers. comm.), which is apparently a common feature of the burials in the Sado middens. There are no field drawings with the human remains excavated at Arapouco. Nevertheless, the museum’s artist has confirmed that he did all field drawings for all the shell middens excavated by the museum after 1958 (Dario de Sousa, pers. comm.); however, these are missing from the museum. Other researchers have commented about the missing field documentation for Arapouco (Umbelino 2006, 141).

Archives of photography of Arapouco consist of 154 photographs (plus 34 photographs in poor preservation) from 1958, 1961 and 1962 (MNA, APMH, 2/11/8). Photographs from 1958 were probably taken during a preliminary survey, before the first excavation in 1961. The 1961 archive consists of photographs from 15 individuals. Photographs from 1962 do not show human remains.

Human remains excavated in 1961 are numbered from 1 to 15. The sequence of human remains excavated in 1962 starts again with the number 1, but the series is distinguished by an additional A, such as 1A, 2A, 3A, and so forth. The assumption about the correlation between the year of excavation and the numbers of the skeletons is based on two observations: (1) the field photographs have handwritten notes on the reverse, and all photographs with human remains are dated to 1961.
and the skeletons are identified from 1 to 15; (2) in the inventory list at MNA *(fichas de desmontagem)* all skeleton numbers from 1962 are identified with the additional *A*, such as 1A 1962, 2A 1962, 3A 1962, and so forth.

Four human skeletons are preserved in blocks of paraffin wax (ARA1961, Sks 5, 7; ARA1962, Sks 1A, 3A). The remaining skeletons are in disarticulated state sorted in containers.

The human remains were studied by a team of anthropologists and the MNI curated at the museum is 32 (Cunha and Umbelino 1995–97, 2001; Umbelino and Cunha 2012). This number suggests that if 15 individuals were excavated in 1961, as suggested by the field photographs, 17 individuals may have been recovered in 1962. The burial population consists of 6 non-adults, and 26 young (20–30 yrs) and mature adults (>35 yrs) (table 4.24). The adult group comprises 14 males and 10 females. In two cases the sex of the individual was not possible to determine. The group of non-adults (Umbelino 2006, 141) consists of two adolescents (c 15 yrs ± 36 months), and four children, three of which are under 6 years old. The youngest child buried at Arapouco is 1.5 to 2.5 years old, followed by a 3 year ± 12 months, and a 3 to 7 year old child. The oldest of these children is c 9 yrs ± 24 months.
Figure 4.21. The only site plan available for Arapouco, Sado valley. Dots: area of the shell midden. Long narrow rectangles: test trenches excavated in 1961 (Sonda 1 to 5). Talhão T: main excavation area where 15 human burials were recovered in 1961. (Adapted from a photograph by J. P. Ruas. MNA, 1961, D. Sousa, A120a)

Table 4.24. Arapouco, Sado valley: minimum number of individuals (MNI) estimated for the material curated at MNA.

<table>
<thead>
<tr>
<th>MNI</th>
<th>Adults</th>
<th>Non-adults</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂</td>
<td>14</td>
<td>6</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>♂</td>
<td>10</td>
<td>26</td>
<td></td>
</tr>
</tbody>
</table>
The following table (table 4.25), courtesy of one of the anthropologists who studied this material in detail (Umbelino 1999), is the reference used in this study regarding sex and age estimates for Arapouco.

Table 4.25. Arapouco, Sado valley: sex and age estimates of 22 individuals. (Data from Cunha and Umbelino 1995–97, 2001; Umbelino 1999)

<table>
<thead>
<tr>
<th>Individual</th>
<th>Container</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6229</td>
<td>Adult</td>
<td>♂</td>
</tr>
<tr>
<td>3</td>
<td>6223</td>
<td>Adult, mature</td>
<td>♀</td>
</tr>
<tr>
<td>4</td>
<td>6221</td>
<td>Adult, mature</td>
<td>♀</td>
</tr>
<tr>
<td>6</td>
<td>6227</td>
<td>Adult, mature</td>
<td>♀</td>
</tr>
<tr>
<td>8</td>
<td>6224</td>
<td>Adult, mature</td>
<td>♂</td>
</tr>
<tr>
<td>9</td>
<td>6236</td>
<td>Adult</td>
<td>♀</td>
</tr>
<tr>
<td>13</td>
<td>6226</td>
<td>15 yrs±36 m.</td>
<td>n/d</td>
</tr>
<tr>
<td>14</td>
<td>6231</td>
<td>9 yrs±24 m.</td>
<td>n/d</td>
</tr>
<tr>
<td>11</td>
<td>6228</td>
<td>Adult, young</td>
<td>♀</td>
</tr>
<tr>
<td>12</td>
<td>6228</td>
<td>3 yrs±1 m.</td>
<td>n/d</td>
</tr>
<tr>
<td>2A</td>
<td>6958</td>
<td>Adult, mature</td>
<td>♀</td>
</tr>
<tr>
<td>4A</td>
<td>6163</td>
<td>Adult, young</td>
<td>♀</td>
</tr>
<tr>
<td>5A</td>
<td>6222</td>
<td>Adult, mature</td>
<td>♂</td>
</tr>
<tr>
<td>6A</td>
<td>6189</td>
<td>Adult, mature</td>
<td>♂</td>
</tr>
<tr>
<td>7A</td>
<td>6209/6202</td>
<td>Adult</td>
<td>♂</td>
</tr>
<tr>
<td>9A</td>
<td>6121</td>
<td>Adult, mature</td>
<td>♂</td>
</tr>
<tr>
<td>11A</td>
<td>24046/6217</td>
<td>Adult</td>
<td>♂</td>
</tr>
<tr>
<td>13A1</td>
<td>6216</td>
<td>Adult, young</td>
<td>♀</td>
</tr>
<tr>
<td>13A2</td>
<td>6198</td>
<td>Adult, young</td>
<td>♂</td>
</tr>
<tr>
<td>14A</td>
<td>6207</td>
<td>Adult, mature</td>
<td>♂</td>
</tr>
<tr>
<td>15A</td>
<td>6120</td>
<td>Adult, mature</td>
<td>♂</td>
</tr>
<tr>
<td>16A</td>
<td>6215</td>
<td>Adult, mature</td>
<td>n/d</td>
</tr>
</tbody>
</table>

Observations about one mislabelled individual

In the course of this dissertation I identified one mislabelled individual in the Arapouco assemblage. This was individual 5 (adult, possibly male), whose remains are preserved in two blocks of paraffin wax (fig. 4.22). Until October 2013, these two blocks were identified as two different individuals. The block with the upper skeleton was identified as Vale de Romeiras and did not have an individual number, while the block with the lower limbs was identified as Arapouco, skeleton 5, container 6225 A and B. Another block, containing mostly the upper skeleton of an adult, possibly female, was identified with the label Arapouco, skeleton 5, container 6225–A (fig. 4.23). The re-identification of skeleton 5 from Arapouco was carried out by the comparison of the field photographs with the human remains preserved in
blocks and by the clear mismatch between the blocks containing the upper and lower skeletons which were originally identified as Arapouco, skeleton 5. The provenience of the individual mislabelled as Arapouco, skeleton 5 is unknown. The observation of the sediment seems to exclude it from Arapouco, and place it possibly at Cabeço do Pez. This tentative identification is based on similarities of the soil found in this block and in the block with the remains of CP1956, Sk2. The soil in both blocks is powdery brown sediment containing very small fragments of shells and a few complete shells of common cockle.

M. Fontanals-Coll and colleagues (2014) sampled a tibia from the individual mislabelled as Arapouco, Skeleton 5, which they identified as a female adult. Because of this mislabelling, the isotopic data for this individual was wrongly published by the team as Arapouco, Skeleton 5. The skeleton is likely to be from another site, presumably Cabeço do Pez. This problem is discussed further in chapter 5, Isotopic signatures: defining the people in each burial place.

Figure 4.22. Re-identification of individual from Arapouco, Sado valley. The field photograph on the right (c) is identified as Arapouco, Skeleton 5 and it matches the human remains in the two paraffin blocks (a, b). In 2013 the block with the upper skeleton (a) was wrongly labelled as Vale de Romeiras without a skeleton number, while the portion with the lower limbs (b) was identified as Arapouco, skeleton 5, container 6225 A and B. (Left, photographs by author at MNA. Right, MNA, APMH, F398)
Figure 4.23. This paraffin block was mislabelled Arapouco, Skeleton 5. The provenience of this burial is unknown. This skeleton in preserved in one paraffin block at MNA. (Photograph by J. P. Ruas)

Chronology of the burial activity

**Previous \(^{14}\)C measurements**

The first \(^{14}\)C measurements of samples from the Sado valley shell middens were submitted in the late 1980s (Arnaud 1989). One sample of shells (Q–2492) reported to be recovered from the middle layers during the 1961–62 excavations was the first \(^{14}\)C date available for Arapouco (table A8).

The first measurements on human bone from Arapouco (Sac–1560) were carried out in the late 1990s (Cunha and Umbelino 2001; Umbelino 2006). The sample was collected from one individual (2A) excavated in 1962. The \(\delta^{13}\)C value

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published along with this $^{14}$C measurement (Sac–1560) was obtained by AMS (Cláudia Umbelino, pers. comm.) and cannot be used for dietary reconstructions or reservoir corrections (Millard 2014, 557; Taylor and Bar-Yosef 2014, 117). Fortunately, recent IRMS measurements on this individual (Guiry et al. 2015) allow the calibration of this $^{14}$C date.

**Objectives of the dating programme**
Contextual information about the burials of Arapouco is poor. The basic aims of the dating programme in relation to the macro-goals outlined in chapter 3 were:
- to estimate the duration of the use of this site for burial activity;
- to estimate when the burial activity started and when it ended.

The site-specific aims of the dating programme for Arapouco were:
- to confirm the apparent antiquity of the site indicated by a non-human sample (Q–2492, 6374–5706 cal BCE, 95% confidence) (table A8).

**Sampling strategy**
Nine samples of human bone were selected for $^{14}$C analysis (table 4.26). The sampling strategy was targeted towards the burials with photographs and/or preserved in blocks.

**Results**
None of the nine samples (Ua–number) provided reliable results (table A1). Three samples (Ua–46937, Ua–47968, and Ua–47969) did not yield enough collagen for reliable $^{14}$C measurements. In three samples (Ua–47970, Ua–47971, and Ua–47972) the C:N ratio is higher than the acceptance range (2.9–3.6). In two samples (Ua–46938 and Ua–46940) the C:N ratio is within the 3.4–3.6 range suggesting contamination which is further confirmed by the high $\delta^{15}$N values (34.5 ‰ and 21.5 ‰ respectively) which are out of range. One of the nine samples (Ua–46939) was later recognized to be collected from a individual mislabelled as skeleton 5; as discussed above its provenience is unclear and it is therefore excluded from the analysis (table A2).

**Calibration and chronological models**
Only one $^{14}$C measurement on human bone collagen from Arapouco is available (table 4.27). This sample (Sac–1560) was calibrated with the recently published $\delta^{13}$C values obtained by IRMS (table 4.28, fig. 4.24). This one date does not allow the construction of a chronological model for the burial activity at Arapouco.
Table 4.26. Samples of human bone (9) from Arapouco collected and submitted for $^{14}$C measurement in the course of this study. With one exception (Ua–46939), all samples are from the 1961 assemblages and were collected at MNA. Sample Ua–46939 was collected from a skeleton mislabelled as Arapouco, skeleton 5 and its provenience remains unclear. *Samples pre-treated with boiling in acetone, ultrasonification first with ether and then with ethanol, and finally filtrated; after that processed as usual (see chapter 3).

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Site plan</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ua–46937</td>
<td>Adult</td>
<td>♂</td>
<td>Femur–R</td>
<td>Trench T</td>
<td>Not measurable</td>
</tr>
<tr>
<td>3</td>
<td>Ua–46938</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Femur–L</td>
<td>Trench T</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>5</td>
<td>Ua–47968*</td>
<td>Adult</td>
<td>♂</td>
<td>Fibula–L</td>
<td>Trench T</td>
<td>Paraffin block Not measurable</td>
</tr>
<tr>
<td>6</td>
<td>Ua–47969*</td>
<td>Adult, &gt;40 yrs</td>
<td>♀</td>
<td>Radius–R</td>
<td>Trench T</td>
<td>Not measurable</td>
</tr>
<tr>
<td>7</td>
<td>Ua–47970*</td>
<td>Adult, young</td>
<td>n/d</td>
<td>Radius–R</td>
<td>Trench T</td>
<td>Paraffin block Doubtful quality</td>
</tr>
<tr>
<td>8</td>
<td>Ua–47971*</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>Humerus–L</td>
<td>Trench T</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>11</td>
<td>Ua–46940</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Long bone</td>
<td>Trench T</td>
<td>Multiple–double burial Doubtful quality</td>
</tr>
<tr>
<td>13</td>
<td>Ua–47972*</td>
<td>Non-adult, 15 yrs±36 m.</td>
<td>n/d</td>
<td>Radius</td>
<td>Trench T</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>?</td>
<td>Ua–46939</td>
<td>Adult</td>
<td>♀</td>
<td>Femur unknown</td>
<td>Trench T</td>
<td>Paraffin block Mislabelled as ARA1961, Sk5 Provenience is unknown</td>
</tr>
</tbody>
</table>

Table 4.27. Human bone collagen sample (1) from Arapouco, Sado valley. $^{14}$C measurement and estimation of non-terrestrial carbon intake (% marine). Marine percentage was estimated from the measured IRMS-based $\delta^{13}$C value by the application of method marine 1 and method marine 2, based on adopted endpoint values of $-12\%^{\circ}$ and $-20\%^{\circ}$ for marine (100%) and terrestrial (100%) diets respectively.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Excav. Museum</th>
<th>Lab no.</th>
<th>14C Age BP</th>
<th>$\delta^{13}$C (‰) VPDB</th>
<th>$\delta^{15}$N (‰) AIR</th>
<th>C:N</th>
<th>M1</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>MNA</td>
<td>1962</td>
<td>7200±130*</td>
<td>$-17.2^#$</td>
<td>12.1^#</td>
<td>3.4^#</td>
<td>41</td>
<td>35</td>
</tr>
</tbody>
</table>

*Cuinha and Umbelino 2001; ^Guiry et al. 2015
Table 4.28. Human bone collagen sample from Arapouco, Sado valley: calibrated date ranges according to two different approaches for the calculation of the marine percentage. Results are presented in both cal BCE and cal BP in 95.4% confidence range.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Lab no.</th>
<th>$^{14}$C Age (BP)</th>
<th>Calibrated date range (95% confidence) cal BP</th>
<th>Calibrated date range (95% confidence) cal BCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A, 1962</td>
<td>Sac–1560</td>
<td>7200±130</td>
<td>8181–7662, M1</td>
<td>6232–5713, M1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8193–7673, M2</td>
<td>6244–5724, M2</td>
</tr>
</tbody>
</table>

Figure 4.24. Probability density function estimated for the death of ARA1962, Sk2A is 6232–5713 cal BCE (95% confidence, marine 1) or 6082–5820 cal BCE (67% confidence, marine 1). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Stable isotopes: carbon and nitrogen

Previous measurements: $\delta^{13}$C and $\delta^{15}$N

In the early 2000s, one sample from the 1961 excavations (individual 9) was analysed at the McMaster University in Canada in the scope of a palaeodietary study, however, the sample did not yield enough collagen for reliable measurements (Umbelino 2006; Umbelino and Cunha 2012).

Recently, two teams sampled this assemblage for stable isotope analysis of carbon and nitrogen (Fontanals-Coll et al. 2014; Guiry et al. 2015). M. Fontanals-Coll and colleagues (2014) analysed four samples at the Biological Anthropology Department at the Universitat Autònoma de Barcelona. Unfortunately, the only
sample that produced results was wrongly labelled as skeleton 5 at the time of the sampling (see above, Site background: a short history of research). This sample was obtained from the tibia of an adult female while the real skeleton 5 from Arapouco is an adult male preserved in a paraffined block and his long bones were not sampled. As discussed, the real provenience of this adult female is unknown and for this reason these measurements (table A2) must be excluded from the Arapouco series. Despite the poor collagen preservation of this assemblage, E. Guiry and colleagues (2015) obtained 12 reliable measurements (table 4.29) from a total of 19 samples. This material was measured on a Thermo-Finnigan Delta Plus XL isotope ratio mass spectrometer coupled via continuous flow to a Carlo Erba elemental analyzer at the Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. The instrumental error for $\delta^{13}$C and $\delta^{15}$N measurements was $\pm 0.1\%$ and $\pm 0.2\%$, respectively (Guiry et al. 2015).

The $\delta^{13}$C value published for individual 2A (Sac–1560) along with its $^{14}$C date (Cunha and Umbelino 2001; Umbelino 2006) was obtained by AMS and not by IRMS (Cláudia Umbelino, pers. comm.). This sample was not included in Umbelino’s palaeodietary study (2006) and as previously discussed it should not be used for dietary reconstructions and/or reservoir corrections.

**Sampling strategy**

In this study, the selection of samples of human remains for $\delta^{13}$C and $\delta^{15}$N measurements was fully dependent on the goals of the radiocarbon dating programme (see above).

**Results**

None of the Ua-number samples (n=8) provided reliable results (tables A2, A9). Overall, the collagen preservation at Arapouco is poor. Despite the multiple samples collected (n=32) which were analysed by four teams, only less than one third of the samples (n=12) presented measurements within the accepted quality ranges.

At Arapouco, the human collagen $\delta^{13}$C values (n=12/no. individuals=12) range from $-17.9\%$ to $-16.1\%$ with a mean value of $-17.0 \pm 0.5\%$. The human collagen $\delta^{15}$N values (n=12/no. individuals=12) range from $+11.0\%$ to $+13.0\%$ with a mean value of $+12.2 \pm 0.4\%$ (table 4.29, fig. 4.25).
### Table 4.29. Arapouco, Sado valley: carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) measurements on human bone collagen samples (12) collected at MNA. Samples are sorted so that the lowest $\delta^{13}C$ values are on the top of the table.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Lab no.</th>
<th>$\delta^{13}C$ (%)</th>
<th>$\delta^{15}N$ (%)</th>
<th>C:N</th>
<th>% marine (±10)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.64.68</td>
<td>–17.9</td>
<td>11.6</td>
<td>3.5</td>
<td>34</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>16A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.57.24</td>
<td>–17.6</td>
<td>12.1</td>
<td>3.3</td>
<td>37</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>11A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.55.96</td>
<td>–17.3</td>
<td>12.0</td>
<td>3.3</td>
<td>40</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>2A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.57.24</td>
<td>–17.2</td>
<td>12.1</td>
<td>3.4</td>
<td>41</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>7A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Cont. 6958</td>
<td></td>
<td>–17.2</td>
<td>11.7</td>
<td>3.3</td>
<td>41</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>3, 1961</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.69.106</td>
<td>–16.8</td>
<td>12.7</td>
<td>3.3</td>
<td>45</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>9A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.54.41</td>
<td>–16.8</td>
<td>12.7</td>
<td>3.3</td>
<td>45</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>14A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.65.99</td>
<td>–16.8</td>
<td>12.0</td>
<td>3.3</td>
<td>45</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>8, 1961</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.51.35</td>
<td>–16.8</td>
<td>11.9</td>
<td>3.4</td>
<td>45</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>13A2, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Rib</td>
<td>999.53.77</td>
<td>–16.5</td>
<td>13.0</td>
<td>3.3</td>
<td>48</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>6, 1961</td>
<td>Adult,</td>
<td>♂</td>
<td>Rib</td>
<td>Cont. 6227</td>
<td>–16.5</td>
<td>12.6</td>
<td>3.4</td>
<td>48</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>6A, 1962</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>999.62.53</td>
<td>–16.1</td>
<td>12.5</td>
<td>3.3</td>
<td>51</td>
<td>Guiry et al. 2015</td>
</tr>
</tbody>
</table>

**Figure 4.25.** Arapouco, Sado valley: correlation between the $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) values of 12 samples of human bone collagen.
Archaeothanatology

Source material and analysis strategy
Archaeothanatological analysis was carried out on a total of 16 individuals (table 4.30), 50% of the MNI (32, Cunha and Umbelino 1995–97) for Arapouco. The source material comprises field photographs available for 15 individuals, and paraffin blocks of four individuals. For the remaining individuals excavated at this site (n=15) there is no source material available, at least at the time of this study.

The first phase of analysis took place at MNA, where the four individuals preserved in paraffin blocks (ARA1961, Sks 5, 7; ARA1962, Sks 1A, 3A) were analysed and photographed. The second phase of analysis consisted of the reassessment of my observations done in the museum, crosschecked with the photographed material and the archival field photographs where available (ARA1961, Sks 5, 7). The analyses based on field photographs exclusively (ARA1961, Sks 1, 2, 3, 4, 6, 8, 9, 11, 12, 13, 14, 15; ARA1962, Sks 1A, 3A) followed the same analytical protocol (see chapter 3, Archaeothanatology).

Results of the archaeothanatological analysis
The nature of the deposits
Analysis of the nature of the deposits at Arapouco indicates an unequivocal pattern of primary burials (table 4.31). The cadavers were placed in the burial features before the degradation of the labile joints, retaining their anatomical integrity. The two cases that raise questions about this pattern come from the analysis of two of the child skeletons analysed (ARA1961, Sks 10, 12). These questions are in part due to the unclear documentation available for these individuals and to the normal degree of fragmentation of juvenile skeletons which are not fully formed, resulting in a greater degree of fragmentation and scattering of the bones in comparison with an adult skeleton. In the case of ARA1961, Sk10 the documentation is also unclear and further analysis is not possible. For ARA1961, Sk12 the graphic documentation is somewhat better but of very low resolution. This 3 year old child (ARA1961, Sk12) is buried with an adult female (ARA1961, Sk11) and while ARA1961, Sk11 is clearly a primary deposit, the analysis of the child skeleton is not conclusive. The right temporomandibular joint is preserved and supports the interpretation of a primary deposit, as this is one of the first articulations to break down during the decomposition process. However, other labile articulations if preserved are not observable in the documentation. The general topography of the body is quite chaotic and the observations at this level are unclear. This scattering could be the result of post-depositional disturbance of the feature; however, the skeleton of the adult in the same feature remains in articulation invalidating this hypothesis (see below, Deposits containing more than one individual).
Table 4.30. Arapouco, Sado valley: source material used for the archaeothanatological analysis. This material is curated at MNA.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Source material</th>
<th>Block</th>
<th>Graphic documentation w/ human remains</th>
<th>Written documentation</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Field photographs</td>
<td>Drawings</td>
<td>Site plan</td>
</tr>
<tr>
<td>1, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>3, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>4, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>5, 1961</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>6, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>7, 1961</td>
<td>yes</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>8, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>9, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>10, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>11, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>12, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>13, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>14, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>15, 1961</td>
<td>n/a</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>1A, 1962</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>3A, 1962</td>
<td>yes</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Table 4.31. Summary of the nature of the deposits with human remains at Arapouco, Sado valley.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Nature of the deposit</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1961</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: phalanges of left hand, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>2, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Most labile articulations are unclear in the documentation except for the bones of the hands which are slightly disarticulated. However, the skeleton is well articulated and the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>3, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of left foot; other joints are not clear in the documentation.</td>
</tr>
<tr>
<td>4, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of right foot; other joints are not clear in the documentation.</td>
</tr>
<tr>
<td>5, 1961</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right hand, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>6, 1961</td>
<td>Adult, &gt;40 yrs</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of left foot. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>7, 1961</td>
<td>Adult, young</td>
<td>n/d</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>8, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>9, 1961</td>
<td>Adult</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of left hand, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>10, 1961</td>
<td>Non-adult, 1.5–2.5 yrs</td>
<td>n/d</td>
<td>Unknown</td>
<td>Poor preservation of diagnostic criteria and unclear documentation.</td>
</tr>
<tr>
<td>11, 1961</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right hand, most metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>12, 1961</td>
<td>Non-adult, 3 yrs±1 m.</td>
<td>n/d</td>
<td>Unclear, primary?</td>
<td>Maintenance of labile articulations: TM joint is preserved but the documentation is unclear for other joints.</td>
</tr>
<tr>
<td>13, 1961</td>
<td>Non-adult, 15 yrs±36 m.</td>
<td>n/d</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>14, 1961</td>
<td>Non-adult, 9 yrs±24 m.</td>
<td>n/d</td>
<td>Probably primary</td>
<td>The labile articulations are poorly preserved and unclear in the documentation. However, the skeleton is well articulated and the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>15, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>The labile articulations are poorly preserved and unclear in the documentation. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>1A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>The preservation of the skeleton is poor. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>3A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Maintenance of labile articulations: most metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
</tbody>
</table>
The space of decomposition of the cadaver

Analysis of the space of decomposition of the cadavers buried in Arapouco indicates a general pattern of filled spaces (table 4.32). The cadavers were covered with sediment immediately after their placement in the features. The decomposition of the bodies took place in this sediment-filled environment. Some cases at Arapouco present very strong indicators not only of a filled space of decomposition but also for very rapid and fluid penetration of sediment. This is demonstrated by the limited or moderate collapse of the thoracic cage (ARA1961, Sks 3, 4, 5, 6, 13). In several cases the bones of the pelvic girdle are maintained in anatomical position and the collapse of the bones is prevented by the immediate penetration of sediment (ARA1961, Sks 2, 4, 5, 7, 9, 13, ARA1962, Sk3A). Observations at the level of the pubic symphysis are not always possible due to the nature of the documentation, but at least in one case (ARA1961, Sk8) the collapse of the os coxae occurs laterally, which is a common movement even in filled spaces of decomposition.

Few cases suggest mixed spaces of decomposition (ARA1961, Sks 6, 12) with original empty spaces in the grave feature and/or by the formation of secondary empty spaces outside the volume of the cadaver within an overall filled environment. One of these cases is presented by ARA1961, Sk6. The analysis of this feature, discussed further below, suggests the existence of perishable material, functioning as a cushion, behind the upper body creating a secondary empty space in this area while it decayed. In the second case, ARA1961, Sk12, the documentation is more ambiguous. The analysis suggests the possibility of original empty spaces in the feature and/or of the creation of secondary empty spaces by the decomposition of a perishable element in the feature, allowing the scattering of the bones of this child. This perishable element could have been a container, such as a pouch or a basket accommodating the child. The analysis is not conclusive and it should be emphasized that children’s bones have a tendency to spread out more, both because they are smaller and because the articulations are less firm. Thus, some of these scattering patterns could be possible even in a filled space. The burial of this child (ARA1961, Sk12) will be discussed further throughout this text.
Table 4.32. *Summary of the space of decomposition of the human remains in the grave features at Arapouco, Sado valley.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Space of decomposition</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1961</td>
<td>Adult</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the bones of left hand are rotated and flexed at the wrist and the bones of left foot are rotated outwards. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>2, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: limited collapse of TC. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>3, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: limited collapse of TC; no collapse of left os coxae. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>4, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: limited collapse of TC; no collapse of left os coxae. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>5, 1961</td>
<td>Adult</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the CV can be followed as an arc forwards; the bones of the right hand are slightly rotated inwards; limited collapse of the TC; limited collapse of os coxae; the right patella is suspended on the distal end of the right femur. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>6, 1961</td>
<td>Adult, &gt;40 yrs</td>
<td>♂</td>
<td>Filled, Mixed</td>
<td>Maintenance of bones in original unbalanced position: the CV can be followed as an arc forward; limited collapse of the TC; the patellae are suspended on the distal end of the femora; the bones of left foot are slightly rotated outwards. Also, the cranium is maintained in a semi-suspended position. Movement at the level of the upper right limb suggests empty space behind this area.</td>
</tr>
<tr>
<td>7, 1961</td>
<td>Adult, young</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse of the TC and of os coxae. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>8, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the right patella is suspended on the distal end of the right femur; the bones of left foot are rotated. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
</tbody>
</table>

*continued...*
<table>
<thead>
<tr>
<th>Date</th>
<th>Age Range</th>
<th>Gender</th>
<th>Filled</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9, 1961</td>
<td>Adult</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the bones of left hand which are slightly rotated; no collapse of os coxae. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>10, 1961</td>
<td>Non-adult, 1.5–2.5 yrs</td>
<td>n/d</td>
<td>Unknown</td>
<td>Poor preservation and unclear documentation.</td>
</tr>
<tr>
<td>11, 1961</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse of TC; the right patella is suspended on the distal end of the right femur; the bones of right foot are slightly rotated. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>12, 1961</td>
<td>Non-adult, 3 yrs±1 m.</td>
<td>n/d</td>
<td>Unclear, mixed?</td>
<td>Overall, the bones are found disarticulated, scattered and fragmented. Movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>13, 1961</td>
<td>Non-adult, 15 yrs±36 m.</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: limited collapse of TC; limited collapse of the bones of os coxae; the patellae are suspended on the distal end of the femora; the bones of right foot are rotated. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>14, 1961</td>
<td>Non-adult, 9 yrs±24 m.</td>
<td>n/d</td>
<td>Filled</td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>15, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>1A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: right patella is in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>3A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: limited collapse of the os coxae. No movement outside initial volume of the cadaver.</td>
</tr>
</tbody>
</table>
The initial position of the cadaver in the feature

The most common position at Arapouco consisted of a cadaver lying on the back (n=10) with the limbs in flexion (table 4.33). The second most common position was the body lying on the lateral side (n=5) with the limbs in flexion and arranged close to the body. It was not possible to reconstruct the initial position of two of the children analysed at this site (ARA1961, Sks 10, 12).

In the case of the individuals placed on the back, the head of the cadaver was often rotated forwards and downwards (n=8) towards the body in the feature, with the neck in flexion or hyperflexion (ARA1961, Sks 1, 2, 5, 6, 7, 8, 13, 14). In only two features (ARA1961, Sk15; ARA1962, 3A) was this not the case. In the case of the individuals placed on the lateral side the head was rotated slightly upwards and backwards (ARA1961, Sks 3, 4). The analysis was not possible in five cases (ARA1961, Sks 9, 10, 11, 12; ARA1962, Sk1A).

The position of the upper limbs was variable but they were always placed close to the body. In seven cases (ARA1961, Sks 1, 2, 6, 8, 11, 15; ARA1961, Sk1A) the limbs were arranged symmetrically with both elbows in semi-flexion (n=2), flexion (n=1), or hyperflexion (n=3). In three cases (ARA1961, Sks 5, 7; ARA1961, Sk3A) they were placed in asymmetrical positions, with one of the elbows in semi-extension and the other in extension (n=2) or flexion (n=1). For the other seven individuals it was not possible to identify the symmetry of the upper limbs due to the fragmentation of the bones and/or due to unclear documentation. The upper limbs were frequently flexed at the level of the elbow joints, from slight or semi-flexion to strong or hyperflexion. The extended position of at least one of the limbs was noted in only four cases (ARA1961, Sks 5, 7, 9, 13).

At Arapouco, the bodies were placed in the feature with the lower limbs always in flexion at the level of the hip and knee joints. The rotation of the limbs presents the variation within this pattern. In the case of the bodies placed on the back (n=10), three individuals presented a rotation towards the right side (ARA1961, Sks 2, 7, 8) while three were rotated towards the left (ARA1961, Sks 1, 15; ARA1962, Sk3A). In three cases the lower limbs were not rotated and the knees were directed forwards (ARA1961, Sks 5, 6, 9). In only two cases were the lower limbs in abduction (ARA1961, Sk6, 11). In the case of the bodies placed on the lateral side the lower limbs were always in flexion or hyperflexion positioned close to the upper body. The feet of the cadavers were commonly (n=9) positioned towards the buttocks (ARA1961, Sks 2, 3, 4, 5, 7, 9, 11, 14; ARA1962 Sk3A) indicating a constrained position of the lower limbs.

Often, the bodies lay in the grave feature in a clump (n=5), on the back or on the lateral side, with the lower limbs in hyperflexion in front of the upper body (ARA1961, Sks 2, 3, 4, 7, 14). This constrained position is particularly striking in the case of skeletons 3 and 4 which became hypercontracted.
Table 4.33. *Summary of the reconstruction of the initial position of the cadaver in the grave features at Arapouco, Sado valley. The initial position of the limbs is indicated as –R or –L and refers to the right or left limb, when their positions are different. Rotation –R or –L indicates the rotation of the skeletal element(s) towards the right or the left side.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Initial position of the cadaver in the feature</th>
<th>Trunk</th>
<th>Upper limbs</th>
<th>Lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1961</td>
<td>Adult</td>
<td>♂</td>
<td>Rotation–L and downwards (neck slightly flexed forwards)</td>
<td>On the back</td>
<td>In hyperflexion</td>
<td>Hip and knee joints: flexion Rotation–L</td>
</tr>
<tr>
<td>2, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>Rotation–R and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In hyperflexion</td>
<td>Hip joints: flexion Knee joints: hyperflexion Rotation–R Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>3, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Rotated slightly upwards and backwards (neck in extension)</td>
<td>On the right</td>
<td>n/a</td>
<td>Hip and knee joints: hyperflexion Rotation–R Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>4, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Rotated slightly upwards and backwards (neck in extension)</td>
<td>On the left</td>
<td>In hyperflexion–R n/a–L</td>
<td>Hip and knee joints: hyperflexion Rotation–L Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>5, 1961</td>
<td>Adult</td>
<td>♂</td>
<td>Rotation–R and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In extension–R In semi–flexion (90°)–L</td>
<td>Hip joints: flexion Knee joints: hyperflexion Knees directed forwards Feet towards buttocks</td>
</tr>
<tr>
<td>6, 1961</td>
<td>Adult, &gt;40 yrs</td>
<td>♀</td>
<td>Rotation–L and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In semi–flexion</td>
<td>Hip and knee joints: flexion Abduction Knees directed forwards</td>
</tr>
<tr>
<td>7, 1961</td>
<td>Adult, young</td>
<td>n/d</td>
<td>Rotation–R and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In extension–R In semi–flexion (90°)–L</td>
<td>Hip and knee joints: flexion Rotation–R Feet towards buttocks Clumping</td>
</tr>
</tbody>
</table>

*continued...*
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Gender</th>
<th>Position</th>
<th>Movement Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>8, 1961</td>
<td>Adult, 35–50 yrs</td>
<td>♂</td>
<td>On the back</td>
<td>Rotation–R and downwards (neck flexed forwards)</td>
</tr>
<tr>
<td>9, 1961</td>
<td>Adult</td>
<td>♀</td>
<td>On the back</td>
<td>In extension or semi-extension–R</td>
</tr>
<tr>
<td>10, 1961</td>
<td>Non-adult, 1.5–2.5 yrs</td>
<td>n/d</td>
<td></td>
<td>Hip joints: flexion</td>
</tr>
<tr>
<td>11, 1961</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>On the back</td>
<td>In semi-flexion</td>
</tr>
<tr>
<td>12, 1961</td>
<td>Non-adult, 3 yrs ± 1 m.</td>
<td>n/d</td>
<td></td>
<td>Hip and knee joints: flexion</td>
</tr>
<tr>
<td>13, 1961</td>
<td>Non-adult, 15 yrs ± 36 m.</td>
<td>n/d</td>
<td>On the left</td>
<td>Hip and knee joints: hyperflexion</td>
</tr>
<tr>
<td>14, 1961</td>
<td>Non-adult, 9 yrs ± 24 m.</td>
<td>n/d</td>
<td>On the left</td>
<td>Hip and knee joints: hyperflexion</td>
</tr>
<tr>
<td>15, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>On the back</td>
<td>Hip joints: flexion</td>
</tr>
<tr>
<td>1A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>On the right</td>
<td>In hyperflexion</td>
</tr>
<tr>
<td>3A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>On the back</td>
<td>Hip and knee joints: flexion</td>
</tr>
</tbody>
</table>
The grave features

The size and shape of the deposits with human remains at Arapouco were not described by the excavators. The archaeothanatological analysis indicates that the bodies were placed in pits dug into the ground. The lateral pressures and wall-effects observed on the skeleton in the feature (table 4.34) indicate that in most cases the shape and size of the pit was just sufficient to contain the body. However, in some cases the grave pits were somewhat wider allowing a relatively expanded position of the body particularly at the level of the lower body (ARA1961, Sks 6, 8, 11). The analysis further indicates that in some cases the design of the grave had a significant impact on the final arrangement of the cadaver in the feature, visible by the clumping of some bodies (ARA1961, Sks 2, 7, 14), and by the extremely constrained positions of some individuals (ARA1961, Sks 3, 4) indicating an increased hypercontraction of the skeleton during decomposition. In these latter cases, the bodies were laid on the lateral side in individual small narrow pits with the limbs in hyperflexion in front of the thoracic cage. The analysis shows not only a strong bilateral pressure towards the body, but also evidence for important constraint effects. The wall-effect is visible in the alignment of the cranium and the back on one side, and of the lower limbs on the other side. This pattern was enhanced during decomposition by the progressive closure of the angles between the limb segments causing the hypercontraction of the skeleton. These wall-effects probably correspond to the physical limits of the pit, just wide enough to contain the individual.

Frequently, the bottom of the feature was irregular and sloping from the upper to the lower end as well as towards one of the sides of the grave. This is demonstrated by the flexion and the collapse forwards and downwards of the head, registered in eight to nine cases, three of which are very pronounced (ARA1961, Sks 5, 6, 13). This is also revealed by the flexion of the cervical vertebrae which can be followed in an arc forwards (ARA1961, Sks 5, 6), and by the position of the crania in anterior view lying in front of the chest (ARA1961, Sks 5, 6, 7, 8, 13) or towards one of the shoulders (ARA1961, Sks 2, 14). This flexion pattern of the CV will be discussed further below. Other observations suggesting a sloping floor are the rotation forwards and downwards of the ribs (ARA1961, Sks 5, 6, 7, 11, 14; ARA1962, Sks 1A, 3A), and the forward rotation of the sacrum (ARA1961, Sks 5, 8). The irregularity of the surface of the graves is also suggested by the general distribution of the bones indicating a transfer of body weight with following patterns of movement towards one side of the feature (ARA1961, Sks 1, 2, 5, 7, 11, 14, 3A). Thus, the cadavers were often placed in a half-sitting position propped up by the sloping characteristics of the floor of the grave.

Often, the narrow shape of the pit imposed a significant physical limit to the cadaver offering lateral support and preventing the collapse of the bones. However, the analysis suggests that in a few cases there might have been extra support offered by some kind of soft container such as light wrapping. This is possibly the case for ARA1961, Sk11, where the pressures observed seem to indicate the
existence of a soft wrapping at the time of the burial involving the upper body, as suggested by the bilateral compression of the upper limbs. This lateral pressure constraining and supporting the upper body is in contrast with the relatively wide space available to accommodate the position of the lower limbs which lie in abduction. Furthermore, this soft wrapping at the level of the upper body (11) possibly also offered support to the body of the 3 year old child (12) placed in front of the left hemithorax of this adult, which will be discussed further below. The data available for ARA1961, Sk6 is more ambiguous and alternative explanations are possible. The alignment of the upper limbs contrasts with the position of the lower limbs which are in abduction. In this case, I suggest that it is possible that some kind of binding, such as that of a rope could have provided the lateral support observed, while allowing the penetration of fluid sediment in the feature as well as the flexibility of movement observed by the disarticulation of the upper limb upwards at the level of the shoulder. This is also the only case (ARA1961, Sk6) where the analysis suggests the possibility of the presence of perishable structures behind the body, as discussed further in this text.

Deposits containing more than one individual

Most deposits with human remains at Arapouco contain the remains of one individual.

One grave feature at Arapouco contains the remains of two individuals (ARA1961, Sks 11, 12). This is a multiple double deposit of one female adult (11) and one 3 year old child (12). The adult was laid in the pit and the child was placed in front of her left hemithorax. This seems to be a synchronous deposit, first because individual 11 was still in anatomical integrity when the second individual (12) was placed in the feature, and second because it seems as if the adult (11) was arranged to hold the child (12).

Another two individuals (ARA1961, Sks 9, 10), also a female adult and a child (1.5 to 2.5 yrs), have been described briefly as a double burial (Cunha and Umbelino 1995–97, 2001; Umbelino and Cunha 2012). Based on the graphic documentation, I argue that it is not evident that these are simultaneous deposits. The bodies are in very close proximity (particularly the heads) and do not disturb each other, but a thick layer of sediment separates both bodies. The body of the child (10) lies on a layer of sediment which covers the left shoulder girdle and left arm of the adult (9). The bodies are not intertwined and do not come in contact with each other and there is no evidence of a common arrangement of the bodies. ARA1961, Sk9 was deposited first, covered with sediment, and only then was individual ARA1961, Sk10 buried. The interval between these deposits is not possible to determine; it could have been some minutes or several years. Based on the current documentation, there is no evidence to support the interpretation of a simultaneous deposit, but this hypothesis cannot be completely rejected either.
Table 4.34. Summary of the key observations used in the reconstruction of the grave features at Arapouco, Sado valley. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Pressures</th>
</tr>
</thead>
<tbody>
<tr>
<td>7, 1961</td>
<td>Adult, young</td>
<td>n/d</td>
<td>1. Wall-effect, right side; 2. Wall-effect, left side. Design of the grave feature.</td>
</tr>
</tbody>
</table>

1. Alignment of upper right limb and projection forwards and upwards of right shoulder and arm; 2. Alignment of lower left limb, involving leg and foot. Pattern enhanced by the sloping floor causing a transfer of body weight towards the left side.

2. Alignment of right limbs. Pattern enhanced by the sloping floor causing a transfer of body weight towards the right side; 2. Alignment of left arm; 3. Alignment of lower limbs and constraint effect towards legs forcing feet towards buttocks.

Hypercontracted skeleton

Hypercontracted skeleton

1. Extreme flexion of neck; 2. Alignment of upper right limb and projection forwards and upwards of right shoulder and arm. Pattern enhanced by the sloping floor causing a transfer of body weight towards the right side; 3. Alignment of lower limbs and constraint effect towards legs forcing feet towards buttocks.

1. Extreme flexion of neck; 2. Alignment of upper right limb, involving arm and forearm, not affecting right shoulder; 3. Affecting right arm in particular; 4. Suggested by the alignment of left arm.

1. Affecting knees and legs in particular, forcing feet towards buttocks; 2. Alignment of upper left limb, involving left shoulder and arm. Pattern enhanced by the sloping floor causing a transfer of body weight towards the left side.

continued...
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Sex</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9, 1961</td>
<td>Adult</td>
<td>♀</td>
<td>1. Wall-effect, lower end. Design of the grave feature.</td>
</tr>
<tr>
<td>10, 1961</td>
<td>Non-adult, 1.5–2.5 yrs</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>12, 1961</td>
<td>Non-adult, 3 yrs±1 m.</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>13, 1961</td>
<td>Non-adult, 15 yrs±36 m.</td>
<td>n/d</td>
<td>1. Extreme rotation forwards and downwards of head and shoulders; 2. Alignment of buttocks, hips and left foot; 3. Alignment of left shoulder and knees.</td>
</tr>
<tr>
<td>14, 1961</td>
<td>Non-adult, 9 yrs±24 m.</td>
<td>n/d</td>
<td>1. Alignment of lower limbs. Pattern enhanced by the sloping floor causing a transfer of body weight towards the left side.</td>
</tr>
<tr>
<td>15, 1961</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Verticalization of clavicles. This lateral pressure affected shoulders but not the upper limbs. 2. Alignment of lower left limb position in constrained position.</td>
</tr>
<tr>
<td>1A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Alignment of right leg; 2. Visible by the even levelling and flattening of the bones in a horizontal plane.</td>
</tr>
<tr>
<td>3A, 1962</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Towards shoulder girdles involving the arms as well. Pattern enhanced by the sloping characteristics of the floor of the grave, slightly more elevated on the lateral sides than on the centre of the feature. 2. Alignment of lower limbs and constraint effect towards lower limbs forcing feet towards buttocks.</td>
</tr>
</tbody>
</table>
Post-depositional manipulations of the cadavers

At Arapouco, the skeletons are apparently complete and lie undisturbed in the grave feature.

The only suggestion for the post-depositional manipulation of the cadavers comes from the double grave of ARA1961, Sks 11 and 12. The skull of individual 11 (cranium and mandible) is missing from the feature. One possible hypothesis is that the individual was originally buried complete and the skull was later removed. The removal of the skull could be explained by (1) post-depositional surface disturbance or (2) by a deliberate act involving the re-opening of the grave and the removal of the skull. In the case of a sloping grave floor such as that of this burial, the head would be the most elevated body part in the feature; hence the closest body part to the surface and easily removed without disturbing other bone elements. Another possible hypothesis is that the individual was buried without the head. In this case, the head would have been removed soon after death, before an advanced stage of decomposition, because the body was buried retaining its anatomical integrity. The viability of this hypothesis depends on whether the atlas (C1) and axis (C2) were present or also missing from the feature, which could not be confirmed at the time of this study. However, these scenarios are working hypotheses and are not possible to test with the current documentation.

The mortuary programme at Arapouco

The burial practices observed at Arapouco present a strong similarity and the minor detected variations do not affect the overall pattern of the treatment of the dead.

While the tables presented above may be consulted for the diagnostic criteria and arguments of analysis, I have chosen to describe ARA1961, Sk5 as a case that clearly illustrates the common principles governing burial practice at Arapouco. In this section I describe also ARA1961, Sks 6, 11, 12 and 13 as cases that present unusual features within the assemblage of Arapouco with several striking elements from an archaeothanatological perspective.

ARA1961, Sk5

ARA1961, Sk5 consisting of the remains of an adult, possibly male, lying on its back in the grave feature, is particularly well-preserved in a paraffin block (fig. 4.26).

This case combines several common elements observed in the human burials at Arapouco. The first common element is the primary nature of the deposit. In the case of this skeleton, the maintenance of the bones of the right hand in anatomical connection, as well as the maintenance of the articulations of the metatarsals and phalanges of the feet in perfect anatomical position are strong arguments supporting this interpretation. The general topography of the body is also indicative of a burial in primary position. The few disarticulations observed at the level of the
cervical vertebrae or at the bones of the left hand, are indicative of minor movements into empty spaces created during the process of decomposition.

The second common element is the decomposition of the body in an environment filled with sediment. This is illustrated by several groups of bones which were maintained in place even though their original position was quite unbalanced. This is the case for the connection maintained between the cervical vertebrae (CV) which can be followed as an arc forwards and downwards (fig. 4.27). A similar movement can be observed in the feature ARA1961, Sk6 between the C3–C7, while the atlas (C1) and axis (C2) became detached (fig. 4.28). This forward flexion of the neck probably also occurs in other features where there is rotation of the head forwards and downwards but the documentation is unclear and in many cases the CV are not visible or preserved. In the case of ARA1961, Sk5, only some CV are exposed. These are flexed forwards with a tendency towards the right side and form an arc behind the cranium. The cervical joints that are visible are not articulated but are in contact. The atlas (C1) is not visible and the axis (C2) is only partially visible on its posterior side below the cranium. Thus, the persistent joint occipital–atlas (C1) is not exposed. C3 presents its posterior view while C4 presents its superior and posterior view. C5 is only partially visible and its lateralization is not clear. The segment C6–C7 is not exposed. The position of the CV shows that one portion, C2–C3, has tipped with the cranium and C1 possibly moved below the cranium, while the other portion, C4–C5, has stayed behind the collapse. The close contact between the CV has been maintained by the immediate penetration of fine sediment throughout the process of decomposition, otherwise the bones would not display this gradual support. Also, the bones of the right hand were rotated slightly inwards but retained a perfect articulation. Another strong argument is the position of the right patella suspended on the distal end of the right femur. These are all indicators of decomposition in a filled space where these bones could be supported, even if in unstable positions.

Other evident movements in this feature can be explained by the dynamics of the decomposition process. The cranium has collapsed slightly forwards, but was maintained in a semi-suspended, elevated position within the feature. Likewise, the dispersal of the bones of the left hand took place in the volume of the initial cadaver and cannot be attributed to empty spaces outside the cadaver. ARA1961, Sk5, like most burials at Arapouco, presents very strong indicators not only of a filled space of decomposition but for a very rapid and fluid penetration of sediment. The collapse of the thoracic cage even in filled volumes is in this case moderate and the position of the ribs is kept in order. This is also the case for the collapse of the os coxae, which in most of the burials is very limited. In the particular case of ARA1961, Sk5 the elevation of the bones of the left forearm by a pocket of sediment is an interesting example of the formation of a filled volume by the interplay of an active area during decomposition where very fluid sediment filled up all tiny empty spaces created during a dynamic stage of decay. Overall, the limited movement of the bones clearly indicates that the space of decomposition was filled and that the sediment penetrated immediately.
Figure 4.26. ARA1961, Sk5 illustrates several common principles governing burial practice at Arapouco, Sado valley. This skeleton in preserved in two paraffin blocks at MNA. (Photograph by J. P. Ruas)
Figure 4.27. ARA1961, Sk5 presents typical patterns of decomposition of the body in a sediment-filled environment. Detail of the CV which can be followed as an arc forwards and downwards indicating the forward flexion of the neck and the gradual support of the skeletal elements by the rapid penetration of fluid sediment. (Photographs by author at MNA)
The initial position of the cadaver ARA1961, Sk5 presents various common elements observed in the human burials at Arapouco. The cadaver was laid on its back in a small pit with a sloping floor, possibly slightly more elevated at the superior left side of the feature. The head was directed forwards and downwards towards the chest, slightly rotated to the right with the neck flexed forwards. This pattern was accentuated during decomposition, first because the body was lying on a slope and second, because the cranium has a tendency to roll after the joints of the neck break down. Also, the head is the most elevated body part in the feature hence the closest body part to the surface of the grave, thus the pressure of the sediment on the back of the head would increase the flexion of the neck, which is a common observation for the burials at Arapouco. The right upper limb of ARA1961, Sk5 was placed in complete extension while the left upper limb was semi-flexed at the elbow with the left hand placed in front of the abdomen. The lower limbs were flexed at the level of the hips and hyperflexed at the knees with a tendency towards the left side.

At Arapouco, the main pressures observed on the bodies in the grave features consist of the weight of the sediment from above enhancing the flexion of the neck and the rotation forwards and downwards of the head, and the wall-effects at the lateral sides and lower end of the graves with consequent pressures providing support as well as constraining the movement of the limbs. This is well illustrated by ARA1961, Sk5 where there are three main pressures. One is the movement
pattern and consequent pressure from the weight of the sediment from above visible by the extreme flexion of the neck. The second is the lateral pressure and a wall-effect on the right side of the feature, visible in the alignment of the upper right limb, involving the right shoulder girdle and arm. This lateral pressure was accentuated by the sloping grave floor, slightly more elevated on the superior left side, causing a transfer of body weight towards the right side. Hence, there is movement pattern and consequent pressure from body weight from the upper left side against the right wall of the grave. The third main pressure observed is a wall-effect at the lower end of the feature visible in the alignment of the lower limbs and the constraint effect towards the legs forcing the feet towards the buttocks. The pressures observed are the result of the design of the grave feature.

**ARA1961, Sk6**

Likewise, the grave feature ARA1961, Sk6 presents all the general elements of the burials known at Arapouco. However, from an archaeothanatological perspective, this case offers an unusual example of localised movement of the bones at the level of the upper right limb which is in contrast with the overall pattern of limited movement of the bones in the grave features, suggesting in this case the formation of a secondary empty space (fig. 4.29).

As with the typical burials at Arapouco, ARA1961, Sk6 was laid in a pit with a sloping floor, on its back, with the head flexed forwards and downwards, and slightly rotated to the left. The upper right limb was semi-flexed at the elbow and placed laterally to the upper body with the right hand lying on the right hip. The upper left limb was semi-flexed at the elbow with the forearm lying in front of the lower abdomen. The lower limbs were flexed at the level of the hips and knees, in slight abduction, while the feet were lying medially in close proximity.

The primary nature of this deposition is demonstrated by the anatomical preservation of the labile joints of the left foot. Also, the few disarticulations observed, at the level of the cervical vertebrae (C1–C2, C2–C3), at the bones of the right hand, or at the bones of the right forearm, are the result of movements into empty spaces created during the process of decomposition. Overall, the skeleton is well articulated and the general topography of the body confirms its primary position. The extreme disarticulation of the upper right limb at the level of the shoulder girdle indicates an important movement of the bones but it is not indicative of a secondary deposition.

The secondary empty space can be observed at the level of the upper right limb. The limb was pushed upwards and forwards becoming disarticulated at the level of the shoulder while retaining its articulations at the elbow. This radical movement upwards, in an overall filled environment such as this, could be explained by the existence of an organic element behind the body in this area creating a secondary empty space after its decomposition to which the limb could migrate.
Results: Sado valley, Arapouco

Figure 4.29. ARA1961, Sk6. The striking displacement upwards of the upper right limb contrasts with the minor movements observed in this feature. The disarticulation of the limb occurs at the level of the shoulder joint and did not affect the articulations at the elbow or at the wrist which remain in articulation. While the bones of the limb are displaced upwards the scapula migrated towards the bottom of the feature. (MNA, APMH, F368, F367)
The analysis indicates four main pressures on the body in the feature. One is the movement pattern following pressure from the weight of the sediment from above, visible by the extreme flexion of the neck. The second is the lateral pressure and a wall-effect on the right side of the feature, visible in the alignment of the upper right limb, involving the arm and forearm, but not affecting the right shoulder girdle. At this level, there is a pressure from the back affecting the arm in particular. The fourth pressure is a wall-effect at the left side of the feature suggested by the alignment of the left arm; however, this observation is not conclusive because the visibility is reduced at this level.

The striking displacement upwards of the upper right limb is in contrast to the minor movements observed in this feature. The disarticulation of the limb occurs at the level of the shoulder joint and did not affect the articulations at the elbow or at the wrist which remain in articulation. While the bones of the limb are displaced upwards the scapula moved towards the bottom of the feature. Oddly, neither the movement upwards nor the wall-effect seems to have affected the shoulder girdle. The bones of the right shoulder girdle do not show the effects of a lateral pressure. The right clavicle is slightly displaced downwards but this is consistent with the general tendency of the bones to move downwards, supporting the interpretation of a sloping grave floor.

These movements could be explained by a combination of elements in the feature. One is the presence of a perishable element behind the body in this area, such as cushioning or padding, creating an empty space during its decay into which these bones could fall. Additionally, the existence of a soft wrapping may be suggested that could support the limb, at the same time allowing the penetration of sediment. One hypothesis is that the upper body was bound by some kind of stout cord, such as rope. Support from a rope would have provided the lateral or bilateral pressure visible in the alignment of the upper right limb, affecting the arm and forearm and possibly the left arm. If the rope had been placed at the level of the arm it would allow the exclusion of the right shoulder girdle from the set of movements affecting the limb. If the body had been wrapped in a more encompassing material, such as a shroud, this would also affect the shoulder girdle while binding by a rope/cord would permit greater flexibility of movement. Furthermore, binding by a rope would have allowed the immediate penetration of sediment as attested in this feature. Thus, as the body collapsed forwards and downwards towards the sloping bottom, the right limb moved upwards in the reverse direction, becoming disarticulated at the level of the shoulder joint while maintaining its alignment by support from the rope. Additionally, while the perishable structure behind the body decayed, the scapula descended, but only slightly, as the fine sediment penetrated providing gradual support and preventing further collapse. These elements – cushioning/padding and wrapping – have possibly affected the left upper limb as well. Unfortunately the documentation is unclear and further observations are not possible. These supports are suggested by the observations at
the level of the upper body and there are no indicators of wrapping or padding at the level of the lower limbs.

Other cases, such as ARA1961, Sks 7 and 11 (figs. 4.30, 4.31), present a similar disarticulation at the level of the right shoulder girdle where the upper right limb is projected forwards and upwards. However, in these cases the movement upwards and forwards affects not only the limb but the shoulder girdle as well. Also, in neither of these cases is the disarticulation as accentuated as in the case of Sk6.

**Figure 4.30.** ARA1961, Sk7 presents a displacement upwards of the right shoulder girdle similar to the movement pattern observed in ARA1961, Sk6. (Left: MNA, APMH, F370. Right: photograph by J. P. Ruas)

_ARA1961, Sks 11 and 12_

At Arapouco, the cadavers are typically placed individually in the grave feature. The deposit containing the remains of an adult female (ARA1961, Sk11) and a 3 year old child (ARA1961, Sk12) is the only clear case of a double burial at the site (fig. 4.31). Furthermore, from an archaeothanatological perspective this burial presents several striking elements. One is the apparent bilateral compression of the upper body which is in contrast with the wide space available to accommodate the lower body. The other singular feature of this burial is the possible placement of the child in a container of sorts arranged in front of the adult. As discussed, another unusual element of this burial is the missing skull of the adult as well as the position of the lower limbs rotated outwards in abduction. Despite these deviant
elements, the feature presents several of the common elements observed in the burials at Arapouco.

Individual 11 is clearly a primary deposit. The skeleton is well articulated and the decomposition of the body took place in this feature. This is well demonstrated by the preservation of many labile articulations such as those of the bones of the right hand and of most bones of the feet. The few disarticulations observed at the level of the right elbow joint and some of the bones of the right hand are indicative of movements into empty spaces created during the process of decomposition, and are not indicative of a secondary deposition. The general topography of the body also indicates a burial in primary position. Individual 12 is possibly a primary deposit, however, as previously discussed, this interpretation is not conclusive both because the documentation is unclear and because the skeleton is very fragmented.

Figure 4.31. ARA1961, Sks 11 (adult female) and 12 (child, c 3 yrs) were buried simultaneously. The remains of the child were found concentrated in front of the left hemithorax of the adult, but also disarticulated and scattered in the feature. (MNA, APHM, F414)
Individual 11 is well articulated and the decomposition of the body took place in a sediment-filled environment. Individual 12 presents a more ambiguous situation. As discussed, although the right labile temporomandibular joint is in articulation, the other few identifiable bones are disarticulated, scattered, and fragmented. One exception is a tibia and a fibula, found articulated, but in isolation at the lower end of the feature. As mentioned, the skeletal remains of children are more prone to scattering due to the smaller size and fragility of the joints. Also, its position in front of the adult’s upper body would have influenced the movement of its bones, because the thoracic region and abdominal cavity are rich in soft tissue and very active areas during decomposition. However, the wide scattering of individual 12 requires further explanation and may suggest a mixed space of decomposition for the child. The different spaces of decomposition could be explained if the adult (11) had been placed directly in the pit while the child (12) had been lain in some kind of container and placed in front of the adult, after which, the feature would have filled with sediment. This container could have been of soft or hard material providing enough space for the movement of the bones while the articulations broke down.

As with most burials at Arapouco, individual 11 was laid in a pit with a sloping floor, possibly slightly more elevated on the upper right side of the feature and lower at the region of the pelvis. The body was positioned on its back. As discussed, the skull of individual 11 (cranium and the mandible) is not in the feature and the original position of the head is unknown.

The upper limbs were slightly flexed at the level of the elbows and the hands were placed on the pelvic region. However, the position of the lower limbs is unusual. They present the typical flexion at the hips and knees, but are rotated in abduction, suggesting an atypical wide pit, at least at this level, while the feet are crossed and placed medially.

There are two main pressures on the adult in the feature. One is a bilateral pressure visible through the alignment of the arms, which are rotated inwards lying very close to the thoracic cage. On the right side of the feature this wall-effect is visible in the alignment of the upper right limb, involving the shoulder girdle and arm. On the left side this wall-effect is suggested by the alignment of the left arm, although this observation is not conclusive because the visibility is reduced at this level. The second is the pressure from the body weight towards the lower and right side, visible by the movement of the abdomen and the pelvis to the right side of the feature, affecting the lumbar vertebrae, pelvic girdle and possibly the lower limbs as well, at the level of the hips. This transfer of body weight and consequent pressure occurs as the vertebral column settles down on an irregular and sloping grave floor, provoking a shift of axis towards the right side. The pressures observed suggest the existence of a soft wrapping at the time of the burial surrounding the upper body, as indicated by the bilateral compression of the upper limbs. This constraining element is in contrast with the wide space available to accommodate the lower limbs.
Figure 4.32. Reconstruction hypothesis of the initial position of individuals 11 and 12 in the grave feature, Arapouco, Sado valley. The analysis suggests that the child (12) was arranged in some kind of soft wrapping such as a pouch or even a semi-hard container, such as a basket, placed in front of the adult female (11) and her arms were wrapped around it. (Drawing by Susanna Berglund)
The initial position of individual 12 in the feature is unknown. Its remains were found concentrated in front of the left hemithorax of individual 11. A disarticulated femur and some unidentifiable fragments are found laterally to the left femur of individual 11. An articulated tibia and fibula are found at the lower right end of the feature together with foot bones, however, it is unclear if these belong to this child or are in fact remains from another burial.

It seems likely that the bilateral pressure observed at the level of the upper body of the adult female could be related to the arrangement of the 3 year old child in the feature. If this was the case, it could be suggested that the child was arranged in some kind of soft wrapping such as a pouch or even a semi-hard container, such as a basket, placed in front of the adult and with her arms wrapped around it (fig. 4.32).

**ARA1961, Sk13**

At Arapouco, the choice of the initial position of the cadaver in the grave feature is consistent. One burial, ARA1961, Sk13, presents a few unusual elements, such as the rotation of the head towards the knees and the placement of at least one of the upper limbs between the thighs. Nevertheless, the burial shares the basic common elements observed in all the burials at Arapouco (fig. 4.33).

The burial is a primary deposit as demonstrated by the maintenance of the bones of the feet in perfect articulation and by the general topography of the body. Also, like most burials at Arapouco, the decomposition of the body took place in filled space. This is well illustrated by the limited collapse of the bones of the pelvic girdle. The normal displacement of these bones was somewhat prevented by a rapid and fluid penetration of sediment. Other strong arguments supporting the decomposition in a sediment-filled environment are the position of both patellae in anatomical connection at the knee joints, as well as the bones of the right foot which were rotated but retained a perfect articulation.

The body was laid in a small pit, possibly slightly more elevated on the left side of the feature. The individual was laid on its left side, with the head directed forwards and downwards towards the lower limbs, probably with the neck in hyperflexion similar to ARA1961, Sks 5, 6. The CV are not visible in the documentation, but the relative position of the cranium suggests that the cranium collapsed forwards towards the lower limbs. This pattern was possibly enhanced during decomposition, firstly because the body was in a very constrained position, particularly at the upper end of the feature, and secondly, because the cranium has a tendency to roll after the joints of the neck break. Also, the pressure of the sediment on the back of the head would have an impact as well. The upper right limb was placed in complete extension with the forearm lying between the thighs. The upper left limb is not visible in the documentation. The buttocks and hips seem to lie on the lowest part of the feature. The lower limbs were placed in front of the upper body, flexed in adduction at the level of the hips and knees. The feet lying at the lower
end of the feature, were crossed and aligned with the buttocks, with the left foot placed over the right foot.

Three main pressures bore down on the body in the feature. One is the wall-effect from the upper end of the pit maintaining the extreme rotation of the head and shoulders forwards and downwards. The second is a wall-effect on the right and lower end of the feature visible in the alignment of the buttocks, hips and left foot. The third pressure was a wall-effect on the left side suggested by the alignment of the left shoulder and knees. The pressures observed are likely to be the result of the design of the grave feature.

Figure 4.33. ARA1961, Sk13 shares the basic common characteristics observed in all burials at Arapouco, but was placed in an unusual position. The body lay on the left side with the head rotated towards the knees, and at least one of the upper limbs was placed between the thighs. (MNA, APMH, F376)
The mortuary programme at Arapouco was consistent and homogeneous, as suggested by the archaeothanatological analysis.

The cadavers were typically placed in individual grave features while retaining their anatomical integrity (individual primary deposits). The feature was then immediately covered with sediment, providing a filled space of decomposition. In several cases the analysis indicates a rapid and fluid penetration of sediment.

The cadavers were commonly laid on the back, or alternatively on the lateral side, always with the limbs in flexion usually arranged close to the body. Typically, the bodies were placed in flexed positions becoming contracted in the small grave features. The floor of the graves tended to be uneven and sloping, and a half-sitting position of the body was common. In these cases, the head of the cadaver was often rotated forwards and downwards towards the body (fig. 4.34).

In most cases, the observed pressures exerted on bodies in the features can be explained as the result of the design of the grave. Normally, these wall-effects and consequent pressures correspond to the physical limits of the pit, just wide enough to contain the individual.

Few cases present deviant elements, but there were exceptional instances of features with, for example, more than one individual, possible perishable elements inserted behind the bodies, and possible wrappings and/or containers. Despite the striking and unusual elements, all these cases followed the common core characteristics of burial practices observed at Arapouco.
Figure 4.34. This illustration presents several key elements observed in the burials at Arapouco. The cadavers were commonly laid on the back, or alternatively on the lateral side, always with the limbs in flexion usually arranged close to the body. The floor of the graves tended to be uneven and sloping, and a half-sitting position of the body was common. In these cases, the head of the cadaver was often rotated forwards and downwards towards the body. In most cases, the observed pressures exerted on bodies in the features can be explained as the result of the design of the grave. Normally, these wall-effects and consequent pressures correspond to the physical limits of the pit, just wide enough to contain the individual. (Drawing by Susanna Berglund)
Sado valley: Cabeço das Amoreiras

Site background: a short history of research

Cabeço das Amoreiras (also known as S. Romão) is a shell midden site located on the eastern part of the Sado valley, and is situated on the left margin of the river at 52 m.a.s.l. (Diniz et al. 2012) (fig. 2.3).

Archaeological material and documentation available for Cabeço das Amoreiras are curated at the National Museum of Archaeology in Lisbon (MNA). The first field season started on the 26th of August of 1958 as indicated by the excavation diary written by J. Roldão (MNA, APMH, 2/3/7/2, p. 4–7). This document reports the first five days of excavation at Cabeço das Amoreiras. During these five days no human remains were found but the graphic documentation indicates that all human burials (n=8) were recovered in 1958. The burials were excavated sometime after these first five days but those pages are missing from the archive. The site was excavated again in 1985–86 (Arnaud 1986) but no human remains were found.

Graphic documentation in the archives of MNA consists of two site plans with the human burials in context (MNA, 1958, D. Sousa, A115, A116) (figs. 4.35, 4.36), twelve drawings of osteological material of human remains and fauna (MNA, 1958, D. Sousa, B45–56), and field sketches (human remains, numbered I–VIII; fauna, numbered a–c). All drawings are from 1958 by Dario de Sousa, MNA, and include a few notes on stratigraphy and orientation of the features.

Archives of photography of Cabeço das Amoreiras consist of 49 photographs from 1958 (MNA, APMH, 2/11/4) of variable quality. The archive contains photographs of the eight individuals excavated at the site (MNA, APMH).

One human skeleton is preserved in a block of paraffin wax (CAMS1958, Sk4), and the remaining skeletons are in disarticulated state sorted in containers. The human remains were studied by a team of anthropologists and the MNI curated at the museum is six (Cunha and Umbelino 1995–97, 2001; Umbelino and Cunha 2012). Graphic documentation indicates the excavation of eight individuals, however, one of them is represented solely by its cranium (CAMS1958, Sk2). The burial population studied by E. Cunha and C. Umbelino (1995–97, 2001; Umbelino and Cunha 2012) consists of five adult males, one non-adult, and one indeterminate. This analysis suggested that four of the adult males were of mature age (>35 yrs) (table 4.35).

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2 This report is in a bundle with other Sado site reports under the archive title Report of Cabeço do Pez 1958 (Relatório do Cabeço do Pez 1958) with no reference to Cabeço das Amoreiras.
Figure 4.35. Cabeço das Amoreiras, Sado valley: site plan and profiles of the main excavation area (Talhão T) where all human remains were found (I to VIII). (Adapted from a photograph by J. P. Ruas. MNA, 1958, D. Sousa, A115)
Results: Sado valley, Cabeço das Amoreiras

Figure 4.36. Cabeço das Amoreiras, Sado valley: site plan of the excavated areas. Bold dots: area of the shell midden. Test trenches are indicated from A to I. Talhão T: main excavation area where all human remains were found. (Adapted from a photograph by J. P. Ruas. MNA, 1958, D. Sousa, A116)

A note on the back of the photograph of CAMS1958, Sk6 is in disagreement with the anthropological analysis. The excavator describes the human remains as a small group of bones of a child (pequeno conjunto de ossos de criança) while the osteological analysis indicates that these are the remains of a mature adult. This inconsistency could be the result of mislabelling of the skeletons. The graphic documentation is unclear, but the misinterpretation in the field is possibly due to the fragmentary state of the material.

The stratigraphic data is provided by the graphic documentation (table 4.36). The top layer is described as brown soil (terra castanha), the second layer as black soil (terra preta), the third layer is generally thicker and is described as grey soil and
Chapter 4

shells (*terra cinzenta e conchas*), and the fourth layer is described as chestnut brown sand. The human remains were excavated in the chestnut brown sand, and some of them were presumably lying directly on the soft bedrock (*piçarreira, chão natural*).

Table 4.35. *Cabeço das Amoreiras, Sado valley: sex and age estimates.*

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Container</th>
<th>Age</th>
<th>Sex</th>
<th>Notes</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–</td>
<td>n/d</td>
<td>n/d</td>
<td></td>
<td>Graphic documentation shows concentration of bone fragments of undidentifiable material. This study</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
<td>Adult?</td>
<td>n/d</td>
<td></td>
<td>Graphic documentation shows one cranium. This study</td>
</tr>
<tr>
<td>3</td>
<td>6253(?)</td>
<td>Adult, mature</td>
<td>♂</td>
<td>–</td>
<td>– Cunha and Umbelino 1995–97, Umbelino 1999</td>
</tr>
<tr>
<td>4</td>
<td>999.68.1</td>
<td>Adult</td>
<td>♂?</td>
<td></td>
<td>Preserved in paraffin block. This study</td>
</tr>
<tr>
<td>5</td>
<td>6239</td>
<td>Adult, mature</td>
<td>♂</td>
<td>–</td>
<td>– Cunha and Umbelino 1995–97; Umbelino 1999</td>
</tr>
<tr>
<td>6</td>
<td>6237</td>
<td>Adult, mature</td>
<td>♂</td>
<td>–</td>
<td>– Cunha and Umbelino 1995–97; Umbelino 1999</td>
</tr>
<tr>
<td>7</td>
<td>6238</td>
<td>Adult, mature</td>
<td>♂</td>
<td>–</td>
<td>– Cunha and Umbelino 1995–97; Umbelino 1999</td>
</tr>
<tr>
<td>8</td>
<td>6233</td>
<td>Non-adult, 7.5–16 yrs</td>
<td>n/d</td>
<td>–</td>
<td>– Cunha and Umbelino 1995–97; Umbelino 1999</td>
</tr>
</tbody>
</table>

Table 4.36. *Cabeço das Amoreiras, Sado valley: stratigraphy and depth of the human burials in relation to top layer. (Data from field drawings, MNA, 1958, D. Sousa)*

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Layer</th>
<th>Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4, chestnut brown sand</td>
<td>n/a</td>
</tr>
<tr>
<td>6</td>
<td>4, chestnut brown sand</td>
<td>n/a</td>
</tr>
<tr>
<td>7</td>
<td>4, chestnut brown sand</td>
<td>120, cranium; 140, post-cranial skeleton</td>
</tr>
<tr>
<td>8</td>
<td>4, chestnut brown sand</td>
<td>125</td>
</tr>
<tr>
<td>4</td>
<td>4, chestnut brown sand</td>
<td>130</td>
</tr>
<tr>
<td>2</td>
<td>4, chestnut brown sand</td>
<td>140</td>
</tr>
<tr>
<td>3</td>
<td>4, chestnut brown sand</td>
<td>140</td>
</tr>
<tr>
<td>5</td>
<td>4, chestnut brown sand</td>
<td>150</td>
</tr>
</tbody>
</table>
Chronology of the burial activity

**Previous ¹⁴C measurements**
The first ¹⁴C measurements of material from Cabeço das Amoreiras were carried out on material excavated in 1985–86: one sample on shells (Q–AM85B2b) and one on charcoal (Q–AM85B2a) (Arnaud 2000), both collected from under a compact layer of shells containing a few fragments of cardium pottery (Arnaud 2000, 29; see Diniz 2010) (table A10).

The first measurements on human bone from Cabeço das Amoreiras (Beta–125110) were carried out in the late 1990s (Cunha and Umbelino 2001), collected from one individual (5) excavated in 1958.

**Objectives of the dating programme**
One human skeleton only (CAMS1958, Sk5) was directly dated before this radiocarbon dating programme. This date (Beta–125110) was the earliest ¹⁴C date available for the site, many centuries older than the other two dates available on non-human samples (Q–AM85B2a and Q–AM85B2b), but it was coeval with the only human burial dated at Arapouco (Sac–1560, ARA1962, Sk2A).

The burial area of this site was small and had relatively few burials. It was expected that the human burials would be coeval in time.

The general aims of the dating programme for Cabeço das Amoreiras followed the macro-goals of the radiocarbon programme of this dissertation, outlined in chapter 3, and were:

- to estimate the duration of the use of this site for burial activity;
- to estimate when the burial activity started and when it ended;
- to estimate the frequency of the burial activity in the site.

The site-specific aims of the dating programme for Cabeço das Amoreiras were:

- to confirm the apparent antiquity of the burial activity at this site indicated by a previous measurement on human bone (Beta–125110) contrasting with more recent dates on charcoal and shells;
- to clarify if this site was used as burial ground during both the Late Mesolithic and the Early Neolithic time frame.

**Sampling strategy**
Four samples of human bone were selected for ¹⁴C analysis (table 4.37). It was previously reported that CAMS1958, Sk6 did not yield enough collagen for isotopic analysis (Fontanals-Coll et al. 2014), and it was excluded from pre-selection. The sampling strategy was targeted towards a good spatial and stratigraphic coverage and it was possible to obtain samples from all pre-selected individuals.
Chapter 4

Results

Two of the four samples submitted as part of this study revealed poor quality during laboratory analysis (Ua–46935 and Ua–46936) and were rejected (table A1). Three 14C measurements on human bone collagen samples from Cabeço das Amoreiras are available now (table 4.38). The three remaining undated individuals (individuals 3, 6 and 8) revealed poor quality for 14C and isotopic measurements. The remains of individuals 1 and 2 were not identified at MNA.

Table 4.37. Samples of human bone (4) from Cabeço das Amoreiras collected and submitted for 14C measurement in the course of this study. All samples are from the 1958 assemblage and were collected at MNA. *Samples pre-treated with boiling in acetone, ultrasonification first with ether and then with ethanol, and finally filtrated; after that processed as usual (see chapter 3).

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Stratigraphy</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Ua–46935</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Humerus–L 999.43.8</td>
<td>Layer 4, 140 cm</td>
<td>Previous stable isotope analysis (Fontanals-Coll et al. 2014; Umbelino 2006) Ua–46935: doubtful quality</td>
</tr>
<tr>
<td>4</td>
<td>Ua–47973*</td>
<td>Adult</td>
<td>♂</td>
<td>Fibula–L 999.46.4</td>
<td>Layer 4, 130 cm</td>
<td>Paraffin block</td>
</tr>
<tr>
<td>7</td>
<td>Ua–47974*</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Fibula 999.47.1</td>
<td>Layer 4, 120–140 cm</td>
<td>Previous stable isotope analysis (Fontanals-Coll et al. 2014)</td>
</tr>
<tr>
<td>8</td>
<td>Ua–46936</td>
<td>Non-adult, 7.5–16 yrs</td>
<td>n/d</td>
<td>Tibia 999.47.1</td>
<td>Layer 4, 125 cm</td>
<td>Not measurable</td>
</tr>
</tbody>
</table>

Table 4.38. Human bone collagen samples (3) from Cabeço das Amoreiras, Sado valley. 14C measurements and estimation of non-terrestrial carbon intake (% marine). Samples are sorted so that the lowest marine percentage is on the top of the table. Marine percentage was estimated from the measured δ13C value of each sample by the application of method marine 1 and method marine 2, based on adopted endpoint values of −12‰ and −20‰ for marine (100%) and terrestrial (100%) diets respectively.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements</th>
<th>% marine</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind.</td>
<td>Lab no.</td>
<td>Age BP</td>
<td>14C (‰)</td>
</tr>
<tr>
<td>4</td>
<td>Ua–47973</td>
<td>6484±39</td>
<td>20.0</td>
</tr>
<tr>
<td>7</td>
<td>Ua–47974</td>
<td>6645±42</td>
<td>20.0</td>
</tr>
<tr>
<td>5</td>
<td>Beta–125110</td>
<td>7230±40*</td>
<td>−19.0*</td>
</tr>
</tbody>
</table>

Calibration and chronological models

The chronological model was built on three 14C dates, two of which are new dates obtained in the scope of this study. The sample Beta–125110 was calibrated with the recently published IRMS–based δ13C values because the originally δ13C value, published along with the 14C measurements, was an AMS-based value which should not be used for calibration (see chapter 3, Reliability of the isotopic measurements).
This is a phase model which groups all dated burial events in a phase of burial activity (Bronk Ramsey 1998, 2000, 2001). This grouping is constrained by a start of burial activity event, and an end of burial activity event (i.e., boundaries) imposing no internal constraints to the relative order of the dated events. All it assumes is that the start event occurs before the dated events, and that these all occur before the end event. For the command files defined for this model see appendix.

**Internal consistency and reliability of the model**

Agreement index (A) for each dated event is high (A ≥ 102.6%) (fig. 4.37). The model shows high overall agreement (Marine 1: A_{overall}=111.3%, Marine 2: A_{overall}=111.6%), which indicates that the 14C dates are in accordance with the prior information incorporated in the model. The index of convergence (C) is good (≥ 96%).

The results obtained when running the model with the different marine values (M1, M2) are statistically insignificant. For this reason, all further observations and graphic presentation are based on the results obtained with the model run with the values of M1. The results obtained with M2 are presented in the tables (table 4.39).

**Figure 4.37.** Chronological model for the burial activity at Cabeço das Amoreiras, calibrated using marine 1 diet values. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, *Sado valley, Cabeço das Amoreiras, Model 1, Marine 1.*

Because of the small number of measurements and the scattering of burials over time, the model estimates a wide time range for the start and end dates of the burial activity probability at the site at 95%, accommodating a wide range of possibilities (figs. 4.38, 4.39). In this case, the variance cannot be determined precisely and the start and end dates will be very uncertain. These estimates can be misleading without further archaeological data allowing related early and/or later burial activi-
ties at the site. The likelihood is greater at 68% probability, and in this case, the posterior density estimated for the start of the burial activity is $6433–5998 \text{ cal BCE}$ (68% probability), and $5460–5028 \text{ cal BCE}$ (68% probability) for the end of the burial activity. These estimates are consistent with the earliest burial known at the site represented by CAMS1958, Sk5 ($6156–5914 \text{ cal BCE}$, 95% probability), and with the latest burial known, indicated by CAMS1958, Sk4 ($5483–5329 \text{ cal BCE}$, 95% probability). The burial activity is estimated to have continued for between 487 and 744 years (95% probability: site use for burial activity) or for 548 and 667 years (68% probability) (fig. 4.40).

**Figure 4.38.** Start of burial activity at Cabeço das Amoreiras derived from the chronological model 1, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is $7754–5928 \text{ cal BCE}$ (95.4% probability), $7159–5928 \text{ cal BCE}$ (92.5% probability), or $6433–5998 \text{ cal BCE}$ (68.2% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

**Figure 4.39.** End of burial activity at Cabeço das Amoreiras derived from the chronological model 1, calibrated with values for marine 1 diet. Posterior density estimated for the end of the burial activity is $5488–3714 \text{ cal BCE}$ (95.4% probability), $5488–4212$ (93.4% probability), or $5460–5040$ (67.9% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

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Figure 4.40. Duration of burial activity at Cabeço das Amoreiras derived from the chrono-
logical model, calibrated with values for marine 1 diet. Posterior density estimated for the
duration of the burial activity is between 487 and 744 years (95% probability), or 548 and 667
years (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower
and higher square brackets respectively.

Table 4.39. Human bone collagen samples (3) from Cabeço das Amoreiras, Sado valley: calibrated date
ranges according to two different approaches for the calculation of the marine percentage (M1, M2). Results
are presented in both (a) cal BCE: and (b) cal BP in 95.4% confidence range. The calibrated date ranges
are probability distributions derived from scientific dating alone. The posterior density estimates (in italic)
are derived from Bayesian modelling. Samples are sorted so that the most recent dates are at the top of the
column.

(a) Cal BCE

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>$^{14}$C Age BP</th>
<th>Calibrated date range (95% confidence)</th>
<th>Posterior density estimate (95% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Ua–47973</td>
<td>6484±39</td>
<td>5486–5316</td>
<td>5483–5329</td>
</tr>
<tr>
<td>7</td>
<td>Ua–47974</td>
<td>6645±42</td>
<td>5626–5478</td>
<td>5620–5481</td>
</tr>
<tr>
<td>5</td>
<td>Beta–125110</td>
<td>7230±40</td>
<td>6206–5919</td>
<td>6156–5914</td>
</tr>
</tbody>
</table>

(b) Cal BP

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>$^{14}$C Age BP</th>
<th>Calibrated date range (95% confidence)</th>
<th>Posterior density estimate (95% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Ua–47973</td>
<td>6484±39</td>
<td>7435–7265</td>
<td>7432–7278</td>
</tr>
<tr>
<td>7</td>
<td>Ua–47974</td>
<td>6645±42</td>
<td>7575–7427</td>
<td>7569–7430</td>
</tr>
<tr>
<td>5</td>
<td>Beta–125110</td>
<td>7230±40</td>
<td>8155–7868</td>
<td>8105–7863</td>
</tr>
</tbody>
</table>
Stable isotopes: carbon and nitrogen

**Previous measurements: δ\textsuperscript{13}C and δ\textsuperscript{15}N**

In the early 2000s, one sample (CAMS1958, Sk3) was analysed in the scope of a palaeodietary study (Umbelino 2006). These analyses were done at the McMaster University in Canada and the precision of the results are ± 0.1‰ for δ\textsuperscript{13}C and ± 0.2‰ for δ\textsuperscript{15}N (Umbelino 2006, 208–209). The C:N ratios were not provided but the laboratory confirmed the quality of the collagen and of the measurements (Umbelino 2006, 315).

Recently, two teams sampled this collection for stable isotope analysis of carbon and nitrogen (Fontanals-Coll et al. 2014; Guiry et al. 2015). M. Fontanals-Coll and colleagues (2014) analysed four samples at Biological Anthropology Department at the Universitat Autònoma de Barcelona, and duplicate measurements were taken in the laboratories of the Institute of Environmental Science and Technology at the same university. The analytical error is below 0.2‰ for both δ\textsuperscript{13}C and δ\textsuperscript{15}N. One sample (CAMS1958, Sk6) presented values outside the accepted quality range and was rejected (Fontanals-Coll et al. 2014). E. Guiry and colleagues (2015) sampled four individuals and the measurements were made on a Thermo-Finnigan Delta Plus XL isotope ratio mass spectrometer coupled via continuous flow to a Carlo Erba elemental analyzer at the Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. The instrumental error for δ\textsuperscript{13}C and δ\textsuperscript{15}N measurements was ±0.1‰ and ±0.2‰, respectively (Guiry et al. 2015).

The δ\textsuperscript{13}C value published for CAMS1958, Sk5 (Beta–125110) along with its \textsuperscript{14}C date (Cunha and Umbelino 2001) was obtained via AMS and not by IRSM (Cláudia Umbelino, pers. comm.). This sample was not included in Umbelino’s palaeodietary study (2006), and as previously discussed it should not be used for dietary reconstructions and/or reservoir corrections.

All previous measurements were included in this study (n=8) as long as they fell within the accepted quality ranges as discussed.

**Sampling strategy**

In this study, the selection of samples of human remains for δ\textsuperscript{13}C and δ\textsuperscript{15}N measurements was fully dependent on the goals of the radiocarbon dating programme (see above).

**Results**

The samples Ua–number (n=2) were measured by IRSM and the precision of the measurements for both δ\textsuperscript{13}C and δ\textsuperscript{15}N is ± 0.1‰.

At Cabeço das Amoreiras, the human collagen δ\textsuperscript{13}C values (n=10/no. individuals=5) range from –20.0‰ to –16.0‰ with a mean value of –18.8 ± 1.1‰. The human collagen δ\textsuperscript{15}N values (n=10/no. individuals=5) range from +7.6‰ to +13.4‰ with a mean value of +9.6 ± 1.5‰. Individual 6 presents a relatively high
set of values. When these are excluded the values range from –20.0‰ to –18.5‰ (–19.1 ± 0.6‰) for carbon and from +7.6‰ to +10.0‰ (+9.2 ± 0.8‰) for nitrogen.

Different bones from individuals 3, 5 and 7 have been sampled and analysed at different laboratories and present different values (fig. 4.41, table 4.40).

Figure 4.41. Cabeço das Amoreiras, Sado valley: correlation between the $\delta^{13}$C (‰) and $\delta^{15}$N (‰) values of 10 samples of human bone collagen from 5 individuals. Individuals 3 (triangle), 5 (circle) and 7 (square) have multiple set of values.
Table 4.40. Cabeço das Amoreiras, Sado valley: carbon ($\delta^{13}$C) and nitrogen ($\delta^{15}$N) measurements on human bone collagen samples collected at MNA. Samples are sorted so that the lowest $\delta^{13}$C values are on the top of the table. Multiple samples of the same individual are sorted together.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Lab no.</th>
<th>$^{14}$C Age BP</th>
<th>$\delta^{13}$C (%)</th>
<th>$\delta^{15}$N (%)</th>
<th>C:N</th>
<th>M1</th>
<th>M2</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>6888.3</td>
<td>analysis for isotopes</td>
<td>$-18.9$</td>
<td>9.2</td>
<td>3.3</td>
<td>25</td>
<td>14</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>3, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>n/p</td>
<td>analysis for isotopes</td>
<td>$-18.5$</td>
<td>9.5</td>
<td>n/a</td>
<td>29</td>
<td>19</td>
<td>Umbelino 2006</td>
</tr>
<tr>
<td>4, 1958</td>
<td>Adult</td>
<td>♂?</td>
<td>Fibula–L</td>
<td>Ua–47973</td>
<td>6484±39</td>
<td>$-20.0$</td>
<td>7.6</td>
<td>2.9</td>
<td>14</td>
<td>0</td>
<td>This study</td>
</tr>
<tr>
<td>7, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Fibula</td>
<td>Ua–47974</td>
<td>6645±42</td>
<td>$-20.0$</td>
<td>8.2</td>
<td>2.8</td>
<td>14</td>
<td>0</td>
<td>This study</td>
</tr>
<tr>
<td>7, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>6886.3</td>
<td>analysis for isotopes</td>
<td>$-19.2$</td>
<td>9.4</td>
<td>3.3</td>
<td>22</td>
<td>10</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>5, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>Beta–125110*</td>
<td>7230±40*</td>
<td>$-19.0#$</td>
<td>9.5#</td>
<td>2.9#</td>
<td>24</td>
<td>13</td>
<td>*Cunha and Umbelino 2001; #Fontanals-Coll et al. 2014</td>
</tr>
<tr>
<td>5, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>6889.3</td>
<td>analysis for isotopes</td>
<td>$-18.5$</td>
<td>10.0</td>
<td>3.3</td>
<td>29</td>
<td>19</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>6, 1958</td>
<td>Adult,</td>
<td>♂</td>
<td>Long bone</td>
<td>6887.6</td>
<td>analysis for isotopes</td>
<td>$-16.0$</td>
<td>13.4</td>
<td>3.2</td>
<td>52</td>
<td>50</td>
<td>Guiry et al. 2015</td>
</tr>
</tbody>
</table>
Archaeothanatology

Source material and analysis strategy

Archaeothanatological analysis was carried out on a total of 5 individuals, 63% of the number of individuals (n=8) excavated at Cabeço das Amoreiras (table 4.41). Analysis was not possible on the remains of CAMS1958, Sks 1 (sex, age: n/d) and 6 (child) due to poor preservation of the material. CAMS1958, Sk2 is represented by its cranium only, and this feature will be discussed throughout this section. The source material comprises field photographs, drawings, a site plan of human remains, and the paraffin blocks of one individual.

The first phase of analysis took place at the MNA, where the individual preserved in paraffin blocks (CAMS1958, Sk4) was analysed and photographed. The second phase of analysis consisted of the reassessment of my observations done in the museum, crosschecked with the photographed material and the archival graphic documentation. The analyses based on field photographs and individual drawings exclusively (CAMS1958, Sks 3, 5, 7, 8) followed the same analytical protocol (see chapter 3, Archaeothanatology).

Table 4.41. Cabeço das Amoreiras, Sado valley: source material used for archaeothanatological analysis. This material is curated at the MNA.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Source material</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Block Graphic documentation w/ human remains Field photographs Drawings Site plan Written documentation</td>
<td></td>
</tr>
<tr>
<td>1, 1958</td>
<td>n/a n/a yes yes n/a</td>
<td>Few small bone fragments of unidentifiable material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>2, 1958</td>
<td>n/a yes yes yes n/a</td>
<td>Isolated human cranium and limited documentation. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>3, 1958</td>
<td>n/a yes yes yes n/a</td>
<td>–</td>
</tr>
<tr>
<td>4, 1958</td>
<td>yes yes yes yes n/a</td>
<td>–</td>
</tr>
<tr>
<td>5, 1958</td>
<td>n/a yes yes yes n/a</td>
<td>–</td>
</tr>
<tr>
<td>6, 1958</td>
<td>n/a yes yes yes n/a</td>
<td>Very fragmented material. Archaeothanatology is not possible.</td>
</tr>
<tr>
<td>7, 1958</td>
<td>n/a yes yes yes n/a</td>
<td>–</td>
</tr>
<tr>
<td>8, 1958</td>
<td>n/a yes yes yes n/a</td>
<td>–</td>
</tr>
</tbody>
</table>
Results of the archaeothanatological analysis

The nature of the deposits

Analysis of the nature of the deposits at Cabeço das Amoreiras indicates an unequivocal pattern of primary burials (table 4.42). The cadavers were placed in the burial features before the degradation of the labile joints, retaining their anatomical integrity. In two cases (CAMS1958, Sks 5, 8) the documentation is unclear and the diagnostic criteria are poorly preserved. However, in both cases, the overall position of the skeletal elements indicates that the bodies were disposed while still retaining their general anatomical integrity, supporting the interpretation of burials in primary position. One possible exception to this pattern is presented by a cranium (CAMS1958, Sk2) lying disarticulated on the left side of CAMS1958, Sk3, which, as discussed further, may suggest a burial in a secondary position (see below, Post-depositional manipulations of the cadavers).

The space of decomposition of the cadaver

Analysis of the space of decomposition of the cadavers buried in Cabeço das Amoreiras indicates a general pattern of filled spaces (table 4.43). The cadavers were covered with sediment immediately after their placement in the features. The decomposition of the bodies took place in this sediment-filled environment. In two cases (CAMS1958, Sks 5, 8) the analysis is unclear due to the poor preservation of the remains. In every case, the movement of the bones is limited suggesting that the space of decomposition was filled and that the sediment could penetrate immediately.

The initial position of the cadaver in the feature

At Cabeço das Amoreiras all cadavers (n=5) were lying on the back in the grave feature (table 4.44).

The position of the upper limbs was variable but they were always placed close to the body. In two cases the limbs were arranged symmetrically (CAMS1958, Sks 4, 7) either in semi-flexion at the level of the elbows, with the hands towards the pelvic region (Sk4) or in extension along the body with the hands lying partially under the buttocks (Sk7). In two cases the limbs were placed in asymmetrical positions (CAMS1958, Sks 5, 8), with the right limb in slight semi-flexion at the elbow and the hand placed on the right hip, while the left limb was in semi-flexion (c 90°) at the elbow, with the forearm laid in front of the abdomen and the hand on the right side of the trunk. The symmetry of the upper limbs was not possible to identify in one case (CAMS1958, Sk3) due to the fragmentation of the bones and unclear documentation. In this case, the right upper limb was in flexion at the elbow and the hand was placed towards the left shoulder lying in front of the face.

At Cabeço das Amoreiras, the bodies were placed in the feature with the lower limbs always in flexion or hyperflexion at the level of the knee joints. The degree of flexion at the hip joints is variable and in one case these are almost in extension (CAMS1958, Sk7). The lower limbs were rotated to the right in two cases.
(CAMS1958, Sks 4, 8) and to the left in one case (CAMS1958, Sk3). In two cases the lower limbs had a slight tendency towards the right (CAMS1958, Sk5) or the left side (CAMS1958, Sk7).

Clumping of the body with the lower limbs brought up towards the upper body was moderate (CAMS1958, Sks 3, 4), with the limbs being placed on one of the sides. Clumping at the level of the lower body was common and in every case (n=5) the feet of the cadavers were positioned towards the buttocks indicating a constrained position of the lower limbs.
Table 4.42. Summary of the nature of the deposits with human remains at Cabeço das Amoreiras, Sado valley.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Nature of the deposit</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: some metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>5, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Probably primary</td>
<td>The labile articulations are poorly preserved and unclear in the documentation. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>7, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of right foot. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>8, 1958</td>
<td>Non-adult, 7.5-16 yrs</td>
<td>n/d</td>
<td>Probably primary</td>
<td>The labile articulations are poorly preserved and unclear in the documentation. However, the overall position of the bones indicates that the general anatomical integrity of the body has been maintained.</td>
</tr>
<tr>
<td>Individual</td>
<td>Age</td>
<td>Sex</td>
<td>Space of decomposition</td>
<td>Arguments</td>
</tr>
<tr>
<td>------------</td>
<td>-----</td>
<td>---------</td>
<td>------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the bones of the feet which are rotated outwards; the right patella is suspended on the distal end of the right femur. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>4, 1958</td>
<td>Adult</td>
<td>♂?</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the bones of the left foot are in contraction and rotated inwards; the left patella is suspended on the distal end of the right femur. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>5, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Probably filled</td>
<td>Poor preservation of diagnostic criteria. Maintenance of left os coxae in original unbalanced position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>7, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the patellae are suspended on the distal ends of the femora; the bones of the right foot are rotated. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>8, 1958</td>
<td>Non-adult, 7.5–16 yrs</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Poor preservation of diagnostic criteria. No movement outside initial volume of the cadaver.</td>
</tr>
</tbody>
</table>

Table 4.43. Summary of the space of decomposition of the human remains in the grave features at Cabeço das Amoreiras, Sado valley.
Table 4.44. Summary of the reconstruction of the initial position of the cadaver in the grave feature at Cabeço das Amoreiras, Sado valley. The initial position of the limbs is indicated as –R or –L and refers to the right or left limb, when their positions are different. Rotation –R or –L indicates the rotation of the skeletal element(s) towards the right or the left side.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Initial position of the cadaver in the feature</th>
<th>Trunk</th>
<th>Upper limbs</th>
<th>Lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Head</td>
<td>Trunk</td>
<td>Hip and knee joints: hyperflexion</td>
</tr>
<tr>
<td>3, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Raised</td>
<td>On the back</td>
<td>In flexion–R</td>
<td>Rotation –L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation–L and downwards</td>
<td></td>
<td>n/a–L</td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(neck flexed forwards)</td>
<td></td>
<td></td>
<td>Clumping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotation–R and downwards</td>
<td></td>
<td></td>
<td>Hip and knee joints: flexion – L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(neck flexed forwards)</td>
<td></td>
<td></td>
<td>Rotation – R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clumping</td>
</tr>
<tr>
<td>5, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Raised</td>
<td>On the back</td>
<td>In semi–flexion–R</td>
<td>Hip joints: semi–flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In semi–flexion (c 90°)–L</td>
<td>Knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rotation–tendency R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Knees directed forwards</td>
</tr>
<tr>
<td>7, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Raised</td>
<td>On the back</td>
<td>In extension</td>
<td>Hip joints: slight semi–flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Knee joints: hyperflexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rotation–tendency L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Knees directed downwards</td>
</tr>
<tr>
<td>8, 1958</td>
<td>Non-adult, 7.5–16 yrs</td>
<td>n/d</td>
<td>Raised</td>
<td>On the back</td>
<td>In semi–flexion–R</td>
<td>Hip joints: semi–flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In semi–flexion (c 90°)–L</td>
<td>Knee joints: flexion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rotation – R</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feet towards buttocks</td>
</tr>
</tbody>
</table>
The grave features

The size and shape of the deposits with human remains at Cabeço das Amoreiras were not described by the excavators. The archaeothanatological analysis suggests that the bodies were placed in pits dug into the ground. The lateral pressures and wall-effects observed on the skeletons in the feature (table 4.45) indicate that the shape and size of the pits was just sufficient to contain the body. The analysis further indicates that in some cases the design of the grave had a significant impact on the final arrangement of the body in the feature, visible by the constrained positions of some individuals (e.g., CAMS1958, Sks 3, 4). However, in one case the pit was somewhat wider allowing a relative expanded position of the body particularly at the level of the lower body (CAMS1958, Sk8).

The floor of the graves tended to be irregular and sloping from the upper to the lower end. This is visible in some of the drawings in profile and confirmed by the raised position of the head in relation to the trunk (CAMS1958, Sks 5, 7, 8) or by the flexion and collapse forwards and downwards of the head (CAMS1958, Sks 3, 4). The fragmented state of the material does not allow detailed observations at the level of ribs and sacrum the rotations of which during the process of decomposition could clarify aspects of the original position of the body in relation to the characteristics of the floor of the grave, such as in the case of bodies lying in a half-sitting position. Also, the possibility cannot be excluded that the elevation of the head could have been aided by some kind of support, other than the floor of the pit, but the documentation is unclear.

Often, the narrow shape of the feature imposed significant physical limits to the cadaver, offering lateral support and preventing the collapse of the bones. However, the analysis suggests that in some cases there might have been an extra support offered by some kind of soft container such as a light wrapping. CAMS1958, Sk7 is one of these cases, where the strong pressures observed could suggest the existence of a soft wrapping at the time of the burial. As in all cases observed at Cabeço das Amoreiras, CAMS1958, Sk7 was lying on the back with the head slightly elevated in relation to the trunk. However, this case presents the only example of an individual placed with the upper limbs in complete extension adjacent to the upper body with the hands lying very close to the hips. The lower limbs are in hyperflexion at the knees which are directed downwards in the opposite direction of the feet which were placed towards the buttocks (fig. 4.42).

The most striking feature of this burial is the overall compression through the medial axis of the body, which is observed throughout the skeleton. The analysis suggests two main pressures exerted on the body in the feature. One is a bilateral pressure visible in the alignment of the upper limbs which are rotated inwards. This is illustrated by the right scapula which presents the anterior view with a lateral component, and is rotated forwards and upwards, while the right clavicle became verticalized and disarticulated from the scapula indicating strong projection forwards of the shoulder.
Figure 4.42. CAMS1958, Sk7. The transverse compression exerted on the skeleton indicates significant physical limits on the cadaver. This case could suggest the existence of extra support provided by a soft wrapping at the time of the burial, but the data is not conclusive. (MNA, APMH, F807)

The bone preservation in the left side is poor and the diagnostic elements at the level of the shoulder girdle are not preserved. However, the compression and verticalization of the ribs, and the alignment of the arm and forearm placed very close to the thoracic cage, are strong indicators of a lateral pressure at this level. The second main pressure observed in this feature is an overall wall-effect at the lower end of the grave visible by the contraction and clumping of the lower limbs which were maintained on an extremely constrained position. The pressures observed may suggest a tight wrapping of the body. However, the overall compression of the skeleton could also be explained by the narrow characteristics of the pit where the walls of the grave could have had the same supporting effect on the skeletal elements, which seems to be a common element at this burial ground. Nothing in this feature suggests that the pit was wider than the area occupied by the body, and the hypothesis of an unwrapped body placed in a very narrow pit remains as valid as the wrapping possibility.
Likewise, in the feature containing the remains of CAMS1958, Sk5 there is a strong bilateral compression of the upper body indicated by the oblique position of the right clavicle and the verticalization of the left clavicle, which are clear indications of strong projection forwards of the shoulders. However, in this case, other diagnostic elements such as the scapulae and the thoracic cage are not preserved, and further observations are not possible with the current documentation.

**Deposits containing more than one individual**

At Cabeço das Amoreiras all deposits with human remains contained the remains of one individual.

**Post-depositional manipulations of the cadavers**

At Cabeço das Amoreiras, the skeletons are apparently complete and lie undisturbed in the grave feature. There is evidence suggesting the post-depositional manipulation of the cadavers.

This is documented by the feature with the disarticulated cranium of CAMS1958, Sk2 lying on the left side of the complete skeleton of CAMS1958, Sk3 (fig. 4.43). This deposit consists of a cranium poorly preserved, apparently without the mandible or any postcranial bones. It is unclear whether this cranium was originally placed in the feature in articulation with its postcranial skeleton, which would later be completely removed, or if the cranium was deposited already in disarticulated state. The field photograph of the cranium (fig. 4.44) shows fragments of what could be a portion of the pelvic girdle, yet it is unclear if these fragments are skeletal elements. Unfortunately, the remains of CAMS1958, Sk2 are not inventoried in the material curated at the MNA. Nevertheless, the description on the back of this photo seems to support the hypothesis of a feature with an isolated cranium: “cranium II (fragments) without skeleton”. Also, the drawing of the remains in the feature presents the cranial fragments only. In any case, this feature suggests the handling of the human remains after death. It is not clear, however, if the cranium was placed in the feature already in disarticulated state and clean of most soft tissue, or if this is the original place of decomposition of CAMS1958, Sk2, the postcranial skeleton of which has been removed sometime after the decomposition of the soft tissues.

The relationship between CAMS1958, Sk2 and Sk3 is also ambiguous. The relative position of the body of individual 3 towards cranium 2 could suggest a common and intentional arrangement. The remains of both individuals lie at the same depth, in the same layer (4: chestnut brown sand) and in very close proximity, but do not disturb or come in contact with each other. Interestingly, individual 3 presents a general rotation towards the left side where the cranial fragments of individual 2 are deposited. The interval between these deposits is not possible to determine and despite the close proximity and suggestive arrangement of the remains the evidence supporting the interpretation of a related and/or simultaneous deposit is not conclusive.
Table 4.45. Summary of the key observations used in the reconstruction of the grave features at Cabeço das Amoreiras, Sado valley. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Pressures</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design of the grave feature.</td>
<td></td>
<td>1. Wall-effect, upper right side; 2. Wall-effect, left side; 3. Wall-effect, lower end.</td>
<td>1. Alignment of the upper right limb, involving right shoulder and arm; 2. Suggested by projection forwards and upwards of left shoulder; 3. Affecting lower limbs and forcing feet towards buttocks. Also, visible by contraction of left foot.</td>
</tr>
<tr>
<td>5, 1958</td>
<td>Adult, mature</td>
<td>♂</td>
<td>1. Wall-effect, upper right side; 2. Wall-effect, upper left side; 3. Wall-effect, lower end.</td>
<td>1. Alignment of upper right limb, involving shoulder, arm and forearm; 2. Alignment of upper left limb, involving the shoulder and arm; 3. Alignment of and constraint effect towards lower limbs forcing feet towards buttocks.</td>
</tr>
<tr>
<td></td>
<td>Prob. design of the grave feature.</td>
<td></td>
<td>1. Wall-effect, upper right side; 2. Wall-effect, upper left side; 3. Wall-effect, lower end.</td>
<td>1. Alignment of upper right limb, involving shoulder, arm and forearm; 2. Alignment of left arm and forearm; 3. Alignment and constraint effect towards lower limbs forcing feet towards buttocks.</td>
</tr>
<tr>
<td>8, 1958</td>
<td>Non-adult, 7.5–16 yrs</td>
<td>n/d</td>
<td>1. Wall-effect, upper left side; 2. Wall-effect, lower end. Design of the grave feature.</td>
<td>1. Suggested by the alignment of left arm; 2. Alignment and constraint effect towards lower limbs forcing feet towards buttocks.</td>
</tr>
</tbody>
</table>
Figure 4.43. Cabeço das Amoreiras, Sado valley, 1958: field photograph of individual 3 (complete skeleton) and individual 2 (cranium). (MNA, APMH, F790)
The mortuary programme at Cabeço das Amoreiras

Cabeço das Amoreiras has a relatively low number of individuals (n=8), one of which is represented by an isolated cranium (CAMS1958, Sk2). Nevertheless, it is possible to observe some patterns in the mortuary practices at the site.

The individuals buried at Cabeço das Amoreiras were predominantly adult males except in the case of two individuals belonging to juvenile skeletons (CAMS1958, Sks 6, 8) the sex of which is not determinable. Also, sex and age of individuals 1 and 2 are not possible to determine due to fragmentation of the material.
At Cabeço das Amoreiras the cadavers were typically placed in individual grave features while retaining their anatomical integrity (individual primary deposits). The feature was then immediately covered with sediment, providing a filled space of decomposition. As discussed, one case (CAMS1958, Sk2) suggests the post-depositional manipulation of the cadaver, which could either indicate the re-opening and removal of the postcranial skeleton from an individual primary deposit or, more likely, it could indicate the secondary deposition of selected elements, in this case, the cranium.

In the case of the individual primary deposits, the cadavers were always lying on the back with the upper limbs positioned close to the body in various arrangements. The lower limbs were normally rotated to one side and were always flexed or hyperflexed at the knees. The degree of flexion at the hip joints was more variable. In some cases the hip joints were flexed or hyperflexed and the limbs were brought up towards the upper body, but in other cases these joints were almost in extension. Interestingly, in any of these variants, the feet of the cadavers were always placed towards the buttocks in a forced position, and clumping at the level of the lower body was a common characteristic of burial practices at Cabeço das Amoreiras.

The floor of the graves tended to be uneven and sloping from the upper to the lower end of the feature. The heads of the cadavers were often rotated forwards and downwards towards the body, and in some cases the head was in a more elevated position than the trunk.

In most cases the pressures exerted on bodies in features can be explained as the result of the design of the grave. Typically, the wall-effects and consequent pressures corresponded to the physical limits of the pit, just wide enough to contain the individual. However, some observations may suggest the tight wrapping of the body at the time of the burial, at least in one case (CAMS1958, Sk7), but the data is not conclusive. In contrast to the typical narrow graves, in one case (CAMS1958, Sk8) the pit was somewhat wider allowing a relatively expanded position of the body, particularly at the level of the lower body.

Overall, the mortuary programme at Cabeço das Amoreiras presents a consistent set of practices and all cases observed follow a common way of burying the dead.
Sado valley: Vale de Romeiras

Site background: a short history of research

Vale de Romeiras is a shell midden site located on the eastern side of the Sado valley (fig. 2.3). The site is located on the right margin of the Sado River at 55 m.a.s.l. (Diniz et al. 2012), and has excellent visibility over the river valley. From here we can see the site of Cabeço das Amoreiras on the opposite margin some kilometres away, and the site of Cabeço do Pez on the neighbouring hilltop.

Archaeological material and documentation available for Vale de Romeiras are curated at the National Museum of Archaeology in Lisbon (MNA). The year of identification of the site is unclear, but according to the literature it can be assumed to be sometime between 1950 and 1955 (Heleno 1956, 229). The documentation indicates that Vale de Romeiras was excavated in two seasons in 1959 and 1960 by the staff of MNA. The excavation diary (MNA, APMH, 2/3/6/1) shows that the first field season started on the 18th of August 1959, but unfortunately, like other documents, this report is incomplete. During the first five days at the site, the excavators identified three skulls and some bone elements in articulation, and at least two burials were completely excavated. Yet the site plans indicate that c 23 individuals were recovered in 1959. Most of the burials were excavated after these first five days but those pages are missing from the archives. The site was excavated briefly in 1960, but since no human remains were found, the work was dismissed and the field team moved to Poças de S. Bento (MNA, APMH, 51/1/654/51 and 53, Aug. and Sep. 1960).

Graphic documentation consists of one site plan with all burials in the excavation context (fig. 4.45), several individual drawings of the human burials and fauna, and photographs. Unfortunately, the quality of the 58 photographs available for Vale de Romeiras (MNA, APMH, 2/11/83) is poor and most images are extremely blurry and indistinguishable. Drawings of the human remains are, however, the best graphic documentation available for any of the shell middens in Portugal. This documentation is available in the format of field sketches with 33 drawings of human remains and fauna, a small booklet of 10 pages with all burials in 1:20 scale and eight detailed ink drawings of individuals 4, 7, 8, 10, 11, 16, and 18, as well as faunal concentrations (MNA, 1959, B37–B44). All drawings are from 1959 by Dario de Sousa, MNA, and include a few notes on stratigraphy and orientation of the features.
Figure 4.45. Vale de Romeiras, Sado valley: site plan and profiles of the excavation area. (Adapted from a photograph by J. P. Ruas. MNA, 1959, D. Sousa, A120)
Human skeletons are in disarticulated state and preserved in containers. The osteological material was studied by a team of anthropologists in the 1990s (Cunha and Umbelino 1995–97, 2001; Umbelino and Cunha 2012). The MNI identified in the museum is 26 while just 23 are represented in the site plan. The burial population studied by E. Cunha and C. Umbelino consists of 20 adults (five females, five males, ten indeterminate), six of which are young adults under 30 years old, and six are non-adults in the first infancy (Cunha et al. 2002, 191, 192) (table 4.46).

Table 4.46. Vale de Romeiras, Sado valley: minimum number of individual (MNI) estimated for the material currently curated at MNA.

<table>
<thead>
<tr>
<th>MNI</th>
<th>Adults</th>
<th>Non-adults</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>♀</td>
<td>5</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>♂</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indet.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>20</td>
<td>6</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
</tbody>
</table>

The following table (table 4.47), courtesy of one of the anthropologists who studied this material in detail (Umbelino 1999), is the reference used in this study regarding sex and age estimates for Vale de Romeiras.

Table 4.47. Vale de Romeiras, Sado valley: sex and age estimates of 20 individuals. (Data from Cunha and Umbelino 1995–97, 2001; Umbelino 1999)

<table>
<thead>
<tr>
<th>Individual</th>
<th>Container</th>
<th>Age</th>
<th>Sex</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>6186</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6115</td>
<td>Adult</td>
<td>♂</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6194</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>6156</td>
<td>Adult</td>
<td>♀</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>6123</td>
<td>Non-adult, 3–4 yrs±12 m.</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>6203</td>
<td>Adult</td>
<td>♂</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6155</td>
<td>Adult, young</td>
<td>♂</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>6115</td>
<td>Adult, young</td>
<td>♀</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>6122</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>6118</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>6161</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>6189</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>6157</td>
<td>Non-adult, 12 yrs±36 m.</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>6185</td>
<td>Non-adult, 3 yrs±12 m.</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>6162</td>
<td>Non-adult, 2–6 yrs</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>6195</td>
<td>Adult, young</td>
<td>♀</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>6119</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>6116</td>
<td>Adult</td>
<td>♂</td>
<td></td>
</tr>
<tr>
<td>1 or 21?</td>
<td>6190</td>
<td>Adult, young</td>
<td>♀</td>
<td></td>
</tr>
<tr>
<td>23?</td>
<td>6197</td>
<td>Adult</td>
<td>n/d</td>
<td></td>
</tr>
</tbody>
</table>
Stratigraphic data is provided by the graphic documentation (table 4.48). Most burials (n=14) were found lying on the soft bedrock (layer 6, piçarreira) but at various depths ranging from 10 to 84 cm. One short entry in the excavation diary describes the first two burials excavated at the site, possibly individuals 1 and 2, being recovered at 20–30 cm from the top. In the same entry the excavator predicts that the maximum depth of the shell midden is probably not more than 50 cm. This is because individual 1 was found in the soft bedrock layer, at only 20 cm deep. However, most burials were recovered at lower depths, suggesting a significant erosion of the midden in the south-west area, possibly due to a downslope position, where also individual 1 was found. Likewise, individuals 5, 13 and 14 buried in the same area, were found on the bedrock layer at depths ranging from 10 to 18 cm.

Table 4.48. Vale de Romeiras, Sado valley: stratigraphy and depth of the human burials. Samples are sorted so that the upper layer is on top of the table. (Data from field drawings, MNA, 1959, D. Sousa)

<table>
<thead>
<tr>
<th>Individual</th>
<th>Layer</th>
<th>Depth (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2, grey soil with (few) shells</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>2, grey soil with shells</td>
<td>35</td>
</tr>
<tr>
<td>15</td>
<td>4, yellowish clay-like soil, beginning</td>
<td>48</td>
</tr>
<tr>
<td>17</td>
<td>4, yellowish clay-like soil, beginning</td>
<td>48</td>
</tr>
<tr>
<td>16</td>
<td>4, yellowish clay-like soil, beginning</td>
<td>49</td>
</tr>
<tr>
<td>18</td>
<td>4, yellowish clay-like soil</td>
<td>54</td>
</tr>
<tr>
<td>21</td>
<td>5, chestnut brown sand</td>
<td>45</td>
</tr>
<tr>
<td>19</td>
<td>5, chestnut brown sand</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>5/6, chestnut brown sand/soft bedrock</td>
<td>50</td>
</tr>
<tr>
<td>13</td>
<td>6, soft bedrock</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>6, soft bedrock</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>6, soft bedrock</td>
<td>18</td>
</tr>
<tr>
<td>1</td>
<td>6, soft bedrock</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>6, soft bedrock</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>6, soft bedrock</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>6, soft bedrock</td>
<td>37</td>
</tr>
<tr>
<td>9</td>
<td>6, soft bedrock</td>
<td>43, cranium; 62, pelvic girdle</td>
</tr>
<tr>
<td>11</td>
<td>6, soft bedrock</td>
<td>60</td>
</tr>
<tr>
<td>12</td>
<td>6, soft bedrock</td>
<td>60</td>
</tr>
<tr>
<td>10</td>
<td>6, soft bedrock</td>
<td>70</td>
</tr>
<tr>
<td>22</td>
<td>6, soft bedrock</td>
<td>75</td>
</tr>
<tr>
<td>20</td>
<td>6, soft bedrock</td>
<td>84</td>
</tr>
<tr>
<td>23</td>
<td>6, soft bedrock</td>
<td>84</td>
</tr>
</tbody>
</table>
Three burials (Sks 4, 19, 21) were found in layer 5, described as chestnut brown sand (*terra acastanhada, areenta*), at depths ranging from 45 to 60 cm. Interestingly both burials 19 and 21 are eccentric to the burial ground, lying on the northernmost area of the site. Individual 4 is in the interface of layer 5/6 and well positioned with other burials. Three of the four burials found in yellowish soil (layer 4, *terra amarelada, barrenta*) are children (Sks 16, 17, 18) buried next to each other, c 50 cm deep, on the west part of the burial area. No burials were found in layer 3, described as a black soil (*terra preta*), suggesting a possible hiatus in the burial activity. Layer 2 is the layer containing shells (grey soil with shells, *terra cinzenta e conchas*) where just two individuals were found (Sks 2, 8). The top layer (layer 1, brownish soil, *terra acastanhada, vegetal*) covered the layer with shells and had no burials.

**Chronology of the burial practice**

**Previous ¹⁴C measurements**

Three ¹⁴C measurements on the material excavated in 1959 were carried out in the late 1980s: one sample on unidentified fauna (ICEN–144) and two samples on shells (ICEN–146 and ICEN–150) (Arnaud 2000) (table A11).

Previous attempts to date the human remains (individuals 8 and 12) were unsuccessful due to insufficient quantity of bone collagen (Cunha et al. 2002, 189; Umbelino 2006, 137) (table 4.49).

**Objectives of the dating programme**

The dates available on non-human material (ICEN–144, ICEN–146 and ICEN–150) indicate an early use of the site, which is coeval with the non-human sample available for Arapouco (Q–2492) but several centuries older than both the human (Beta–125109) and non-human (Q–2496 and Q–2497) measurements available for the neighbouring site Cabeço do Pez.

The burial area of this site is relatively small but with high concentration of human burials. The general aims of the dating programme for Vale de Romeiras followed the macro-goals of the radiocarbon programme of this dissertation, outlined in chapter 3, and were:

- to define when the burial activity started and when it ended;
- to estimate the duration of the use of this site for burial activity;
- to estimate the frequency of the burial activity in the site.

The site-specific aims of the dating programme for Vale de Romeiras were:

- to test the suggestion of a coeval group of burials;
- to test the suggestion of this site being used as burial ground for the neighbouring site Cabeço do Pez.
Table 4.49. *Samples of human bone (13) from Vale de Romeiras collected and submitted for $^{14}$C measurement in the course of this study. All samples are from the 1959 assemblage and were collected at MNA.* *Samples pre-treated with boiling in acetone, ultrasonification first with ether and then with ethanol, and finally filtrated; after that processed as usual (see chapter 3).*

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Stratigraphy</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Ua–46967</td>
<td>Adult</td>
<td>♂</td>
<td>Tibia–R</td>
<td>Layer 5/6, brownish sand/bedrock, 50 cm</td>
<td>Previous stable isotope analysis by Umbelino 2006 Ua–46967: doubtful quality</td>
</tr>
<tr>
<td>7</td>
<td>Ua–47982*</td>
<td>Adult</td>
<td>♀</td>
<td>Tibia–R</td>
<td>Layer 6, bedrock, 32 cm</td>
<td>Not measurable</td>
</tr>
<tr>
<td>8</td>
<td>Ua–46968</td>
<td>Non-adult, 3–4 yrs±12 m.</td>
<td>n/d</td>
<td>Tibia</td>
<td>Layer 2, grey soil with shells, 35 cm</td>
<td>Previous $^{14}$C dating without results (Cunha et al. 2002, 189)</td>
</tr>
<tr>
<td>9</td>
<td>Ua–47983*</td>
<td>Adult</td>
<td>♂</td>
<td>Radius–R</td>
<td>Layer 6, bedrock, 43-62 cm</td>
<td>Not measurable</td>
</tr>
<tr>
<td>11</td>
<td>Ua–46969</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Humerus–L</td>
<td>Layer 6, bedrock, 60 cm</td>
<td>Not measurable</td>
</tr>
<tr>
<td>12</td>
<td>Ua–47984*</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone</td>
<td>Layer 6, bedrock, 60 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>13</td>
<td>Ua–47985*</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia–L</td>
<td>Layer 6, bedrock, 10 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>14</td>
<td>Ua–46970</td>
<td>Adult</td>
<td>n/d</td>
<td>Tibia</td>
<td>Layer 6, bedrock, 10 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>16</td>
<td>Ua–46971</td>
<td>Non-adult, 12 yrs±36 m.</td>
<td>n/d</td>
<td>Femur</td>
<td>Layer 4, yellowish soil, 49 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>18</td>
<td>Ua–47986*</td>
<td>Non-adult, 2–6 yrs</td>
<td>n/d</td>
<td>Tibia–L</td>
<td>Layer 4, yellowish soil, 54 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>19</td>
<td>Ua–46972</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Tibia–R</td>
<td>Layer 5, brownish soil, sand like, 60 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>20</td>
<td>Ua–47987*</td>
<td>Adult</td>
<td>n/d</td>
<td>Femur–R</td>
<td>Layer 6, bedrock, 84 cm</td>
<td>Doubtful quality</td>
</tr>
<tr>
<td>22</td>
<td>Ua–47988*</td>
<td>Adult</td>
<td>♂</td>
<td>Fibula</td>
<td>Layer 6, bedrock, 75 cm</td>
<td>Not measurable</td>
</tr>
</tbody>
</table>
Sampling strategy
Thirteen samples of human bone were selected for 14C analysis (table 4.49). The sampling strategy was targeted towards a good spatial and stratigraphic coverage. In some cases it was not possible to obtain samples from the pre-selected individuals due to preservation/curation of the material.

Results
Ten of the thirteen samples submitted as part of this study revealed poor quality during laboratory analysis and were rejected (table A1). Three 14C measurements on human bone collagen samples from Vale de Romeiras are available now (table 4.50). One of these measurements (Ua–46968, VR1959, Sk8) has a modern age and for this reason it was excluded from the chronological modelling, but its context is discussed further in chapter 5.

Table 4.50. Human bone collagen (3) samples from Vale de Romeiras, Sado valley. 14C measurements and estimation of non-terrestrial carbon intake (% marine). Samples are sorted by lowest to highest % marine. Marine percentage was estimated from the measured δ13C value of each sample by the application of method marine 1 and method marine 2, based on adopted endpoint values of –12‰ and –20‰ for marine (100%) and terrestrial (100%) diets respectively.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements</th>
<th>% marine</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind.</td>
<td>Excav.</td>
<td>Museum</td>
<td>Lab no.</td>
</tr>
<tr>
<td>9</td>
<td>1959</td>
<td>MNA</td>
<td>Ua–47983</td>
</tr>
<tr>
<td>19</td>
<td>1959</td>
<td>MNA</td>
<td>Ua–46972</td>
</tr>
<tr>
<td>8</td>
<td>1959</td>
<td>MNA</td>
<td>Ua–46968</td>
</tr>
</tbody>
</table>

Calibration and chronological models
The chronological model is limited to two 14C dates, both obtained in the scope of this study (table 4.51, fig. 4.46). Individual 8 (Ua–46968) was not included in the model because its date is modern and is out of the scope of this study (table A2).

This is a phase model which groups all dated burial events in a phase of burial activity (Bronk Ramsey 1998, 2000, 2001). This grouping is constrained by a start of burial activity event, and an end of burial activity event (i.e., boundaries) imposing no internal constraints to the relative order of the dated events. All it assumes is that the start event occurs before the dated events, and that these all occur before the end event. For the command files defined for this model see appendix.
Results: Sado valley, Vale de Romeiras

Internal consistency and reliability of the model

Agreement index (A) for each dated event is high (A ≥ 97%). The model shows high overall agreement (Marine 1: A_{overall}=104%, Marine 2: A_{overall}=101.2%), which indicates that the 14C dates are in accordance with the prior information incorporated in the model. The index of convergence (C) is good (≥ 97%).

The results obtained when running the model with the different marine values (M1, M2) are statistically insignificant. For this reason, all further observations and graphic presentation are based on the results obtained with the model run with the values of M1. The results obtained with M2 are presented in the tables (table 4.51). This model was built with a small number of measurements. For this reason, and because of the scattering of the dates, the model estimates a wide time range for the start and end dates of the burial activity at 95% probability, and accommodates a large range of possibilities, although with low likelihood. As in the model for Cabeço das Amoreiras (see above), the variance cannot be determined precisely and the start and end dates will be very uncertain. Without further archaeological data allowing related early and/or later burial activities at the site the estimates for start and end dates should be considered with caution (figs. 4.47, 4.48). The burial activity is estimated to have continued for between 779 and 1074 years (95% probability: site use for burial activity) or for 842 and 978 years (68% probability) (fig. 4.49).

Table 4.51. Human bone collagen (2) samples from Vale de Romeiras, Sado valley: calibrated date ranges according to two different approaches for the calculation of the marine percentage (M1, M2). Results are presented in both (a) cal BCE and (b) cal BP in 95.4% confidence range. The calibrated date ranges are probability distributions derived from scientific dating alone. The posterior density estimates (in italic) are derived from Bayesian modelling. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>¹⁴C Age BP</th>
<th>(95% confidence)</th>
<th>(95% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cal BCE, M1</td>
<td>Calibrated date range</td>
<td>Modelled cal BCE, M1</td>
</tr>
<tr>
<td>9</td>
<td>Ua–47983</td>
<td>6625±51</td>
<td>5633–5471</td>
<td>5625–5475</td>
</tr>
<tr>
<td>19</td>
<td>Ua–46972</td>
<td>7640±55</td>
<td>6598–6371</td>
<td>6593–6370</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>¹⁴C Age BP</th>
<th>(95% confidence)</th>
<th>(95% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cal BP, M1</td>
<td>Calibrated date range</td>
<td>Posterior density estimate</td>
</tr>
<tr>
<td>9</td>
<td>Ua–47983</td>
<td>6625±51</td>
<td>7582–7420</td>
<td>7574–7424</td>
</tr>
<tr>
<td>19</td>
<td>Ua–46972</td>
<td>7640±55</td>
<td>8547–8320</td>
<td>8542–8319</td>
</tr>
</tbody>
</table>

299
Figure 4.46. Chronological model for the burial activity at Vale de Romeiras, calibrated using marine 1 diet values. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, Sado valley, Vale de Romeiras, Model 1, Marine 1.

Figure 4.47. Start of burial activity at Vale de Romeiras derived from the chronological model 1, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is 8459–6409 cal BCE (95.4% probability), 7736–6409 cal BCE (78.2% probability), 8456–6425 cal BCE (68.2% probability), or 7283–6425 cal BCE (64.9%). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.
Results: Sado valley, Vale de Romeiras

Figure 4.48. End of burial activity at Vale de Romeiras derived from the chronological model 1, calibrated with values for marine 1 diet. Posterior density estimated for the end of the burial activity is 5601–3594 cal BCE (95.4% probability), 5601–4249 cal BCE (79.5% probability), 5597–3597 cal BCE (68.2% probability), or 5597–4749 cal BCE (64.9% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Figure 4.49. Duration of burial activity at Vale de Romeiras derived from the chronological model, calibrated with values for marine 1 diet values. Posterior density estimated for the duration of the burial activity is between 779 and 1074 years (95% probability), or 842 and 978 years (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.
Stable isotopes: carbon and nitrogen

**Previous measurements: δ\(^{13}\)C and δ\(^{15}\)N**

In the early 2000s, one sample from the 1959 excavations (VR1959, Sk4) was analysed in the scope of a palaeodietary study (Umbelino 2006). These analyses were done at the McMaster University in Canada and the precision of the results are ± 0.1‰ for δ\(^{13}\)C and ± 0.2‰ for δ\(^{15}\)N (Umbelino 2006, 208–209). The C:N ratios were not provided but the laboratory confirmed the quality of the collagen and of the measurements (Umbelino 2006, 315).

Recently, one team sampled this collection for stable isotope analysis of carbon and nitrogen (Guiry et al. 2015), and obtained seven reliable measurements (table 4.52) from a total of 17 samples. This material was measured on a Thermo-Finnigan Delta Plus XL isotope ratio mass spectrometer coupled via continuous flow to a Carlo Erba elemental analyzer at the Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. The instrumental error for δ\(^{13}\)C and δ\(^{15}\)N measurements was ±0.1‰ and ±0.2‰, respectively (Guiry et al. 2015).

All previous measurements were included in this study (n=8) as long as they fell within the accepted quality ranges as discussed.

**Sampling strategy**

In this study, the selection of samples of human remains for δ\(^{13}\)C and δ\(^{15}\)N measurements was fully dependent on the goals of the radiocarbon dating programme (see above).

**Results**

Samples Ua–number (n=2) were measured by IRSM and the precision of the measurements for both δ\(^{13}\)C and δ\(^{15}\)N is ± 0.1‰.

VR1959, Sks 4, 9, and 19 have multiple samples on different bones (this study; Guiry et al. 2015; Umbelino 2006) and present different values (fig. 4.50, table 4.52).

At Vale de Romeiras, the human collagen δ\(^{13}\)C values (n=10/no. individuals=7) range from −20.5‰ to −18.4‰ with a mean value of −19.2 ± 0.7‰. The human collagen δ\(^{15}\)N values (n=9/no. individuals=7) range from +7.7‰ to +10.3‰ with a mean value of +9.5 ± 0.9‰. The measurement of δ\(^{15}\)N was not possible in the sample of individual 4 (without lab no.) (Umbelino 2006).

One of the two sets of values obtained for individual 9 (Ua–47983) seems to be an outlier in the series (fig. 4.50). When excluded, the values range from −20.2‰ to −18.4‰ (−19.1 ± 0.6‰) for carbon and from +8.7‰ to +10.3‰ (+9.7 ± 0.6‰) for nitrogen.

When considering the \(^{14}\)C dated individuals (n=2) the values range from −20.5‰ to −20.2‰ (−20.4 ± 0.2‰) for carbon and from +7.7‰ to +8.7‰ (+8.2 ± 0.7‰) for nitrogen.
Results: Sado valley, Vale de Romeiras

Figure 4.50. Vale de Romeiras, Sado valley: correlation between the $\delta^{13}C$ ($\%$) and $\delta^{15}N$ ($\%$) values of 9 samples of human bone collagen from 7 individuals. Individuals 9 (square) and 19 (triangle) have two sets of values.
Table 4.52. Vale de Romeiras, Sado valley: carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) measurements on human bone collagen samples collected at MNA. Samples are sorted so that the lowest $\delta^{13}C$ values are on top of the table. Multiple samples of the same individual are sorted together.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements by AMS; $\delta^{13}C$ and $\delta^{15}N$ by IRMS</th>
<th>% marine (±10)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind.</td>
<td>Age</td>
<td>Sex</td>
<td>Bone</td>
</tr>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Radius–R 999.26.10</td>
</tr>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone 999.26.68</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Tibia–R 999.29.9</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Rib 999.29.53</td>
</tr>
<tr>
<td>5, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.21.21</td>
</tr>
<tr>
<td>1 (21?)</td>
<td>1959</td>
<td>Adult, young</td>
<td>♀</td>
</tr>
<tr>
<td>4, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone 999.25.65</td>
</tr>
<tr>
<td>4, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone n/p</td>
</tr>
<tr>
<td>11, 1959</td>
<td>Adult, young</td>
<td>♀</td>
<td>Long bone 999.24.61</td>
</tr>
<tr>
<td>23?, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.22.8</td>
</tr>
</tbody>
</table>

$^3$ E. Guiry and colleagues (2015) were in doubt about the identification of this adult female: 1 or 21. According to my analysis, this is likely to be individual 1, because the skeletal elements of individual 21 are very fragmented and sex identification would not be possible.
Archaeothanatology

Source material and analysis strategy
Archaeothanatological analysis was carried out on a total of 19 individuals, c 83% of the MNI (23 in site plan, 26 estimated by Cunha and Umbelino 1995–97) for Vale de Romeiras. One of these 19 individuals (VR1959, Sk8) revealed a recent 14C date and its analysis will be considered separately, thus the sample size for the general observations is 18. The completeness and detail of each analysis is dependent on the character and quality of the available source material which in several cases is very limited. At Vale de Romeiras, the preservation of the human remains is relatively poor, in particular at the level of the upper body. The source material comprises deteriorated field photographs, available for 14 individuals, good individual drawings and a site plan of the burials (table 4.53).

Results of the archaeothanatological analysis

The nature of the deposits
Analysis of the nature of the deposits at Vale de Romeiras suggests a pattern of primary burials (table 4.54) indicating that the cadavers were placed in the burial features before the degradation of the labile joints. In several cases the diagnostic criteria are poorly preserved, however, the overall position of the skeletal elements strongly indicates that the bodies were disposed while still retaining their general anatomical integrity, supporting the interpretation of burials in primary position. One possible exception to this pattern is presented by two disarticulated long bones lying on the left side of VR1959, Sk9, which, as discussed further, may suggest a deposit in a secondary position (see below, Post-depositional manipulations of the cadaver).
Table 4.53. *Vale de Romeiras, Sado valley: all individuals identified and excavated (n=23) and the respective source material used for the archaeothanatological analysis. This material is curated at the MNA.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Source material</th>
<th>Graphic documentation w/ human remains</th>
<th>Written documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>Field photographs</td>
<td>Drawings</td>
<td>Site plan</td>
</tr>
<tr>
<td>1, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>2, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>3, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>4, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>5, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>6, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>7, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>8, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>9, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>10, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>11, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>12, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>13, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>14, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>15, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>16, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>17, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>18, 1959</td>
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<td>yes</td>
</tr>
<tr>
<td>19, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>20, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>21, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>22, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>23, 1959</td>
<td>n/a</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
Table 4.54. Summary of the nature of the deposits with human remains at Vale de Romeiras, Sado valley.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Nature of the deposit</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of right foot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>4, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right hand; metatarsals and phalanges of feet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>5, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>6, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>7, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of right foot.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>10, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Primary</td>
<td>Maintenance of labile articulations: bones of right hand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>11, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>12, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>13, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>14, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
</tbody>
</table>

continued...
<table>
<thead>
<tr>
<th>Year</th>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>16, 1959</td>
<td>Non-adult, 12 yrs ± 36 m.</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>17, 1959</td>
<td>Non-adult, 3 yrs ± 12 m.</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>18, 1959</td>
<td>Non-adult, 2–6 yrs</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of labile articulations: moderate collapse of bones of right hand. Maintenance of the general anatomical integrity of the body</td>
</tr>
<tr>
<td>20, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>22, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
<tr>
<td>23, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body suggests a burial in primary position.</td>
</tr>
</tbody>
</table>
The space of decomposition of the cadaver

Analysis of the space of decomposition of the cadavers buried in Vale de Romeiras indicates a general pattern of filled spaces (table 4.55). The cadavers were covered with sediment immediately after their placement in the feature. The decomposition of the bodies took place in this sediment-filled environment. In several cases the analysis is unclear due to the poor preservation of the remains. In every case, the movement of the bones is limited suggesting that the space of decomposition was filled and that the sediment could penetrate immediately.

Few cases suggest mixed spaces of decomposition (VR1959, Sks 5, 6) with original empty spaces in the grave feature and/or by the formation of secondary empty spaces outside the volume of the cadaver within an overall filled environment. The analysis of VR1959, Sk5 suggests a mixed space of decomposition by the formation of a secondary empty space outside the volume of the cadaver within an overall filled environment but there is no clear indication of original empty spaces in the feature. Unfortunately, the analysis is constrained by the poor preservation of the material however it is possible to advance some observations (fig. 4.51).

Figure 4.51. VR1959, Sk5. Although poorly preserved this case is suggestive of a mixed space of decomposition. The collapse forwards and downwards of the skull (cranium and mandible), right shoulder girdle, and bones of the right arm and forearm, contrasts with the position of the pelvic girdle which stayed behind, probably remaining close to the original burial position. These movements suggest the formation of a secondary space in front of the upper body where the bones could migrate during the process of decomposition while being supported by the penetration of sediment in a filled environment. (MNA, 1959, D. Sousa)
The mixed space of decomposition is suggested by the significant collapse forwards and downwards of the skull (cranium and mandible), right shoulder girdle, and bones of the right arm and forearm. This movement contrasts with the position of the pelvic girdle which seems to have stayed behind, remaining probably close to its original burial position. This contrasting movement could be explained if the upper body was rotated forwards and suspended over what would become a void, by the liberation of space during decomposition of perishable material placed in front of the body.

While this secondary empty space was formed the skeletal elements of the upper body migrated forwards and downwards regaining equilibrium in these new empty spaces. Also, the skull was likely the most elevated element in the feature and the closest to the surface of the grave. In this case, the pressure of the sediment would have had an impact on its collapse along with other skeletal elements of the upper body. While these movements suggest the formation of a pocket of empty space in front of the upper part of the body, other elements suggest that decomposition took place in a filled environment. Most diagnostic criteria are not preserved, but the mandible follows the movement of the cranium suggesting that the labile temporomandibular joint was maintained. Also, the skeletal elements involved in this migration forwards and downwards, remained in order, suggesting continuous support by the penetration of sediment preventing further displacements.

The analysis of VR1959, Sk6 is also limited due to unclear documentation (fig. 4.52). Nevertheless, some patterns in this feature suggest localized movements in a mixed space of decomposition. Overall, the skeleton is well articulated and the movement of the bones is limited. The exception is noted at the level of the upper left limb which is disarticulated upwards suggesting the existence of perishable material, functioning as a cushion, behind this area creating a secondary empty space while it decayed to where the skeletal elements could migrate, in a similar pattern as observed in the feature ARA1961, Sk6.
Figure 4.52. VR1959, Sk6. The striking displacement upwards of the upper left limb contrasts with the minor movements observed in the feature. The documentation is limited but the disarticulation at the level of the shoulder joint and consequent movement presents similarities to the pattern observed at ARA1961, Sk6. (Top: MNA, APMH, F1416. Bottom: MNA, 1959, D. Sousa)
Table 4.55. *Summary of the space of decomposition of the human remains in the grave features at Vale de Romeiras, Sado valley.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Space of decomposition</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position; the bones of right foot are rotated inwards. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>4, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position; the bones of right hand are slightly rotated inwards; the patellae are suspended on the distal ends of the femora; the bones of the feet. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>5, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Mixed?</td>
<td>Poor preservation and unclear documentation. However, significant collapses suggest pocket of empty space in front of upper body.</td>
</tr>
<tr>
<td>6, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled, Mixed?</td>
<td>Maintenance of bones in original unbalanced position: the patellae are suspended on the distal ends of the femora. Movement at the level of the upper left limb suggests empty space behind this area.</td>
</tr>
<tr>
<td>7, 1959</td>
<td>Adult</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse of the right hemithorax as well as the right hip bone; the right patella is suspended on the distal end of the femur. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse of pelvic girdle; the bones of the feet are slightly rotated inwards. Also, the cranium is maintained in a semi-suspended position. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>10, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the bones of right hand are rotated and flexed at the wrist. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>11, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position; the right patella has slid slightly downwards, but is maintained in a suspended position between the femur and tibia. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>12, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver.</td>
</tr>
</tbody>
</table>

*continued...*
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Sex</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>13, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Poor preservation and unclear documentation but no movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>14, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver. Also, the cranium is maintained in a semi-suspended position.</td>
</tr>
<tr>
<td>16, 1959</td>
<td>Non-adult, 12 yrs±36 m.</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver. Also, the cranium is maintained in a semi-suspended position.</td>
</tr>
<tr>
<td>17, 1959</td>
<td>Non-adult, 3 yrs±12 m.</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver. Also, the cranium is maintained in a semi-suspended position.</td>
</tr>
<tr>
<td>18, 1959</td>
<td>Non-adult, 2–6 yrs</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: the bones of the right hand are rotated inwards but collapse is moderate. Also, the cranium is maintained in a semi-suspended position. Poor preservation but no movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>20, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Probably filled</td>
<td>Poor preservation and unclear documentation but no movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>22, 1959</td>
<td>Adult</td>
<td>♂♀</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver. Also, the cranium is collapsed forwards but maintained in a semi-suspended position.</td>
</tr>
<tr>
<td>23, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation but no movement outside initial volume of the cadaver. Also, the cranium is collapsed forwards but is maintained in a semi-suspended position.</td>
</tr>
</tbody>
</table>
Chapter 4

The initial position of the cadaver in the feature

The most common position at Vale de Romeiras consists of a cadaver lying on the back (n=15 to 16) with the lower limbs in flexion or hyperflexion (table 4.56). In two cases the body was lying on one side, always on the left, with the limbs in flexion and arranged close to the body. Some of the bodies lying on the back were generally rotated to the left side (VR1959, Sks 4, 9, 10).

The position of the upper limbs varied considerably but they were always placed close to the body, symmetrically or asymmetrically, in extension, semi-flexion, flexion or hyperflexion at the elbows.

At Vale de Romeiras, the bodies were placed in the feature with the lower limbs in flexion or hyperflexion at the level of the hip and knee joints (n=14). In nine cases the hip and knee joints were in hyperflexion (VR1959, Sks 1, 6, 7, 11, 13, 16, 17, 22, 23), and in flexion in three to four cases (VR1959, Sks 2, 10, probably 14, 18). In one case (VR1959, Sk20) the hip joints were flexed while the knees were in hyperflexion. In three cases (VR1959, Sks 9, 12, 19) the hip joints were in semi-flexion, always with the knees in hyperflexion, directed forwards (Sk9), downwards (Sk19) or forwards with a tendency to the left side (Sk12). In one case (VR1959, Sk5) it was not possible to identify the position of the lower limbs. The rotation of the lower limbs was variable. In six cases (VR1959, Sks 1, 7, 13, 16, 17, 23) the lower limbs were in adduction in front of the trunk. The rotation of the limbs to the left side was also common (VR1959, Sks 2, 6, 10, 20) even if just as a tendency (VR1959, Sks 9, 12). VR1959, Sk22 combines these two rotations and the lower limbs were placed in front of the trunk with a tendency towards the left side. The rotation to the right was less common (VR1959, Sks 11, 18, 19). In two cases it was not possible to observe the rotation of the lower limbs (VR1959, Sks 5, 14).

Clumping of the body was common, and in most cases the analysis suggests that the limbs were somewhat nested on the upper body and the feet were forced towards the buttocks. The pattern was enhanced during decomposition by the progressive closure of the angles between the segments and several skeletons became hypercontracted (VR1959, Sks 1, 6, 7, 13, 16, 17, 22, 23). The nesting of the lower limbs could explain the general poor preservation of the bones at the level of the upper body, since the placement of the thighs in this region would add a mass of soft tissue increasing the decomposition activity in the area while contributing to a lower preservation of the bones.
Table 4.56. Summary of the reconstruction of the initial position of the cadaver in the grave features at Vale de Romeiras, Sado valley. The initial position of the limbs is indicated as –R or –L, and refers to the right or left limb, when their positions are different. Rotation –R or –L indicates the rotation of the skeletal element(s) towards the right or the left side.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Initial position of the cadaver in the feature</th>
<th>Trunk</th>
<th>Upper limbs</th>
<th>Lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>On the back</td>
<td>In flexion</td>
<td>Hip and knee joints: hyperflexion In adduction in front of trunk Feet towards buttocks Clumping</td>
<td></td>
</tr>
<tr>
<td>4, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Rotation downwards (neck flexed forwards)–tendency L</td>
<td>On the back</td>
<td>In semi–flexion–R In flexion–L</td>
<td>Hip and knee joints: flexion Rotation–L Feet towards buttocks</td>
</tr>
<tr>
<td>5, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Prob. rotated downwards (neck flexed forwards)</td>
<td>Prob. on the back</td>
<td>In semi–flexion–R Prob. in extension–L</td>
<td>n/a</td>
</tr>
<tr>
<td>6, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>On the left</td>
<td>On the left</td>
<td>In flexion–R n/a–L</td>
<td>Hip and knee joints: hyperflexion Rotation–L Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>7, 1959</td>
<td>Adult</td>
<td>♀</td>
<td>Raised Rotated–L and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In semi–flexion (¢ 90°)–R In semi–flexion–L</td>
<td>Hip and knee joints: hyperflexion Rotation–tendency L In adduction in front of trunk Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Raised Rotation–L and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In flexion–R In hyperflexion–L</td>
<td>Hip joints: semi-flexion Knee joints: hyperflexion Rotation–tendency L Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>10, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>Raised Rotation downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In flexion</td>
<td>Hip and knee joints: flexion Rotation–L Feet towards buttocks Clumping</td>
</tr>
<tr>
<td>11, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Raised Rotation–L and downwards (neck flexed forwards)</td>
<td>On the back</td>
<td>In flexion</td>
<td>Hip and knee joints: flexion Rotation–R Feet towards buttocks Clumping</td>
</tr>
</tbody>
</table>

continued…
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Status</th>
<th>Description</th>
<th>Position</th>
<th>Hip</th>
<th>Knee</th>
<th>Foot</th>
<th>Additional Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>12, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Rotation–L</td>
<td>On the back</td>
<td>Prob. extension–R&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Knee joint–R: semi–flexed&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Hip and knee joints: hyperflexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>n/a–L&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>13, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>n/a</td>
<td>On the back</td>
<td>In extension?</td>
<td>Hip and knee joints: hyperflexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>In adduction in front of trunk</td>
<td>Feet towards buttocks. Clumping</td>
</tr>
<tr>
<td>14, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Prob. raised&lt;sup&gt;1&lt;/sup&gt; Rotation–L and downwards&lt;sup&gt;1&lt;/sup&gt; (neck flexed forwards)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>On the back</td>
<td>In semi–flexion&lt;sup&gt;1&lt;/sup&gt; (c 90°–R&lt;sup&gt;1&lt;/sup&gt;)</td>
<td>Hip and knee joints: prob. flexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16, 1959</td>
<td>Non-adult, 12 yrs±36 m.</td>
<td>n/d</td>
<td>Rotation downwards&lt;sup&gt;1&lt;/sup&gt; (neck flexed forwards)&lt;sup&gt;1&lt;/sup&gt;– tendency R</td>
<td>On the left</td>
<td>In flexion–R&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Hip and knee joints: hyperflexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>In adduction in front of trunk</td>
<td>Feet towards buttocks. Clumping</td>
</tr>
<tr>
<td>17, 1959</td>
<td>Non-adult, 3 yrs±12 m.</td>
<td>n/d</td>
<td>Rotation downwards&lt;sup&gt;1&lt;/sup&gt; (neck flexed forwards)&lt;sup&gt;1&lt;/sup&gt;– tendency R</td>
<td>On the back</td>
<td>n/a</td>
<td>Hip and knee joints: hyperflexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>In adduction in front of trunk</td>
<td>Feet towards buttocks. Clumping</td>
</tr>
<tr>
<td>18, 1959</td>
<td>Non-adult, 2–6 yrs</td>
<td>n/d</td>
<td>Rotation–R and slightly downwards</td>
<td>On the back</td>
<td>In extension?–R&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Hip and knee joints: flexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Rotation–R</td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Raised Rotation downwards&lt;sup&gt;1&lt;/sup&gt; (neck flexed forwards)&lt;sup&gt;1&lt;/sup&gt;–prob. tendency L</td>
<td>On the back</td>
<td>In extension</td>
<td>Hip joints: semi–flexed&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Knee joints: hyperflexed&lt;sup&gt;2&lt;/sup&gt; (knees directed downwards)</td>
<td>Feet towards buttocks</td>
</tr>
<tr>
<td>20, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Rotated to the left</td>
<td>On the back</td>
<td>In semi–flexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Hip joints: flexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Knee joints: hyperflexion&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Rotation–L&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>22, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Rotation downwards&lt;sup&gt;1&lt;/sup&gt; (neck flexed forwards)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>On the back</td>
<td>In semi–flexion–R&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Hip joints: flexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Knee joints: hyperflexion&lt;sup&gt;2&lt;/sup&gt;</td>
<td>In adduction in front of trunk</td>
</tr>
<tr>
<td>23, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>Rotation–L and downwards&lt;sup&gt;1&lt;/sup&gt; (neck flexed forwards)&lt;sup&gt;1&lt;/sup&gt;</td>
<td>On the back</td>
<td>In semi–flexion</td>
<td>Hip and knee joints: hyperflexion&lt;sup&gt;1&lt;/sup&gt;</td>
<td>In adduction in front of trunk. Clumping</td>
<td></td>
</tr>
</tbody>
</table>
**The grave features**

The size and shape of the deposits with human remains at Vale de Romeiras were not described by the excavators. Archaeoanthropological analysis suggests that the bodies were placed in pits dug into the ground. The lateral pressures and wall-effects observed on the skeleton in the feature indicate that the shape and size of the pit was just sufficient to contain the body (table 4.57). The construction of these simple features seems to be dependent on the planned burial position. Furthermore, the analysis indicates that in most cases the design of the grave had a significant impact on the final arrangement of the body in the feature, visible by the constrained positions of most skeletons. At Vale de Romeiras, the compressing effect observed on most skeletons can be explained by the narrow shape of the graves. While the pit imposed a significant physical limit to the cadaver, it also provided lateral support preventing the collapse of the skeletal elements. It is possible that in some cases there might have been an extra support offered by a tight wrapping at the time of the burial. However, the analysis did not reveal any clear evidence for wrapping of the body that could not be explained by the impact of the limits of the grave and the rapid penetration of fine sediment. Thus, the analysis suggests that the forced positions observed at Vale de Romeiras could be sustained by the limits of the grave features without an extra support such as tight wrappings. Although the use of wrappings is not explicit in the analysis, it is clear that this kind of additional support would facilitate the neat placement of the cadaver in very small and narrow features, such as those observed at Vale de Romeiras.

The bottom of the graves tended to be irregular and sloping from the upper to the lower end of the feature. This is visible in some of the drawings in profile and confirmed by the raised position of the head in relation to the trunk (VR1959, Sks 7, 9, 10, 11, prob. 14, 19) and/or by the common flexion and collapse forwards and downwards of the head (VR1959, Sks 4, prob. 5, 9, 11, 14, 17, 19, 22, 23). The fragmented state of the material does not allow detailed observations at the level of ribs and sacrum the rotations of which during the process of decomposition could clarify aspects of the original position of the body in the feature, in relation to the characteristics of the floor of the grave, such as in the case of bodies placed in a half-sitting position. Also, it cannot be excluded that the elevation of the head could be aided by some kind of support, other than the floor of the pit, but the documentation is unclear.
Table 4.57. *Summary of the key observations used in the reconstruction of the grave features at Vale de Romeiras, Sado valley. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.*

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Pressures</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>1. Wall-effect, upper right side; 2. Overall strong lateral pressure and</td>
<td>1. Alignment of upper right limb, involving the arm;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>compressing effect. Design of the grave feature.</td>
<td>2. Contraction and clumping of lower limbs which were maintained on an</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>extreme constrained position;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Hypercontracted skeleton.</td>
</tr>
<tr>
<td>4, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>1. Wall-effect, upper left side;</td>
<td>1. Alignment of the upper left limb, involving shoulder and arm, accentuated</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Wall-effect, lower end. Design of the grave feature.</td>
<td>by the sloping floor causing a transfer of body weight towards the left</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>side;</td>
</tr>
<tr>
<td>5, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>6, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Wall-effect, left side; 2. Overall strong lateral pressure and</td>
<td>1. Alignment and clumping of lower limbs including feet;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>compressing effect. Design of the grave feature.</td>
<td>2. Hypercontracted skeleton.</td>
</tr>
<tr>
<td>7, 1959</td>
<td>Adult</td>
<td>♀</td>
<td>1. Wall-effect, right side; 2. Wall-effect, left side and distal end;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Overall strong lateral pressure and compressing effect. Design of the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>grave feature.</td>
<td></td>
</tr>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>1. Wall-effect, upper right side; 2. Wall-effect, lower end. Design of</td>
<td>1. Alignment of upper right limb and projection forwards of shoulder and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the grave feature.</td>
<td>arm;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Alignment and clumping of lower limbs including feet;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Hypercontracted skeleton.</td>
</tr>
<tr>
<td>10, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>1. Wall-effect, upper right side; 2. Wall-effect, lower end. Design of the</td>
<td>1. Alignment of upper right limb and projection forwards of shoulder and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>grave feature.</td>
<td>arm;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Alignment and clumping of lower limbs including feet. This wall-effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>corresponds to the physical limits of the pit and was accentuated by the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>slope characteristics of the bottom, lower at the level of the pelvic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>girdle, enhancing the nesting of the lower body.</td>
</tr>
<tr>
<td>11, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>1. Wall-effect, upper left side;</td>
<td>1. Alignment of upper left limb and projection forwards of shoulder and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Wall-effect, lower end. Design of the grave feature.</td>
<td>arm;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Alignment and clumping of lower limbs including feet. This wall-effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>corresponds to the physical limits of the pit and was accentuated by the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>slope characteristics of the bottom, lower at the level of the pelvic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>girdle, enhancing the nesting of the lower body.</td>
</tr>
</tbody>
</table>

*continued...*
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Gender</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Wall-effect, lower end. Poor preservation.</td>
</tr>
<tr>
<td>13, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Wall-effect, left side; 2. Wall-effect, lower end 3. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
</tr>
<tr>
<td>14, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Wall-effect, right side; 2. Wall-effect, left side; 3. Wall-effect, lower end.</td>
</tr>
<tr>
<td>15, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
</tr>
<tr>
<td>16, 1959</td>
<td>Non-adult, 12 yrs±36 m</td>
<td>n/d</td>
<td>1. Wall-effect, left side. 2. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
</tr>
<tr>
<td>17, 1959</td>
<td>Non-adult, 3 yrs±12 m</td>
<td>n/d</td>
<td>1. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♂</td>
<td>The observations do not indicate any main pressures towards the body in the feature. Poor preservation.</td>
</tr>
<tr>
<td>20, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Prob. wall-effect, left side and distal end. Poor preservation and unclear documentation.</td>
</tr>
<tr>
<td>22, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>1. Wall-effect, left side and lower end; 2. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
</tr>
<tr>
<td>23, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
</tr>
</tbody>
</table>

The observations do not indicate any main pressures towards the body in the feature. Poor preservation.
Deposits containing more than one individual

At Vale de Romeiras the deposits with human remains contain the remains of one individual. In the site plan (1959), the deposits with individuals 2 and 3, 9 and 12, 18 and 23 seem to be somehow related, either by being buried simultaneously (18 and 23) or by being disturbed by a later inhumation (2 and 3; 9 after 12). However, the analysis does not support any of these hypotheses.

In the site plan (fig. 4.45), the features containing the remains of VR1959, Sks 2, 3 are in very close proximity and seem to overlap. In both features, the human remains are poorly preserved and an archaeothanatological analysis is not possible (table 4.53). Stratigraphically, the grave feature containing individual 3 (depth: 37 cm, layer 6: soft bedrock) seems to ante date the deposit with individual 2 which was found in an upper layer (depth: 15 cm, layer 2: grey soil with few shells). One hypothesis is that the disposal of VR1959, Sk2 had disturbed the grave of VR1959, Sk3, in a deeper layer. However, this does not seem to be the case when looking at the site profile, because grave 2 does not intersect with grave 3 (fig. 4.53).

Figure 4.53. Profile A–A', Vale de Romeiras, Sado valley. The close proximity and possible overlapping of the remains of VR1959, Sks 2, 3, as suggested by the observation of the site plan, is not confirmed in the site profile. The relation of these two burials remains ambiguous. Roman numerals: human remains. Letters: animal bones. (Adapted from a photograph by J. P. Ruas. MNA, 1959, D. Sousa, A120-detail)

Another hypothesis could be suggested by the relative completeness of VR1959, Sk3 in comparison to the sparse remains in the feature with VR1959, Sk2. This could indicate an older date for the latter, suggested by its disturbance at the time of the burial of VR1959, Sk3. However, the fragmentary state of VR1959, Sk2 could also be explained by its proximity to the top soil. Unfortunately, despite the suggestive reference in the site plan, the documentation is unclear and it is not possible to test any of these hypotheses.

This is also the case for the features VR1959, Sks 18, 23. In the site plan they seem to be placed in close proximity, suggesting a common arrangement. However, in the site profile, it is clear that is not the case. Stratigraphically, VR1959,
Sk23 was buried first. It was found at a depth of 84 cm at the time of the excavation (layer 6: soft bedrock) while VR1959, Sk18 was found at a depth of 54 cm (layer 4: yellowish soil), suggesting a later deposit (fig. 4.54).

Figure 4.54. Profile B–B’, Vale de Romeiras, Sado valley. The close proximity and possible overlapping of the remains of VR1959, Sks 18, 23 as suggested by the observation of the site plan is not confirmed in the site profile. Roman numerals: human remains. Letters: animal bones. (Adapted from a photograph by J. P. Ruas. MNA, 1959, D. Sousa, A120-detail)

VR1959, Sks 9, 12 are shown in the site plan as partially overlapping, which in this case, is also confirmed in the site profile (fig. 4.55). The graves were found in the same layer (6: soft bedrock), each containing the remains of an adult male overlapping at the level of the lower body. The analysis suggests that these features do not constitute a double burial, but separate events in time, possibly involving post-depositional manipulation of skeletal elements, which will be discussed further below. VR1959, Sk12 was the first to be deposited. At the time of the excavation this feature was found at a depth of 60 cm (layer 6). The remains are poorly preserved but the skeleton seems complete, articulated and undisturbed, except for the bones of the left lower limb which are all missing. VR1959, Sk9 was found lying on a sloping floor in layer 6 with the cranium at a depth of 43 cm and the pelvic girdle 20 cm lower, at a depth of 62 cm. According to the site plan, the lower body of VR1959, Sk9 lies in front of the lower body of VR1959, Sk12, at a depth of c 60 cm. Despite the overlapping, the disposal of VR1959, Sk9 does not seem to disturb VR1959, Sk12, and both individuals seem to maintain their anatomical integrity when they come in contact with each other, supporting the hypothesis of synchronous multiple deposit. However, the absence of the bones of the lower left limb of VR1959, Sk12 is a strong argument supporting the hypothesis of separate burial events, because the removal of these elements could only have happened after decomposition of most soft tissue and before the disposal of the second individual VR1959, Sk9.
Post-depositional manipulations of the cadavers

At Vale de Romeiras, the skeletons are apparently complete and lie undisturbed in the grave feature. In a few cases there is also evidence suggesting the post-depositional manipulation of the cadavers.

One case is documented by VR1959, Sk12 containing the remains of an adult male lying on the back with the upper limbs in extension placed laterally to the trunk, and the lower right limb hyperflexed at the level of the knee, folded backwards with the foot lying behind the buttocks (fig. 4.56). As discussed, despite the fragmentary state of this material, the skeleton seems to be complete, except for the bones of the lower left limb which are all absent. The general topography of the body indicates a burial in primary position, decomposed in a filled environment as suggested by the limited movement of the bones in the feature. The missing bones, the left femur, tibia, fibula, and possibly the patella and bones of the left foot, have been removed probably after the decomposition of the body in the grave. It seems unlikely that the absence of the whole lower limb could be explained by taphonomic processes such as preservation and/or animal activity. Despite the poor preservation of the bones in the feature, most elements are present and recognizable in the documentation, even if in a very fragmentary state, thus, it is unlikely that the strongest and most dense bones in the body, the femur and tibia, would decompose completely before all other elements. Also, it seems unlikely that an animal would completely remove these large bones without disturbing other elements in the feature. Accordingly, this case seems to suggest the re-opening of the grave and the human removal of the bones of the lower left limb, probably after decomposition of the soft tissues was advanced or completed.

As discussed, VR1959, Sk12 lies partially under VR1959, Sk9 (fig. 4.57). Interestingly, this latter feature (VR1959, Sk9) presents another case of post-depositional manipulation, which could be possibly be related to the removal of the lower left limb of the individual lying underneath (VR1959, Sk12). VR1959, Sk9 was lying on the back with the lower limbs in hyperflexion and rotated upwards (fig. 4.58). The overall arrangement of the bones indicates a general rotation towards the left side of the feature. The graphic documentation shows two long bones lying on the left side of VR1959, Sk9, in which direction the individual is rotated, suggesting a common arrangement. One of these bones is a human femur.
The other element is unclear but could be a tibia. These bones were found in the upper layer (2, greyish sand) and very close to VR1959, Sk9. The presence of these bones lying on the side of VR1959, Sk9 coincide with the missing long bones in VR1959, Sk12. Although it is not possible to be completely sure if these disarticulated elements belong to individual 12, it is suggestive that these have been removed and later (impossible to determine precisely when), individual 9 was buried, partially on top of 12, and the removed bones then were placed on the side of the new burial. This is a probable scenario; however, the correlation of the events is not possible to confirm.

Figure 4.56. VR1959, Sk12 contains the human remains of an adult male. Despite the poor preservation of the bone material, the skeleton seems complete, articulated and undisturbed, except for the bones of the lower left limb which are all missing, possibly due to the post-depositional manipulation of the cadaver. (MNA, 1959, D. Sousa)
Figure 4.57. Detail of the site plan of VR1959, Sks 9, 12, showing disarticulated long bones on the left side of Sk9. (MNA, 1959, D. Sousa, A120-detail)

Figure 4.58. VR1959, Sk9 and disarticulated long bones (one femur, and one tibia?) on his left side. (MNA, 1959, D. Sousa)
Other cases are less clear and difficult to describe due to the unclear nature of the documentation. Fragments of unidentifiable disarticulated long bones are found close to the features VR1959, Sks 4, 10, apparently in the same layer, but association with the burial deposits is not possible to define. Nothing suggests a common arrangement of the burial feature or a deliberate post-depositional manipulation of the foreign bones. These disarticulated elements could belong to a disturbed burial, such as VR1959, Sks 2, 3. Likewise, VR1959, Sk13 contains a few bone elements found at the level of the lower limbs, possibly foreign to the feature (fig. 4.59).

![Figure 4.59. VR1959, Sk13.](image)

The deposit is poorly preserved and the analysis is limited. Although none of the diagnostic criteria are preserved, there is no clear indication of movements outside of the initial volume of the body, suggesting a primary deposit in a filled space of decomposition. In this scenario, this concentration of foreign skeletal elements could be explained by the presence of a previous human burial in the same location, and the possible post-depositional manipulation of bone elements would be in this case difficult to assert. Furthermore, the cranium of VR1959, Sk13 is not
present, possibly due to preservation. A few fragments are visible from what seems to be the remains of the maxilla invalidating the hypothesis of intentional removal of the cranium. The poor preservation of this feature could be explained by surface disturbance, as this deposit was excavated at a depth of 10 cm from the modern surface (fig. 4.55).

One other feature in the same area as VR1959, Sk13 seems to suggest the manipulation of cranial elements, however, this hypothesis should be viewed with caution due to the fragmentary nature of the documentation, and could likewise be the result of taphonomic causes. This is the case of VR1959, Sk1 whose skull (cranium and mandible) was not found in the grave feature (fig. 4.60).

![Figure 4.60. VR1959, Sk1. The cranium and mandible are not in the feature. (MNA, 1959, D. Sousa)](image)

The postcranial skeleton is apparently complete, articulated and undisturbed. This individual was recovered close to the current top layer of the site, c 20 cm deep, which could explain the disturbance of the feature. The absence of the cranium and mandible could also be explained by a deliberate act involving the re-opening of the grave and removal of these elements, sometime after the break down of the labile cervical joints. It is also possible that the individual was buried without the head, which could be demonstrated by traces of trauma at the level of the cervical vertebrae. Unfortunately, all these scenarios remain as working hypotheses, and are not possible to test with the current documentation.
As discussed throughout this section, at Vale de Romeiras, several burials are poorly preserved and the possible disturbance of the features, taphonomic or deliberate, is difficult to determine. However, in most cases, rather than the result of post-depositional manipulations of the cadavers, the disturbance of the graves can be explained by the original and/or current proximity to the surface of the site, rendering the skeletons more vulnerable to taphonomic agents. That seems to be the case of VR1959, Sk2 (depth: 15 cm) which is not just poorly preserved, but possibly disturbed, and several skeletal elements are missing. The scenario of reopening of the grave, for the deliberate removal of selected bones is not possible to demonstrate. The reduction of the feature to accommodate new deposits is another possible explanation. Nevertheless, this does not seem to be the case, because the burials found in the same area (VR1959, Sks 4, 3, 7) are well aligned in a deeper level at a depth of c 35 cm (Sks 3, 7) and 50 cm (Sk4), and as discussed above, VR1959, Sk2 seems to be a later interment, thus not disturbed by any of these deposits, which excludes the possibility of a case of reduction of VR1959, Sk2. Likewise, VR1959, Sk5 (fig. 4.51), found 18 cm deep, lies in close proximity to other burials (VR1959, Sks 1, 14) but it is not disturbed by them. Again, its fragmentation and partial preservation can be explained by its close proximity to the surface of the site as well as by the probable greater decomposition activity, increased by the inclusion of perishable material placed in front of the body, as discussed above. In any case, the possibility of post-depositional manipulation of the cadaver is not demonstrated.

Other observations

Animal bones

At Vale de Romeiras, several concentrations of animal bones have been found. These concentrations consist of apparently disarticulated bones, and the nature of these deposits is unknown. It is possible that some of these elements were deposited or discarded in articulated state and intentionally buried, but the material is fragmented and the documentation is unclear. Some of the concentrations of animal bones lie in close proximity to the features with human remains.

Only the case of VR1959, Sk1 and the animal group h are recorded in the same layer (4) and depth (48 cm) (fig. 4.54). It is unclear if these are simultaneous deposits and there is no evidence for a common arrangement of the features. Unfortunately, the documentation is very limited at this level and it is impossible to determine a relationship between the features with human remains and the deposits with animal bones.

Other burials

VR1959, Sk8 is $^{14}$C dated to the early modern period in Europe with a calibrated date range of 1445–1632 cal CE (95% confidence), and for this reason it was not included in the general analysis.
The deposit contains the remains of a child of 3 to 4 yrs ± 12 months in primary position, as suggested by the maintenance of the general anatomical integrity of the body (fig. 4.61). The material is poorly preserved but there is no evidence for movement outside the initial volume of the cadaver, suggesting a filled space of decomposition. The child was lying on the left side with the upper limbs in extension placed in front of the body and the lower limbs in flexion at the level of the knees and rotated to the left. The body was placed in a small pit but wide enough to contain the body in a natural and unforced position, which has not been observed in any other burial at Vale de Romeiras. Although the material is fragmented the analysis did not indicate any particular pressures on the body in the feature. An unidentified flat bone lies at the distal end of the left forearm of the child. The bone does not seem to belong to the skeleton of this individual and it is also unclear if the bone is human. Unfortunately the limited documentation does not allow a further observation.

*Figure 4.61. VR1959, Sk8. Grave feature with the remains of a 3–4 yrs ± 12 months child buried in the centre of the burial area in the second layer (grey soil with shells) at a depth of 35 cm from the modern surface. ¹⁴C measurements on a tibia revealed a surprisingly modern date with a calibrated date range of 1445–1632 cal CE (95% confidence). (MNA, 1959, D. Sousa)*
The mortuary programme at Vale de Romeiras

At Vale de Romeiras, bone preservation is relatively poor and in several cases the diagnostic criteria are not preserved and/or are unclear in the documentation. Nevertheless, the archaeothanatological analysis indicates a strong similarity of burial practices observed at the site and the minor detected variations do not affect the overall pattern of the treatment of the dead. The bodies were normally laid in small pits in contracted positions, with the limbs nested on the upper body, and with the feet forced towards the buttocks. In several cases this pattern was enhanced during decomposition and the skeletons become hypercontracted.

While the tables presented above may be consulted for the diagnostic criteria and arguments of analysis, I have chosen to describe VR1959, Sks 11, 7 which I consider representative of the practices at Vale de Romeiras. VR1959, Sks 19, 23 are also further described, as these burials present variations to the common practice and reveal striking elements from an archaeothanatological perspective. The selection of the burials for description was constrained to those graves whose remains are relatively well preserved and hold sufficient documentation for consistent argumentation.

VR1959, Sk11

VR1959, Sk11 consisting of the remains of an adult female is particularly well documented by graphic documentation (fig. 4.62). This case combines several common elements observed in the burials at Vale de Romeiras. The cadaver was laid on its back in a small pit with a sloping floor (fig. 4.54), possibly slightly more elevated at the superior right side of the feature. The head was rotated to the left and was the most elevated body part in the feature; hence the closest body part to the surface of the grave. The upper limbs were flexed at the elbows and the hands were placed in front of the abdomen, with the right hand lying in front and below the left hand. The lower limbs were flexed at the level of the hips and hyperflexed at the knees, rotated upwards towards the upper body, with a tendency towards the right side. The feet were positioned medially in front of each other while placed towards the buttocks.

There were two main pressures on the body in the feature. One was a lateral pressure visible in the alignment of the upper left limb, affecting the left clavicle and humerus. While the left scapula is not visible in the documentation, there is a clear verticalization of the left clavicle, and projection forwards and upwards of the left humerus which is rotated inwards lying very close to the thoracic cage. This alignment is explained by a wall-effect on the left side of the feature, accentuated by the sloping floor of the grave, slightly more elevated on the superior right side, causing a transfer of body weight towards the left side. While the cadaver slowly slid to the left, the right shoulder girdle stayed behind and the right scapula became exposed between the humerus and thoracic cage.
Figure 4.62. VR1959, Sk11 is representative of a typical grave feature at Vale de Romeiras, Sado valley. Normally, the cadavers were laid on their backs in small pits with sloping floors. The upper limbs were placed close to the upper body and the lower limbs were clumped together, typically flexed at the level of the hips and hyperflexed at the knees, rotated upwards towards the upper body. The feet were positioned medially and placed towards the buttocks (MNA, 1959, D. Sousa, B42)
Results: Sado valley, Vale de Romeiras

The second main pressure observed is not only a strong lateral pressure exerted on the body, but also the evidence for significant constraint effects. The lateral pressure and wall-effect at the lower end of the feature is visible in the alignment and clumping of the lower limbs including both feet. This wall-effect corresponded to the physical limits of the pit, and its impact was increased by the sloping bottom, lower at the level of the pelvic girdle, enhancing the nesting of the lower body. The pressures observed are the result of the design of the grave feature. This contraction, affecting the lower limbs in particular, is a typical trait observed at Vale de Romeiras. In several cases, this pattern is enhanced during decomposition and the skeleton becomes hypercontracted.

VR1959, Sk7

VR1959, Sk7 is illustrative of a hypercontracted skeleton. This burial is relatively well preserved and the documentation, although limited, allows a more in depth observation of these typical features at Vale de Romeiras (fig. 4.63).

In this case as well, the cadaver was laid on its back in a small pit with a moderate sloping floor. The head is poorly preserved but the analysis suggests that the head was the most elevated body part in the feature and the closest body part to the surface of the grave (fig. 4.53).

The right upper limb was placed in semi-flexion at the level of the elbow in c 90 degrees with the forearm laid in front of the trunk. The left upper limb was placed in semi-flexion with the left hand lying on the pelvic region towards the right thigh.

The lower limbs were hyperflexed at the level of the hips and knees, rotated upwards, and placed in adduction in front of the trunk, with a slight tendency towards the left side of the feature.

Two main pressures bore down on the body. One was the wall-effect on the right side of the feature, visible in the alignment and projection forwards of the right upper limb, involving the right shoulder girdle and the arm. The second main pressure, is similar to what has been observed in the previously described feature (VR1959, Sk11), indicating strong lateral pressure on the body, and significant constraint effects. The lateral pressure and a wall-effect at the lower end and left side of the feature are visible in the alignment and clumping of the lower limbs including both feet. This wall-effect corresponds to the physical limits of the pit, just big enough to contain the individual. This pattern was enhanced during decomposition by the penetration of fluid sediment which progressively closed the angles between the skeletal segments, causing a contracted position to become a hypercontracted skeleton. The pressures observed are the result of the grave design, although as discussed above, the possibility of wrapping cannot be excluded, but the data is not conclusive.
VR1959, Sk23

VR1959, Sk23 is another example of a hypercontracted skeleton, but in this case the burial position is noted as unusual at Vale de Romeiras. Unfortunately, the feature contains poorly preserved remains and the analysis is limited. However, it is possible to advance some observations.

The striking element of this feature is presented by the unusual position of the lower limbs. Like the typical burials at Vale de Romeiras, VR1959, Sk23 was placed
on the back with the upper limbs in hyperflexion rotated towards the upper body. In this case, however, the limbs were lying apart, at each lateral side, leaving the trunk completely exposed. The grave feature containing the cadaver seems to have been smaller than usual. According to the notes in the field drawing, the maximum length occupied by the skeleton at the time of excavation was c 49 cm and the maximum width c 32 cm. These atypical features constitute a burial feature that resembles a square grave, which could be called a square shaped burial (fig. 4.64).

Figure 4.64. VR1959, Sk23 is another example of a hypercontracted skeleton although placed in an atypical square shaped burial position. (MNA, 1959, D. Sousa)

The pit was possibly slightly more elevated at the superior end of the feature as noted by the rotation of the head to the right and downwards, towards the body in the feature. This movement could be explained if the cranium was suspended over what would become a void by the liberation of space during decomposition in the thoracic cage. A moderate slope elevation would have had an impact on the
collapse forwards and the pressure of the sediment would have accentuated this movement.

The thoracic skeleton is only partially preserved. The few ribs observable are displaced and rotated downwards but their lateralization is not possible to determine. A few bone fragments are found lying in the region of the thoracic cage but the documentation does not allow further observation.

The bones of the upper limbs are only partially exposed and are covered by the bones of the lower limbs, particularly at the level of the shoulder girdles and arms. The arms were lying laterally to the trunk and the forearms were crossed in front of the abdomen with the right hand placed towards the left hip and the left hand towards the right hip. The left forearm was placed in front of the right forearm. The bones of the hands are not visible in the documentation possibly due to poor preservation. Like the bones of the hands, the bones of the feet are not visible in the documentation possibly due to poor preservation.

The analysis suggests an overall lateral pressure exerted on the body, and a general wall-effect from all sides of the pit. These pressures are visible in the extremely constrained and hyperflexed position of the skeleton, which is particularly striking at the level of the lower limbs. This overall wall-effect corresponds to the physical limits of the pit and the pressures observed are the result of the almost square design of the grave.

**VR1959, Sk19**

VR1959, Sk19, presents the exception to the nesting of the lower limbs on the upper body. This grave is somewhat eccentric to the main burial area, and is also the oldest burial known at the site. The feature contains the remains of a poorly preserved skeleton of an adult female, and presents all general elements of the burials known at Vale de Romeiras. The cadaver was placed on its back on a sloping floor, with the head rotated forwards and downwards towards the upper body. The upper limbs were placed close to the body lying in almost complete extension laterally to the trunk. The lower limbs were placed clumped together with the feet towards the buttocks as normally observed at this site. However, in this case, the lower limbs are not rotated towards the upper body, but folded backwards, in such a way that the knees were directed downwards and the legs would lie under the thighs while the feet were placed under the buttocks. Interestingly, this unusual position of the lower limbs is somewhat similar to one case observed at Cabeço das Amoreiras (CAMS1958, Sk7), and to a certain extent is also similar to VR1959, Sk12 previously discussed for its missing lower limb (fig. 4.65).
Figure 4.65. This illustration presents the key elements observed in two burials at Vale de Romeiras (12, 19) and one at Cabeço das Amoreiras (7). The distinctive trait of these burials is presented by the unusual position of the lower limbs, which were in extension at the hips and hyperflexion at the knees; and while the knees were rotated downwards the feet were directed upwards and placed towards the buttocks. These burials share most general characteristics found in other features, such as the placement of the body on its back in a small pit with a sloping floor. (Drawing by Susanna Berglund)
The mortuary programme at Vale de Romeiras is consistent and homogeneous, as suggested by the archaeothanatological analysis.

The cadavers were typically placed in individual grave features while retaining their anatomical integrity (individual primary deposits). The feature was then immediately covered with sediment providing a filled space of decomposition. In many cases the analysis is limited due to the poor preservation of the archaeological material, but, in most cases the remains provide satisfactory indicators to support these conclusions.

The cadaver was normally laid on the back, and in just a few cases the body was placed on the lateral left side. The arrangement of the upper limbs was variable but they were always placed close to the body. The lower limbs were consistently placed in forced positions, flexed or hyperflexed at the hips and knees, rotated towards the trunk or towards the right or left side. The clumping of the body was common. The limbs were nested on the upper body and the feet always placed towards the buttocks (fig. 4.66). The floor of the graves tended to be uneven and sloping. In these cases, the head of the cadaver was often rotated forwards and downwards towards the body in the feature. The physical limits of the pit had a significant impact on the final arrangement of the body in the feature and the wall-effects and consequent pressures, visible by the contracted and hypercontracted position of most skeletons can be explained as the result of the design of the grave feature.

Few cases present deviant elements, but these are exceptional instances of features with, for example, possible perishable elements inserted behind or in front of the body, rare post-depositional manipulations of the cadaver, or the atypical initial position of the cadaver in the grave. Despite the striking and unusual elements, all these cases follow the common core characteristics of burial practices observed at Vale de Romeiras.
Figure 4.66. This illustration presents several typical elements observed in the burials at Vale de Romeiras. The cadavers were normally laid on the back with the limbs nested on the upper body. The lower limbs were consistently placed in forced positions, flexed or hyper-flexed at the hips and knees, rotated towards the trunk or towards the right or left side. The floor of the graves tended to be uneven and sloping. The head of the cadaver was often rotated forwards and downwards towards the body. The physical limits of the pit had a significant impact on the final arrangement of the body in the feature. The wall-effects and consequent pressures are visible in the contracted and hypercontracted position of most skeletons and can be explained as the result of the design of the graves. (Drawing by Susanna Berglund)
Sado valley: Cabeço do Pez

Site background: a short history of research

Cabeço do Pez (also known as Quinta de Baixo) is a shell midden site located on the eastern part of the Sado valley (fig. 2.3). It is situated on the right margin of the river Sado at 57 m.a.s.l. (Diniz et al. 2012), on a hilltop next to Vale de Romeiras, with good visibility over the river. Cabeço do Pez is one of the largest sites known at the Sado valley and it has the highest number of human burials.

Archaeological material and documentation available for Cabeço do Pez are curated at the National Museum of Archaeology in Lisbon (MNA). The site was identified in the 1930s (Barradas 1936). According to the documentation it was excavated only 20 years later in 1956 and 1958–59 by the staff of MNA. The site plans indicate the excavation of 27 individuals in 1956 and two individuals in 1959. However, the anthropological analysis indicates the excavation of a minimum number of individuals between 32 and 36 (Cunha and Umbelino 1995–97) (table 4.58). The burial population consists of 26 adults (seven females, six males, ten indeterminate), six of which are young adults under 30 years old (Cunha et al. 2002, 191). Among the non-adults (n=6) two are aged between 1 to 2 years old, and one is under 1 year old (Cunha et al. 2002, 191). Small scale excavations took place in 1983 (Arnaud 1986) and 2010 (Arias et al. 2015) but no human remains were found.

Table 4.58. Cabeço do Pez, Sado valley: minimum number of individual (MNI) estimated for the material curated at MNA.

<table>
<thead>
<tr>
<th>MNI</th>
<th>Adults</th>
<th>Non-adults</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂♀</td>
<td>7 6</td>
<td>13</td>
<td>Cunha and Umbelino 1995–97</td>
</tr>
<tr>
<td>32–36</td>
<td>26</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

The following table (table 4.59), courtesy of one of the anthropologists who studied this material in detail (Umbelino 1999), is the reference material used in this study regarding sex and age estimates for Cabeço do Pez.

Skeletal preservation at Cabeço do Pez is generally poor. Eight individuals are preserved or partially preserved in blocks of paraffin wax (CP1956, Sks 2, 9, 10, 11, 17, 21, 27; CP1959, Sk2) while the remaining skeletons are in disarticulated state sorted in containers.

Graphic documentation is very limited and previous authors have commented on the lack of field drawings available for this site (Umbelino 2006, 144). The individuals excavated in 1956 are documented in one site plan (MNA, 1956, A. Paiva) which shows two main areas with human burials (trenches A, B), and the position of the skeletons represented in a simple manner (fig. 4.67).
Table 4.59. *Cabeço do Pez, Sado valley: sex and age estimates of 20 individuals.* (Data from Cunha and Umbelino 1995–97, 2001; Umbelino 1999)

<table>
<thead>
<tr>
<th>Individual</th>
<th>Container</th>
<th>Age</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6258</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>3</td>
<td>6256</td>
<td>Adult</td>
<td>♀</td>
</tr>
<tr>
<td>4</td>
<td>6257</td>
<td>Adult, young</td>
<td>♀</td>
</tr>
<tr>
<td>5</td>
<td>6249</td>
<td>Adult, mature</td>
<td>♀</td>
</tr>
<tr>
<td>6</td>
<td>6247</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>8</td>
<td>6243</td>
<td>Adult, young</td>
<td>♀</td>
</tr>
<tr>
<td>13</td>
<td>6250</td>
<td>15–23 yrs</td>
<td>♂</td>
</tr>
<tr>
<td>14</td>
<td>6241A</td>
<td>Adult</td>
<td>♀?</td>
</tr>
<tr>
<td>16</td>
<td>6247-16</td>
<td>Adult</td>
<td>♂</td>
</tr>
<tr>
<td>19</td>
<td>6255</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>20</td>
<td>6247A</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>22</td>
<td>6247A</td>
<td>Adult</td>
<td>♀?</td>
</tr>
<tr>
<td>24</td>
<td>6240</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>25</td>
<td>6240</td>
<td>Adult, mature</td>
<td>♂</td>
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<tr>
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<td>n/d</td>
</tr>
<tr>
<td>27</td>
<td>6234</td>
<td>Adult</td>
<td>♂</td>
</tr>
<tr>
<td>15(♀?)</td>
<td>6242</td>
<td>3 individuals:</td>
<td>♀ (adult)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adult</td>
<td>♀</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-adults, 6–9 yrs; 10–11 yrs±30 m.</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>–</td>
<td>Adult</td>
<td>♀?</td>
</tr>
</tbody>
</table>

The two individuals excavated in 1959 are documented in individual sketches (MNA, 1959, D. Sousa) (fig. 4.68). The final drawings are missing from the archives of MNA, but their existence is known by a publication in 1974 (Santos et al. 1974). Other drawings consist of one plan with the topography of the site (MNA, 1956, A. Paiva, A10), a plan with a detail of a pit structure in stone of unknown chronology (MNA, 1956, A. Paiva, A11), and several sketches from 1958–59 showing excavation trenches and grids, profiles, as well as concentrations of faunal remains (MNA, D. Sousa). Like the individual skeleton drawings, the final versions of the site plans from 1958–59 are not in the archives of MNA and their existence is known only from the same article (Santos et al. 1974).

Archives of photography of Cabeço do Pez consist of 90 photographs from 1957 and 1958 (MNA, APMH, 2/11/61). However, the human remains were excavated in 1956 and 1959 and the archive does not contain photographs from these field seasons. Several photographs, poorly preserved, were taken in 1950, labelled under the name of Quinta de Baixo (MNA, APMH, 2/11/60), which is the name by which Cabeço do Pez used to be known. These early photographs do not indicate excavation work at the time, and were possibly taken during the first surveys of the area.
Figure 4.67. Cabeço do Pez, Sado valley: site plan of the areas excavated in 1956. (Adapted from a photograph by J. P. Ruas. MNA, 1956, A. Paiva)
Results: Sado valley, Cabeço do Pez

Written documentation consists of diary reports from 1958 and 1959. Unfortunately, several pages are missing from the documents and the reports are incomplete. In the documentation from 1959 (Cabeço do Pez, 23 May to 25 July 1959, MNA, APMH, 2/3/7/3, pp. 1–28) J. Roldão describes briefly the excavation of one skeleton in layer 2. It was identified on the 1st of June 1959 but excavated almost two months later (20–24 July 1959). The skeleton was found in the limits of the trench in one of the baulks of the grid system. The site plan for this year shows a second area with the human remains of a second individual, but these are not described in the available documents. The field sketch shows that the skeletal material was poorly preserved and fragmentary. In his notes, J. Roldão highlights the identification of several areas related to fire activity, which he identifies as ashes or hearths (cinzeiros and lares). One of these is described as very large, 200 cm x 120 cm, with a depth of 10 to 15 cm (diary entry, 23 June 1959). He also describes
recovering a great quantity of tiny sea snails (*Trivia monacha*) almost every day, most of them concentrated in particular areas. The exact location of the fire activities and the pockets of small sea snails are difficult to reconstruct, and a correlation with the human remains is not possible to determine.

Stratigraphic documentation of the individuals excavated in 1956 is limited. According to the site profiles, most skeletons were recovered from the sand layer on top of the bedrock. Not all skeletons are represented in the site profiles and their stratigraphic location remains unclear. The basal sand layer, where apparently most skeletons were found, is covered by a relatively thick layer (c 25 cm) described as dark brown soil with shells, hearths and ashes (*terra castanha escura; conchas, lares e cinzas*). This dark layer with fire activity is covered by the top soil. The two individuals recovered in 1959 were excavated from this dark layer with shells described as layer 2. CP1959, Sk1 was recovered at a depth of c 80 cm while CP1959, Sk2, apparently in the same layer, was recovered closer to the surface at c 18–35 cm deep.

**Chronology of the burial activity**

**Previous ¹⁴C measurements**

Four ¹⁴C measurements are available on non-human samples (table A12). Unfortunately, not all are usable due to the nature of the samples and to the incomplete published data. This is the case for a measurement made on a conglomerate of shell and charcoal (Q–2498, Arnaud 1989, 619) which makes it impossible to securely calibrate. Also, a measurement on animal bone (Q–2499, Arnaud 1989), which unknown δ¹³C is not possible to securely calibrate with the terrestrial curve only.

The first two measurements on human bone from Cabeço do Pez (Sac–1558 and Beta–125109) were carried out in the late 1990s (Cunha and Umbelino 2001) both collected from CP1956, Sk4. However, both δ¹³C values published along with the ¹⁴C dates were obtained by AMS (Cláudia Umbelino, pers. comm.) which cannot be used for dietary reconstructions or reservoir corrections (Millard 2014, 557; Taylor and Bar-Yosef 2014, 117), and these ¹⁴C measurements have to be excluded until IRMS-based δ¹³C values are available.

**Objectives of the dating programme**

Cabeço do Pez is a large site with at least two main areas of burial activity (trenches A, B) (fig. 4.67). Before this radiocarbon dating programme, one human skeleton (CP1956, Sk4) was directly dated but with problematic calibration. Previous measurements on non-human samples (Q–2496 and Q–2497) suggested a relatively more recent use than most shell middens in the valley. Cabeço das Amoreiras also presented slightly more recent dates on non-human samples (Q–AM85B2a and Q–AM85B2b).
The general aims of the dating programme for Cabeço do Pez followed the macro-goals of the radiocarbon programme of this dissertation, outlined in chapter 3, and were:

- to define when the burial activity started and when it ended;
- to estimate the duration of the use of this site for burial activity;
- to estimate the frequency of the burial activity in the site.

The site-specific aims of the dating programme for Cabeço do Pez were:

- to define the temporal relation between the two main burial areas (areas A, B);
- to define the temporal relation between the apparently isolated burials (CP1956, Sks1, 2) and the two main burial areas.

**Sampling strategy**

Five samples of human bone were selected for $^{14}$C analysis (table 4.60). The sampling strategy was targeted towards a good spatial coverage of the material excavated in 1956.

<table>
<thead>
<tr>
<th>Ind. Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Site plan</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Ua–46930</td>
<td>Non-adult, 1.5–2 yrs</td>
<td>n/d</td>
<td>Long bone</td>
<td>T. B (isolated)</td>
<td>Previous stable isotope analysis of a fibula (Fontanals-Coll et al. 2014)</td>
</tr>
<tr>
<td>5 Ua–46931</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Tibia</td>
<td>999.77.92</td>
<td>T. A –</td>
</tr>
<tr>
<td>9 Ua–46932</td>
<td>Adult n/d</td>
<td></td>
<td>Fibula</td>
<td>T. B</td>
<td>Previous stable isotope analysis of a rib (Fontanals-Coll et al. 2014)</td>
</tr>
<tr>
<td>11 Ua–46933</td>
<td>Adult ♂</td>
<td></td>
<td>Long bone</td>
<td>T. B</td>
<td>–</td>
</tr>
<tr>
<td>27 Ua–46934</td>
<td>Adult ♂</td>
<td></td>
<td>Humerus–R</td>
<td>T. A</td>
<td>Previous stable isotope analysis of a long bone (Umbelino 2006) and a humerus (Fontanals-Coll et al. 2014)</td>
</tr>
</tbody>
</table>

**Results**

Seven $^{14}$C measurements on human bone collagen samples from Cabeço do Pez are available now (table 4.61), two of which (Beta–125109 and Sac–1558, CP1956, Sk4) have a problematic calibration and were excluded from the present study (see chapter 3, Reliability of isotopic measurements).
Table 4.61. Human bone collagen samples (5) from Cabeço do Pez, Sado valley: $^{14}$C measurements and estimation of non-terrestrial carbon intake (% marine). Samples are sorted so that the lowest marine percentage is on top of the table. Marine percentage was estimated from the measured $\delta^{13}$C value of each sample by the application of method marine 1 and method marine 2, based on adopted endpoint values of −12‰ and −20‰ for marine (100%) and terrestrial (100%) diets respectively.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements</th>
<th>% marine (±10)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind. Excav. Museum</td>
<td>$^{14}$C by AMS; $\delta^{13}$C and $\delta^{15}$N by IRMS</td>
<td>Lab no.</td>
<td>Age BP</td>
</tr>
<tr>
<td>11</td>
<td>1956</td>
<td>MNA</td>
<td>Ua–46933</td>
</tr>
<tr>
<td>9</td>
<td>1956</td>
<td>MNA</td>
<td>Ua–46932</td>
</tr>
<tr>
<td>27</td>
<td>1956</td>
<td>MNA</td>
<td>Ua–46934</td>
</tr>
<tr>
<td>2</td>
<td>1956</td>
<td>MNA</td>
<td>Ua–46930</td>
</tr>
<tr>
<td>5</td>
<td>1956</td>
<td>MNA</td>
<td>Ua–46931</td>
</tr>
</tbody>
</table>

Calibration and chronological models

The chronological model was built on five $^{14}$C dates, all obtained in the scope of this study (fig. 4.69, table 4.62).

This is a phase model which groups all dated burial events in a phase of burial activity (Bronk Ramsey 1998, 2000, 2001). This grouping is constrained by a start of burial activity event, and an end of burial activity event (i.e., boundaries) imposing no internal constraints to the relative order of the dated events. All it assumes is that the start event occurs before the dated events, and that these all occur before the end event. For the command files defined for this model see appendix.

Internal consistency and reliability of the model

Agreement index (A) for each dated event is high (A≥60%). The model shows high overall agreement (Marine 1: $A_{\text{overall}}$=107.4%, Marine 2: $A_{\text{overall}}$=100.8%), which indicates that the $^{14}$C dates are in accordance with the prior information incorporated in the model. The index of convergence (C) is good (≥96%).

The results obtained when running the model with the different marine values (M1, M2) are statistically insignificant. For this reason, all further observations and graphic presentation are based on the results obtained with the model run with the values of M1. The results obtained with M2 are presented in the tables (table 4.62).

The chronological model for Cabeço do Pez, calibrated with M1 values, estimates the start of the burial activity to have been in 6909–5626 cal BCE (95.4% probability; start of burial activity) (figs. 4.70, 4.71, table 4.63), and its end to have been in 4471–3170 cal BCE (95.4% probability; end of burial activity) (figs. 4.70, 4.72, table 4.63). The burial activity is estimated to have continued for between 1192 and 1412...
Results: Sado valley, Cabeço do Pez

years (95% probability: site use for burial activity), or for 1246 and 1359 years (68% probability) (table 4.63, fig. 4.73). However, the posterior density estimated for the duration of burial activity at Cabeço do Pez, calculated without CP1956, Sk2, which date is coeval with Middle Neolithic groups in Portugal (Ua–46930), is between 0 and 123 years (95.4% probability), or 0 and 58 years (68.2% probability). The latter chronological model is discussed in chapter 5.

Figure 4.69. Chronological model for the burial activity at Cabeço do Pez, calibrated using marine 1 diet values. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, Sado valley, Cabeço do Pez, Model 1, Marine 1.

Figure 4.70. Start and End of burial activity at Cabeço do Pez derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is 6909–5626 cal BCE (95% probability) or 6028–5658 cal BCE (68% probability). Posterior density estimated for the end of the burial activity is 4471–3170 cal BCE (95% probability) or 4430–4038 cal BCE (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.
Table 4.62. Human bone collagen samples (5) from Cabeço do Pez, Sado valley: calibrated date ranges according to two different approaches for the calculation of the marine percentage. Results are presented in both (a) cal BCE and (b) cal BP in 95.4% confidence range. The calibrated date ranges are probability distributions derived from scientific dating alone. The posterior density estimates (in italic) are derived from Bayesian modelling. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>(^{14}C) Age BP</th>
<th>Calibrated date range (95% confidence)</th>
<th>Posterior density estimate (95% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unmodelled cal BCE, M1</td>
<td>Modelled cal BCE, M1</td>
</tr>
<tr>
<td>2</td>
<td>Ua–46930</td>
<td>5579±41</td>
<td>4466–4246</td>
<td>4461–4266</td>
</tr>
<tr>
<td>27</td>
<td>Ua–46934</td>
<td>6734±51</td>
<td>5713–5496</td>
<td>5705–5510</td>
</tr>
<tr>
<td>5</td>
<td>Ua–46931</td>
<td>6791±43</td>
<td>5727–5509</td>
<td>5711–5536</td>
</tr>
<tr>
<td>11</td>
<td>Ua–46933</td>
<td>6788±46</td>
<td>5746–5563</td>
<td>5733–5566</td>
</tr>
<tr>
<td>9</td>
<td>Ua–46932</td>
<td>6780±48</td>
<td>5733–5543</td>
<td>5726–5552</td>
</tr>
</tbody>
</table>

(b) Cal BP

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>(^{14}C) Age BP</th>
<th>Calibrated date range (95% confidence)</th>
<th>Posterior density estimate (95% probability)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unmodelled cal BP, M1</td>
<td>Modelled cal BP, M1</td>
</tr>
<tr>
<td>2</td>
<td>Ua–46930</td>
<td>5579±41</td>
<td>6415–6195</td>
<td>6410–6215</td>
</tr>
<tr>
<td>27</td>
<td>Ua–46934</td>
<td>6734±51</td>
<td>7662–7445</td>
<td>7654–7459</td>
</tr>
<tr>
<td>5</td>
<td>Ua–46931</td>
<td>6791±43</td>
<td>7676–7458</td>
<td>7660–7485</td>
</tr>
<tr>
<td>11</td>
<td>Ua–46933</td>
<td>6788±46</td>
<td>7695–7512</td>
<td>7682–7515</td>
</tr>
<tr>
<td>9</td>
<td>Ua–46932</td>
<td>6780±48</td>
<td>7682–7492</td>
<td>7675–7501</td>
</tr>
</tbody>
</table>

Table 4.63. Posterior density estimates for the dates of archaeological events (Start/End) and the duration of burial activity at Cabeço do Pez. Data derived from model described in fig. 4.69

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Modelled cal BCE, M1</th>
<th>Modelled cal BCE, M2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Posterior density estimate (68% probability)</td>
<td>Posterior density estimate (95% probability)</td>
</tr>
<tr>
<td>Start of burial activity</td>
<td>6028–5658</td>
<td>6020–5656</td>
</tr>
<tr>
<td>End of burial activity</td>
<td>4430–4038</td>
<td>4438–4058</td>
</tr>
<tr>
<td>Span of burial activity, duration</td>
<td>1246–1359 yrs</td>
<td>1229–1334 yrs</td>
</tr>
<tr>
<td>Overall model agreement (Aoverall)</td>
<td>107.4%</td>
<td>103.1%</td>
</tr>
</tbody>
</table>
Results: Sado valley, Cabeço do Pez

Figure 4.71. Start of burial activity at Cabeço do Pez derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is 6824–5626 cal BCE (95.1% probability) or 6017–5658 cal BCE (67.7% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Figure 4.72. End of burial activity at Cabeço do Pez derived from the chronological model, calibrated with values for marine 1 diet. Posterior density estimated for the end of the burial activity is 4471–3170 cal BCE (95.4% probability) or 4430–4038 cal BCE (68.2% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.
Stable isotopes: carbon and nitrogen

Previous measurements: δ^{13}C and δ^{15}N

In the early 2000s, one sample (CP1956, Sk27) was analysed in the scope of a palaeodietary study (Umbelino 2006). These analyses were done at the McMaster University in Canada and the precision of the results are ± 0.1‰ for δ^{13}C and ± 0.2‰ for δ^{15}N (Umbelino 2006, 208–209). The C:N ratios were not provided but the laboratory confirmed the quality of the collagen and of the measurements (Umbelino 2006, 315).

The δ^{13}C values published for CP1956, Sk4 (Sac–1558 and Beta–125109) along with its 14C dates (Cunha and Umbelino 2001) were obtained via AMS and not by IRSM (Cláudia Umbelino, pers. comm.). These samples were not included in Umbelino’s palaeodietary study (2006), and as previously discussed these should not be used for dietary reconstructions and/or reservoir corrections.

Recently, two teams sampled this assemblage for stable isotope analysis of carbon and nitrogen (Fontanals-Coll et al. 2014; Guiry et al. 2015). M. Fontanals-Coll and colleagues (2014) analysed nine samples at Biological Anthropology Department at the Universitat Autònoma de Barcelona, and duplicate measurements were taken in the laboratories of the Institute of Environmental Science and Technology at the same university. The analytical error is below 0.2‰ for both δ^{13}C and δ^{15}N. Two of these samples (individuals 10, 3A) did not yield enough collagen for analysis (Fontanals-Coll et al. 2014).
E. Guiry and colleagues (2015) obtained 14 reliable measurements (table 4.64) from a total of 16 samples. This material was measured on a Thermo-Finnigan Delta Plus XL isotope ratio mass spectrometer coupled via continuous flow to a Carlo Erba elemental analyzer at the Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany. The instrumental error for $\delta^{13}C$ and $\delta^{15}N$ measurements was $\pm 0.1\%$ and $\pm 0.2\%$, respectively (Guiry et al. 2015).

All previous measurements were included in this study ($n=22$) (table 4.64; fig. 4.74) as long as they fell within the accepted quality ranges as discussed.

**Sampling strategy**

In this study, the selection of samples of human remains for $\delta^{13}C$ and $\delta^{15}N$ measurements was fully dependent on the goals of the radiocarbon dating programme (see above).

**Results**

The samples Ua–number ($n=5$) were measured by IRSM and the precision of the measurements for both $\delta^{13}C$ and $\delta^{15}N$ is $\pm 0.1\%$.

Individuals 2, 5, 9 and 27 have multiple samples on different bones (this study; Fontanals-Coll et al. 2014; Guiry et al. 2015; Umbelino 2006) and present different values (table 4.64, fig. 4.74).

At Cabeço do Pez, the human collagen $\delta^{13}C$ values ($n=27$/no. individuals=21) range from $-20.7\%$ to $-17.2\%$ with a mean value of $-19.3 \pm 0.7\%$. The human collagen $\delta^{15}N$ values ($n=27$/no. individuals=21) range from $+6.7\%$ to $+13.5\%$ with a mean value of $+9.8 \pm 1.5\%$ (table 4.64, fig. 4.74).

When considering the $^{14}C$ dated individuals ($n=5$) and the Ua– values in the case of individuals with more than one set of measurements, the values range from $-20.7\%$ to $-18.3\%$ ($-19.5 \pm 0.9\%$) for carbon and from $+6.7\%$ to $+13.5\%$ ($+11.0 \pm 2.7\%$) for nitrogen.

When considering the $^{14}C$ dated individuals ($n=5$) and all sets of isotopic results the values range from $-20.7\%$ to $-17.2\%$ ($-19.1 \pm 1.0\%$) for carbon and from $+6.7\%$ to $+13.5\%$ ($+10.8 \pm 2.0\%$) for nitrogen. When excluding CP1956, Sk2, which $^{14}C$ date is coeval with Middle Neolithic groups in Portugal (see chapter 5), the ranges remain very similar ($-19.2 \pm 1.1\%; +10.6 \pm 2.1\%$).
Table 4.64. Cabeço do Pez, Sado valley: carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) measurements on human bone collagen samples. All samples were collected at MNA. Samples are sorted so that the lowest $\delta^{13}C$ values are on the top of the table. Multiple samples of the same individual are sorted together.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements</th>
<th>% marine (±10)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ind.</td>
<td>Age</td>
<td>Sex</td>
<td>Bone</td>
</tr>
<tr>
<td>11, 1956</td>
<td>Adult</td>
<td>♂?</td>
<td>Long bone</td>
</tr>
<tr>
<td>A, 1956–59</td>
<td>Adult</td>
<td>n/d</td>
<td>Cranium</td>
</tr>
<tr>
<td>9, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>Rib</td>
</tr>
<tr>
<td>9, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>Fibula</td>
</tr>
<tr>
<td>B, 1956–59</td>
<td>Adult</td>
<td>n/d</td>
<td>Cranium</td>
</tr>
<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>Humerus-R 999.89.2</td>
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<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>Humerus</td>
</tr>
<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone</td>
</tr>
<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone 999.87.16</td>
</tr>
<tr>
<td>13, 1956</td>
<td>15–23 yrs</td>
<td>♂</td>
<td>Rib 999.40.47</td>
</tr>
<tr>
<td>14, 1956</td>
<td>Adult</td>
<td>♀?</td>
<td>Rib 999.95.6</td>
</tr>
<tr>
<td>6, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.78.12</td>
</tr>
<tr>
<td>8, 1956</td>
<td>Adult, young</td>
<td>♀</td>
<td>Vertebra 999.79.35</td>
</tr>
<tr>
<td>15 (9)?, 1956</td>
<td>Adult</td>
<td>♀?</td>
<td>Long bone 999.86.12</td>
</tr>
</tbody>
</table>

continued...
<table>
<thead>
<tr>
<th>Year</th>
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<th>Sex</th>
<th>Bone</th>
<th>ID</th>
<th>Analysis</th>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Adult</td>
<td>n/d</td>
<td>Rib</td>
<td>999.92</td>
<td>for isotopes</td>
<td>19.5</td>
<td>8.7</td>
<td>3.3</td>
<td>19</td>
<td>6</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Non-adult, 5–7 yrs</td>
<td>n/d</td>
<td>Long bone</td>
<td>n/p</td>
<td>for isotopes</td>
<td>19.4</td>
<td>9.3</td>
<td>2.9</td>
<td>20</td>
<td>8</td>
<td>Fontanals-Coll et al. 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Adult</td>
<td>n/d</td>
<td>Rib</td>
<td>999.84</td>
<td>for isotopes</td>
<td>19.4</td>
<td>8.9</td>
<td>3.5</td>
<td>20</td>
<td>8</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Adult</td>
<td>♀</td>
<td>Humerus</td>
<td>n/p</td>
<td>for isotopes</td>
<td>19.3</td>
<td>9.2</td>
<td>2.9</td>
<td>21</td>
<td>9</td>
<td>Fontanals-Coll et al. 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Adult, mature</td>
<td>♂</td>
<td>Rib</td>
<td>999.85</td>
<td>for isotopes</td>
<td>19.3</td>
<td>8.6</td>
<td>3.4</td>
<td>21</td>
<td>9</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Adult</td>
<td>n/d</td>
<td>Rib</td>
<td>999.89</td>
<td>for isotopes</td>
<td>19.2</td>
<td>9.7</td>
<td>3.4</td>
<td>22</td>
<td>10</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Adult</td>
<td>n/d</td>
<td>Rib</td>
<td>999.83</td>
<td>for isotopes</td>
<td>19.2</td>
<td>8.8</td>
<td>3.3</td>
<td>22</td>
<td>10</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Non-adult, 1.5–2 yrs</td>
<td>n/d</td>
<td>Long bone</td>
<td>Ua–46930</td>
<td>for isotopes</td>
<td>19.1</td>
<td>11.5</td>
<td>3.6</td>
<td>23</td>
<td>11</td>
<td>This study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Non-adult, 1.5–2 yrs</td>
<td>n/d</td>
<td>Fibula</td>
<td>n/p</td>
<td>for isotopes</td>
<td>18.4</td>
<td>11.9</td>
<td>3.2</td>
<td>30</td>
<td>20</td>
<td>Fontanals-Coll et al. 2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Adult</td>
<td>♂</td>
<td>Rib</td>
<td>999.88</td>
<td>for isotopes</td>
<td>18.9</td>
<td>9.6</td>
<td>3.3</td>
<td>25</td>
<td>14</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone</td>
<td>999.74</td>
<td>for isotopes</td>
<td>18.5</td>
<td>10.2</td>
<td>3.2</td>
<td>29</td>
<td>19</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Tibia</td>
<td>999.77</td>
<td>for isotopes</td>
<td>18.3</td>
<td>13.0</td>
<td>3.5</td>
<td>31</td>
<td>21</td>
<td>This study</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Rib</td>
<td>999.77</td>
<td>for isotopes</td>
<td>17.2</td>
<td>12.4</td>
<td>3.5</td>
<td>41</td>
<td>35</td>
<td>Guiry et al. 2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4.74. Cabeço do Pez, Sado valley: correlation between the $\delta^{13}$C (‰) and $\delta^{15}$N (‰) values of 27 samples of human bone collagen from 21 individuals. Individuals 2 (circle), 5 (dash), 9 (square) and 27 (triangle) have multiple sets of values.

Archaeothanatology

Source material and analysis strategy

The archival documentation available for the burials at Cabeço do Pez is limited and although some skeletons are maintained in blocks, most of them are poorly preserved, limiting the possibilities of the archaeothanatological analysis. This is unfortunate because this is a large site with minimum number of individuals of 32 (Cunha and Umbelino 1995–97) clustered in two main areas (A and B).

Archaeothanatological analysis was carried out on a total of seven individuals, six from the material excavated in 1956 (26% of 27 individuals in site plan) and one from the two individuals excavated in 1959. The completeness and detail of each analysis is largely compromised by the character and quality of the available source material (table 4.65). The source material comprises paraffin blocks of eight individuals, in various states of preservation, drawings for the individuals excavated in 1959, and two site plans of the burials. One of these blocks contains the remains of CP1959, Sk2, but the material was extremely fragmentary at the time of the
excavation and archaeothanatological analysis is not possible; although this burial will be commented upon briefly throughout this text. For the remaining individuals excavated at this site (n=20) there is no source material available, at least at the time of this study.

Table 4.65. Cabeço do Pez, Sado valley: list of individuals considered for archaeothanatological analysis, based on the preservation of the material. This material is curated at MNA.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Source material</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>Graphic documentation w/ human remains</td>
<td>Written doc.</td>
</tr>
<tr>
<td>Field photographs</td>
<td>Drawings</td>
<td>Site plan</td>
</tr>
<tr>
<td>2</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>9</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>10</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>11</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>17</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>21</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>27</td>
<td>yes</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2</td>
<td>yes</td>
<td>n/a</td>
</tr>
</tbody>
</table>

The first phase of analysis took place at the MNA, where the eight individuals preserved in paraffin blocks were analysed and photographed (CP1956, Sk2, 9, 10, 11, 17, 21, 27; CP1959, Sk2). The second phase of analysis consisted of the reassessment of my observations done in the museum, crosschecked with the photographed material.
Results of the archaeothanatological analysis

The nature of the deposits

Analysis of the nature of the deposits at Cabeço do Pez indicates a pattern of primary burials (table 4.66). The cadavers were placed in the burial features before the degradation of the labile joints, retaining their anatomical integrity. In some cases the documentation is unclear and the diagnostic criteria are poorly preserved, however, the overall position of the skeletal elements indicates that the bodies were disposed while still retaining their general anatomical integrity. This is also the case for the poorly preserved CP1959, Sk2 (non-adult), where the maintenance of the general anatomical integrity of the few preserved elements suggests a burial in primary position.

Table 4.66. Summary of the nature of the deposits with human remains at Cabeço do Pez, Sado valley.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Age</th>
<th>Sex</th>
<th>Nature of the deposit</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Maintenance of labile articulations: some bones of right hand; metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>10</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Poor preservation of the upper body. Maintenance of labile articulations: metatarsals and phalanges of left foot. The bones of the lower body are well articulated suggesting the maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>11</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Poor preservation and heavily covered with paraffin wax. Maintenance of labile articulations: TM joint, CV, metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>17</td>
<td>Non-adult, 5–7 yrs</td>
<td>n/d</td>
<td>Probably primary</td>
<td>Poor preservation of diagnostic criteria. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>21</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Poor preservation and heavily covered with paraffin wax. Maintenance of labile articulations: metatarsals and phalanges of feet. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>27</td>
<td>Adult</td>
<td>♂</td>
<td>Primary</td>
<td>Poor preservation. Maintenance of labile articulations: cervical vertebrae; a few metatarsals and phalanges of a foot. Maintenance of the general anatomical integrity of the body.</td>
</tr>
<tr>
<td>1</td>
<td>Adult</td>
<td>n/d</td>
<td>Primary</td>
<td>Maintenance of labile articulations: metatarsals and phalanges of left foot. Maintenance of the general anatomical integrity of the body.</td>
</tr>
</tbody>
</table>

The space of decomposition of the cadaver

Analysis of the space of decomposition of the cadavers buried in Cabeço do Pez indicates a general pattern of filled spaces (table 4.67). The cadavers were covered with sediment immediately after their placement in the feature. The decomposition of the bodies took place in this sediment-filled environment. In several cases the analysis is unclear due to the poor preservation of the remains. In every case, the movement of the bones is limited suggesting that the space of decomposition was filled and that the sediment could penetrate immediately.
Table 4.67. Summary of the space of decomposition of the human remains in the grave features at Cabeço do Pez, Sado valley.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Age</th>
<th>Sex</th>
<th>Space of decomposition</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Adult 1956</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: some bones of right hand are rotated and flexed at the wrist, as well as several bones of feet. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>10</td>
<td>Adult 1956</td>
<td>n/d</td>
<td>Filled</td>
<td>The upper body is poorly preserved. The bones of the lower body are well articulated. Maintenance of bones in original unbalanced position: bones of left foot.</td>
</tr>
<tr>
<td>11</td>
<td>Adult 1956</td>
<td>♂</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: bones of feet are rotated and placed in front of each other. No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>17</td>
<td>Non-adult 1956</td>
<td>n/d</td>
<td>Filled</td>
<td>Poor preservation of diagnostic criteria but no movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>21</td>
<td>Adult 1956</td>
<td>♀</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: moderate collapse of left os coxae, bones of feet are rotated inwards and placed towards one another (right behind left). No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>27</td>
<td>Adult 1956</td>
<td>♂</td>
<td>Filled</td>
<td>Poor preservation of diagnostic criteria. Maintenance of bones in original unbalanced position: moderate collapse of right os coxae (left is not preserved). No movement outside initial volume of the cadaver.</td>
</tr>
<tr>
<td>1</td>
<td>Adult 1959</td>
<td>n/d</td>
<td>Filled</td>
<td>Maintenance of bones in original unbalanced position: left patella is suspended on the distal end of femur; bones of left foot are rotated outwards. Also, the cranium is in a semi-suspended position.</td>
</tr>
</tbody>
</table>

The initial position of the cadaver in the feature

At Cabeço do Pez all bodies analysed were lying on the back (n=7) (table 4.68) and the remaining burials, sketched in the site plan, confirm this pattern.

The position of the upper limbs was consistent, typically placed close to the body in semi-flexion at the level of the elbow joints. One exception is the burial of a child (CP1956, Sk17) where the upper left limb was lying in semi-flexion but in slight abduction. In the few cases where both limbs are well preserved, the analysis indicates that the positions were symmetrical (n=3), semi-flexed at the elbows and the hands placed in front of the body. This observation is not available for the remaining four burials analysed.

At Cabeço do Pez, the bodies were placed in the feature with the lower limbs in flexion or hyperflexion at the level of the hip joints and always in hyperflexion at the level of the knees. The lower limbs were rotated to the right (CP1956, Sks 11, 17, 27—tendency) or with a tendency towards the left side (CP1956, Sks 10, 21; CP1959, Sk1). The lower limbs are not observable in one case (CP1956, Sk11).

Clumping of the body was common (n=5), with the limbs somewhat nested on the upper body and the feet forced towards the buttocks (CP1956, Sks 9, 10, 21, 27; CP1959, Sk1). In the other two cases this is not observable due to fragmentation of the remains (CP1956, Sks 11, 17), although this was very likely the case of individual 17.
Table 4.68. Summary of the reconstruction of the initial position of the cadaver in the grave features at Cabeço do Pez, Sado valley. The initial position of the limbs is indicated as –R or –L and refers to the right or left limb, when their positions are different. Rotation –R or –L indicates the rotation of the skeletal element(s) towards the right or the left side.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Initial position of the cadaver in the feature</th>
<th>Lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
<td>Sex</td>
</tr>
<tr>
<td>9, 1956</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>10, 1956</td>
<td>Adult</td>
<td>n/d</td>
</tr>
<tr>
<td>11, 1956</td>
<td>Adult</td>
<td>♂?</td>
</tr>
<tr>
<td>17, 1956</td>
<td>Non-adult, 5–7 yrs</td>
<td>n/d</td>
</tr>
<tr>
<td>21, 1956</td>
<td>Adult</td>
<td>♀</td>
</tr>
<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
</tr>
<tr>
<td>1, 1959</td>
<td>Adult</td>
<td>n/d</td>
</tr>
</tbody>
</table>
The grave features

The size and shape of the deposits with human remains at Cabeço do Pez were not described by the excavators. The archaeothanatological analysis suggests that the bodies were placed in pits dug into the ground. The lateral pressures and wall-effects observed on the skeleton in the feature (table 4.69) indicate that the shape and size of the pit was just sufficient to contain the body. Overall, the pressures exerted on the upper body are difficult to observe due to the poor preservation of the diagnostic criteria. Nevertheless, the analysis suggests that in most cases the design of the grave had a significant impact on the final arrangement of the cadaver in the feature, visible by the clumping of the bodies (CP1956, Sks 9, 10, 21; CP1959, Sk1) becoming hypercontracted in one case (CP1956, Sk27). The narrow shape of the graves imposed a significant limit to the cadaver providing lateral support and preventing the collapse of the bones. These wall-effects probably correspond to the physical limits of the pit, just wide enough to contain the cadaver.

The documentation is limited but some cases suggest that the bottom of the graves were irregular and sloping from the upper to the lower end of the feature. This is indicated by the observation of the flexion and collapse forwards and downwards of the head (CP1956, Sks 9, 17; CP1959, Sk1), suggesting that, at least in these cases, the head was possibly slightly more elevated in the grave feature in relation to the trunk. However, the fragmented state of the material does not allow detailed observations at the level of ribs and sacrum rotations of which during the process of decomposition could clarify aspects of the original position of the body in the feature, in relation to the characteristics of the floor of the grave, such as in the case of bodies placed in a half-sitting position.
Table 4.69. Summary of the key observations used in the reconstruction of the grave features at Cabeço do Pez, Sado valley. Observed pressures on the body are presented in a number sequence. The arguments supporting these observations are indicated by the same number in the respective column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Pressures</th>
<th>Arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>9, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Wall-effect, upper right side; 2. Wall-effect, upper left side; 3. Wall-effect, lower end. Design of the grave feature.</td>
<td>1. Alignment of upper right limb and projection forwards and upwards of right shoulder and arm. Pattern enhanced by the sloping floor causing a transfer of body weight towards the right side; 2. Alignment of upper left limb and projection forwards and upwards of left shoulder and arm; 3. Alignment and dumping of lower limbs.</td>
</tr>
<tr>
<td>10, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>Upper body is poorly preserved. 1. Wall-effect, lower left end. Design of the grave feature.</td>
<td>1. Alignment and dumping of lower limbs.</td>
</tr>
<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>1. Wall-effect, upper right side; 2. Overall constraint effect. Design of the grave feature.</td>
<td>1. Alignment of upper right limb, involving right girdle (arm is not preserved in the block); 2. Hypercontracted skeleton.</td>
</tr>
<tr>
<td>1, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>1. Weight of sediment from above; 2. Overall strong lateral pressure and compressing effect. Design of the grave feature.</td>
<td>1. Extreme flexion of the neck suggested by significant rotation forwards and downward of the cranium lying in front of TC; 2. Suggested by alignment of arms close to TC, possible medial tendency of TC, and alignment of lower limbs.</td>
</tr>
</tbody>
</table>
Deposits containing more than one individual

At Cabeço do Pez most deposits with human remains contain the remains of one individual but there is some evidence supporting the hypothesis of double burials at the site.

In the site plan, the deposits with the individuals 4 and 5, 9 and 10, 12 and 13 and 25 and 27 seem to be somehow related, either by being buried simultaneously or by being disturbed by a later inhumation. Unfortunately, in most cases the documentation is limited and a detailed analysis is not possible.

In one case only (CP1956, Sks 9, 10) the documentation is robust enough to support the scenario of a multiple burial of two adults. The individuals were lying in grave positioned in very close proximity. Individual 10 was possibly the first to be deposited and shortly after individual 9 was placed on its left side. This is demonstrated by the position of the right humerus of individual 10 which lies behind the left elbow of individual 9 (figs. 4.75, 4.76), suggesting that individual 10 was still in anatomical integrity when the second individual (9) was placed in the feature. The upper body of CP1956, Sk10 is poorly preserved, but its lower limbs are well articulated and not disturbed, attesting to the primary position of the body in the feature and supporting the double burial hypothesis. The bodies are partially intertwined and come in contact with each other without disturbance of any joints, suggesting a common arrangement of the bodies and a synchronous deposit.

Figure 4.75. CP1956, Sk9 in two blocks of paraffin. The distal end of the right humerus of CP1956, Sk10 is preserved in the block with skeleton 9. Its position behind the left elbow of CP1956, Sk9 suggests a common arrangement of the bodies and a synchronous deposit. Preserved in several paraffin blocks at MNA. (Photographs by J. P. Ruas)
A similar case (CP1956, Sks 25, 27) is suggested by observations from the site plan where the bodies also seem to intertwine also at the level of the elbow joints, suggesting a common arrangement (fig. 4.77). Individual 27 is partially preserved in a paraffin block but the material is very fragmented at the level of the upper body and there is no evidence suggesting either disturbance or common arrangement with individual 25. Thus, in this case, the multiple burial hypothesis is not conclusive since it cannot be tested against other lines of evidence.

In the site plan, two other cases are represented in very close proximity (CP1956, Sks 4 and 5; Sks 12 and 13) (figs. 4.76, 4.77), suggesting a common and synchronous arrangement. Unfortunately, the current documentation is limited to the site plan and the hypothesis of multiple double deposits cannot be tested.

**Post-depositional manipulations of the cadavers**

At Cabeço do Pez, the skeletons are apparently complete and lie undisturbed in the grave feature. However, the unclear nature of the documentation does not allow a reliable assessment at this level.

**Other observations**

The analysis of the paraffin blocks showed that some grave features may contain other elements, possibly mixed in the grave filling. This is the case for CP1956, Sk9 where one small fragment of a non-human long bone was found lying in front of the left os coxae. Another case (CP1956, Sk11) presented a fragment of a long bone of a child, possibly a humerus, lying close to the thoracic vertebrae of the adult. In either case it is not possible to determine the nature of these inclusions.

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*Figure 4.76. Burial area B at Cabeço do Pez, Sado valley. The drawing suggests the hypothesis of double burial of Sks 9 and 10, which is confirmed by the skeletal remains preserved in block. CP1956 Sks 12, 13 lie in close proximity but the data is not conclusive regarding the simultaneous deposit of these individuals. (MNA, 1956, A. Paiva)*
The mortuary programme at Cabeço do Pez

The archaeoanthropological analysis at Cabeço do Pez is limited due to the scarce and unclear nature of the documentation. Also, the skeletons maintained in paraffin blocks are poorly preserved, particularly at the level of the upper body. Nevertheless, it is possible to observe some patterns in the mortuary practices at the site.

At Cabeço do Pez, the cadavers were typically placed in individual grave features while retaining their anatomical integrity (individual primary deposits). The feature was then immediately covered with sediment providing a filled space of decomposition. Some cases suggest the synchronous burial of two individuals in a common grave feature, but as discussed, in one case only the data is sufficient to support the scenario of a double burial.

The bodies were normally laid on the back with the upper limbs placed close to the body, which were commonly semi-flexed at the elbows. The lower limbs were brought up towards the upper body and rotated to one side, and were always hyperflexed at the knees. The feet of the cadavers were always placed towards the buttocks in a forced position. The clumping of the cadavers at the level of the lower body is a common feature of these burials.

The pressures exerted on bodies in features can be explained as the result of the narrow design of the grave where the wall-effects and consequent pressures correspond to the physical limits of the pit, just wide enough to contain the individual. However, the documentation is limited and extra support of cadavers, provided by soft wrappings, cannot be excluded.

The data is limited but some cases suggest that the floor of the graves tended to be uneven and sloping from the upper to the lower end of the feature.

Overall, and despite the limitation of this data set, the mortuary programme at Cabeço do Pez suggests a consistent set of mortuary practices and all cases observed follow a common way of burying the dead, both in area A and area B.
Sado valley: Várzea da Mó

Site background: a short history of research

Várzea da Mó is a shell midden site located on the eastern side of the Sado valley (fig. 2.3). It is situated on the right margin of the Sado River, but the precise location of the site is unknown, and it was not yet relocated during the scope of current fieldwork in the region (Diniz et al. 2012).

Archaeological material and documentation available for Várzea da Mó are curated at the National Museum of Archaeology in Lisbon (MNA). The year of identification of the site is unclear but according to a short article by M. Heleno (1956, 229) the site was already known before the identification of Vale de Romeiras, Cabeço das Amoreiras, and Arapouco. The excavation diary (MNA, APMH, 2/3/17/1) shows that the first field season started on the 3rd of August 1959, but unfortunately, like other documents, this report is incomplete and the last entry does not correspond to the last day of excavation. In these notes there are no references to the identification of human remains.

Graphic documentation in the archives of MNA consists of one site plan with one human skeleton plotted in the excavation area and profile (MNA, 1959, D. Sousa, A117), a few poorly preserved photographs (MNA, APMH, 2/11/84), and individual sketches of the only human skeleton excavated at the site (figs. 4.78, 4.79).

According to the documentation, this individual was excavated at a depth of c 65 cm. The notes in the field sketch and in the final version of the site profile are contradictory regarding the layer where the human remains were found. In the sketch the layer is described as grey soil with few shells, while in the site profile the skeleton is plotted in the bottom layer of white sand, under the grey soil.

The skeleton belongs to an adult individual, probably middle aged (Cunha et al. 2002, 193). It is preserved in a block of paraffin but the bone elements are very fragmented.
Results: Sado valley, Várzea da Mó

Figure 4.78. Várzea da Mó, Sado valley: site plan and profile of the area with human remains. (Adapted from a photograph by J. P. Ruas. MNA, 1959, D. Sousa, A117)

Figure 4.79. VM1959, Sk1 preserved in paraffin block at MNA. (Photograph by J. P. Ruas. Drawing by D. Sousa, MNA)
Chronology of the burial activity

Previous $^{14}$C measurements
One sample of shells (ICEN–273), reported to be collected from the middle layers of the shell midden excavated in 1959, was dated in the 1980s (Arnaud 2000) (table A13).

Objectives of the dating programme
The aim of the dating programme for Várzea da Mó was to date the only human burial known at the site and to contextualize it in the chronological framework of the burial activity in the valley.

Sampling strategy
One sample of human bone from VM1959, Sk1 was collected for $^{14}$C analysis (table 4.70).

Table 4.70. Sample of human bone (1) from Várzea da Mó collected and submitted for $^{14}$C measurement in the course of this study. The sample is from the 1959 assemblages and was collected at MNA.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Stratigraphy</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ua–46310</td>
<td>adult</td>
<td>n/d</td>
<td>Radius</td>
<td>Bottom, c 65 cm</td>
<td>Paraffin block</td>
</tr>
</tbody>
</table>

Results
The only human burial known for this site is now dated (table 4.71).

Table 4.71. Human bone collagen sample (1) from Várzea da Mó, Sado valley: $^{14}$C measurement and estimation of non-terrestrial carbon intake (% marine). Marine percentage was estimated from the measured $\delta^{13}$C value of the sample by the application of method marine 1 and method marine 2, based on adopted endpoint values of –12‰ and –20‰ for marine (100%) and terrestrial (100%) diets respectively.

<table>
<thead>
<tr>
<th>Ind. Excav.</th>
<th>Lab no.</th>
<th>$^{14}$C Age BP</th>
<th>$\delta^{13}$C (‰) VPDB</th>
<th>$\delta^{15}$N (‰) AIR</th>
<th>C:N</th>
<th>M1</th>
<th>M2</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1959, MNA</td>
<td>Ua–46310</td>
<td>6305±44</td>
<td>–20.5</td>
<td>8.1</td>
<td>3.6</td>
<td>10</td>
<td>0</td>
<td>This study</td>
</tr>
</tbody>
</table>

Calibration and chronological models
The $^{14}$C measurement on human bone collagen from Várzea da Mó dates the burial activity at the site to have been in 5345–5071 cal BCE (95% confidence, M1) or 5462–5207 cal BCE (95% confidence, M2) (fig. 4.80, table 4.72).
Results: Sado valley, Várzea da Mó

Figure 4.80. Probability density function estimated for the death of VM1959, Sk1 is 5345–5071 cal BCE (95.4% confidence, marine 1), 5345–5194 cal BCE (79.9% confidence, marine 1), or 5309–5214 cal BCE (68.2% confidence, marine 1). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Table 4.72. Human bone collagen sample from Várzea da Mó, Sado valley: calibrated date ranges according to two different approaches for the calculation of the marine percentage. Results are presented in both cal BCE and cal BP in 95.4% confidence range.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Lab no.</th>
<th>(^\text{14}C) Age BP</th>
<th>cal BP</th>
<th>cal BCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 1959</td>
<td>Ua–46310</td>
<td>6305±44</td>
<td>7294–7020, M1</td>
<td>5345–5071, M1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7411–7156, M2</td>
<td>5462–5207, M2</td>
</tr>
</tbody>
</table>

Stable isotopes: carbon and nitrogen

Previous measurements: $\delta^{13}$C and $\delta^{15}$N

The first attempt to measure stable isotopes on the only individual buried at Várzea da Mó did not yield enough collagen (Fontanals-Coll et al. 2014).

Sampling strategy

One sample was collected from the VR1959, Sk1 in the scope of the radiocarbon dating programme (chapter 3).

Results

Sample Ua–46310 was measured by IRMS and the precision of the measurements for both $\delta^{13}$C and $\delta^{15}$N is $\pm 0.1\%$. At Várzea da Mó, the human collagen $\delta^{13}$C value (n=1) is $-20.5\%$ and the $\delta^{15}$N value (n=1) is $+8.1\%$ (fig. 4.81).
Chapter 4

Figure 4.81. Várzea da Mó, Sado valley: correlation between the $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) values of one sample of human bone collagen from the only burial known at the site.

Archaeothanatology

The individual buried at Várzea da Mó is preserved in a paraffin block but the skeletal elements are poorly preserved and very fragmented. Archival documentation consists of field photographs, sketches and one site plan with the burial (table 4.73).

Table 4.73. Várzea da Mó, Sado valley: source material used for archaeothanatological analysis. This material is curated at MNA.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Source material</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>Graphic documentation w/ human remains</td>
<td>Written documentation</td>
</tr>
<tr>
<td>Field photographs</td>
<td>Drawings</td>
<td>Site plan</td>
</tr>
<tr>
<td>1, 1959</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The nature of the deposit, the space of decomposition, and the initial position of the cadaver

The primary nature of VR1959, Sk1 is suggested by the maintenance of the general anatomical integrity of the body. The labile articulations are unclear in the documentation, however, the concentration of several hand bones on the pelvic region indicates moderate collapse of these labile joints.
Decomposition of the body was possibly in a sediment-filled environment as suggested by the moderate collapse of the bones of the hands. Also, the skeletal elements remained in order, and there is no movement outside the initial volume of the cadaver.

The cadaver was lying on the back with the upper limbs along the body and the hands placed in front of the lower abdomen. The lower right limb was semi-flexed (c 90°) at the hip, suggesting that the knee was directed forwards. Other skeletal elements of the lower limbs were presumably not in the feature at the time of the excavation. This could be explained by disturbance of the feature, but the documentation does not allow further analysis.

The cranium was poorly preserved and several fragments are concentrated on the upper right side of the TC, in the paraffin block. However, the field sketch indicates these fragments were found in anatomical position and this placement in front of the TC was possibly after excavation, at the time the block was being prepared for transportation to the museum.

The verticalization of the clavicles and ribs suggests significant compression towards the medial axis of the body. Most diagnostic elements are unclear in the documentation, however, the rotation of these elements is a strong indicator of a bilateral pressure exerted on the body. This bilateral wall-effect could be explained by the narrow shape of the pit, imposing a significant limit to the cadaver while offering lateral support and preventing the collapse of the bones. In this scenario, the size and shape of the deposit was just sufficient to contain the body in a relatively constrained position.

Post-deposition manipulations of the cadaver

Nothing noted.
Chapter 5
Analysis and Synthesis of the Results

Introduction

The methodological choices of this dissertation were explicitly targeted towards the human remains excavated in the shell middens of the Tagus and Sado valleys. This strategy was aimed to understand the significance of the mortuary activity in these sites. The data obtained in the course of this study offers significant evidence to start defining who was buried in these places, as well as when and how. In this chapter, Analysis and Synthesis of the Results, I examine the results presented in chapter 4 in the light of the general aims and questions of this dissertation, in terms of time, people, and funerary practices.

I start with an examination of the Chronology of the burial activity in each site and in each valley. The analysis is presented by following the objectives of the dating programme, the general aims of which were to define the chronology of the burial activity in terms of duration, start/end, and frequency (see chapter 3, Enquiry-dependent chronologies: the radiocarbon dating programme in this study), along with site-specific questions (see chapter 4, Site/Objectives of the dating programme). In each case I evaluate the representativeness of the results, and compare with previously published proposals when available, as well as with the current chronological framework proposed for the Late Mesolithic in Portugal, c 6350–5250 cal BCE (Araújo 2015). This is an interpretative chronology for the burial activity based on the chronological models presented in chapter 4, and new data may refine and/or redefine some of these scenarios. The models are based on 14C dates on buried human bone exclusively. Other dates are available, but in most cases the contexts are unclear and the relationship with the burials is unknown. It is not possible at the moment to discuss the chronology of other contexts in most middens because there is a lack of a reliable data set, along with a clear definition of what these other uses are (i.e., ritual, non-funerary, domestic?). The discussion in this dissertation is on the use of these sites for burial practice. Ongoing (Bicho et al. 2013; Diniz and Arias 2012) and future research will possibly clarify these and other questions that have persisted for decades. The analysis at the level of each site is followed by a discussion on the implications of the chronological data for the local setting, at the scale of each valley, Tagus vs Sado.

The second section of this chapter is centred on the Isotopic signatures as a means to define the people in each burial place. Here I integrate the data obtained in this study
with previously published isotopic signatures (Fontanals-Coll et al. 2014; Guiry et al. 2015; Lubell et al. 1994; Umbelino 2006), and examine the isotopic data from the perspective of funerary practices. The aim is to identify isotopic signature patterns that may reflect homogeneity or heterogeneity of the burial groups at the scale of the site, valley and inter-valley. In this section, I introduce the temporal dimension as presented in the section *Chronology of the burial activity*, and investigate the impact of time in the observed patterns and outlier signatures. Even at its most elementary level of analysis, the isotopic data ($\delta^{13}C$ and $\delta^{15}N$) were proved to be a powerful data set for the interpretation of these sites, which future studies will be able to refine.

In the third and last section of this chapter, I present a synthesis of the results of the archaeothanatological analysis presented in chapter 4. *The treatment of the dead: synthesis of the archaeothanatological analysis* is presented in terms of central aspects about the nature of the deposits, the space of decomposition of the cadaver, the initial position of the cadaver in the feature, the grave features, the deposits containing more than one individual, and the post-depositional manipulation of the cadavers. The mortuary programme described for each site in the previous chapter is examined here at the scale of the valley and compared across the Tagus and Sado valleys.

**Chronology of the burial activity**

**Moita do Sebastião, Tagus valley**

The chronological model proposed for the burial activity at Moita do Sebastião is presented in chapter 4 and is based on 18 $^{14}C$ measurements on human remains which can be considered representative of the assemblage:

1. Five measurements are from the nineteenth century excavations (MNI 52) selected on the basis of representative enveloping sediment (Lubell and Jackes 1985). Despite the differences in sediment the $^{14}C$ dates are consistent, with one exception (TO–135, individual CT) which presents a more recent date than the other four samples.

2. Thirteen measurements are from the 1952–54 excavations (MNI 34) and represent a good spatial coverage of the burial area. With one exception (Ua–46264, individual 9) which presents an earlier date, the $^{14}C$ results for these samples are highly consistent.

3. The results obtained for both groups of samples, nineteenth century and 1952–54, are highly coherent and can be analysed as one series. This is consistent with the stratigraphic data available for the site which indicates that despite the c 3 metres depth of the midden, most skeletons were excavated from the basal sand layer (Jackes and Alvim 2006).
Chronological relationship of the burial areas

The new dates obtained for the burials excavated in 1952–54 are coeval with previous 14C measurements of the burials recovered in the areas excavated in the nineteenth century. Two of the new dates (Ua–47978, MS1952–54, Sk10 and Ua–46270, MS1952–54, Sk33) are consistent with TO–135 (MS19th c., SkCT), which was rightly interpreted as an outlier (Jackes and Lubell 2012). Now, this burial is well established in the chronology of the site consistent with a later burial activity. The burials in the excavation areas of both the nineteenth century and 1952–54 were in use at the same time and do not correspond to different burial phases. However, some of the older burials are located in the 1952–54 excavation in a central area of the shell midden (area A) (fig. 4.1). Also, the new 14C dates indicate that the different burial areas (A, B and C) identified in 1952–54 are coeval in time. The 14C data demonstrates that the different spatial areas are synchronic (fig. 5.1). However, the chronological sequence suggests that the burial activity clusters in three chief moments in time, possibly discontinuously, with relatively short hiatuses between them without significant burial activity (fig. 5.2).

Figure 5.1. Moita do Sebastião, Tagus valley, 1952–54: site plan and 14C dated human remains. Dash stroke: earlier burials (1, 9). Full stroke: main burial activity (5, 15, 17, 18, 22, 25, 30, 31, 34). Polygon: later burials (10, 33). Unreliable measurements (14). (Site plan reproduced from Roche 1972, 116, fig. 29)
Figure 5.2. Chronological model for the burial activity at Moita do Sebastião, as presented in chapter 4. **Shade:** highlights the moment of most frequent burial activity at the site c 5950–5650 cal BCE.

**Burial activity: duration, start/end, frequency**

The new $^{14}$C dates suggest an earlier use of the site than previously considered. This is demonstrated by the measurements obtained for MS1952–54, Sks 9, 1 (Ua–46264, Ua–46263, 1952–54, area A) presenting the earliest dates on human bone collagen known at the Tagus valley. The posterior density estimated for the time of
their burial is \(6292–6023\) \textit{cal BCE} (95\% probability) for individual 9 and \(6218–5998\) \textit{cal BCE} (95\% probability) for individual 1. Interestingly, MS1952–54, Sks 9 (male adult, Ferembach 1974), was the only individual buried with the lower limbs in full extension, which is unique at both the Tagus and Sado valleys. According to J. Roche (1972, 117), the feature containing MS1952–54, Sk1 (sépulture 1) included the remains of two adults probably disturbed at the time of the burial of MS1952–54, Sk5 (fig. 5.3). The \(^{14}\text{C}\) measurements confirm that the burial of individual 5 is more recent (Ua–47977, \(5972–5672\) \textit{cal BCE}, 95\% probability).

![Figure 5.3. MS1952–54, Sks 5, 9, 12, 15: \(^{14}\text{C}\) data. (Adapted from a photograph in Cardoso and Rolão 1999–2000, 200, fig. 38 and site plan in Roche 1972, 116, fig. 29)](image-url)

The second main moment of burial activity at Moita do Sebastião is where most \(^{14}\text{C}\) dates cluster (n=13) indicating that the burial activity was continuous and more frequent during this time span. The new dates support the suggestion of Jackes and Lubell (2012) of a main group of burials clustering at c 5850 cal BCE. Burials from all excavated areas fall into this time span, suggesting that when the burial practice was more frequent, the extent of the burial area was as large as the total burial area known at Moita do Sebastião. The earliest burials from this second time cluster are represented by a child buried in area C (MS19\textsuperscript{th} c., Sk22, TO–131) with a posterior density estimated for the time of burial of \(6021–5705\) \textit{cal BCE} (95\% probability), and MS19\textsuperscript{th} c., Sk29 (TO–133 with a posterior density estimated for the time of burial of \(6017–5707\) \textit{cal BCE} (95\% probability). The \(^{14}\text{C}\) dates for this time span are consis-
tent with the dates of most individuals, and all present identical ranges. One of the latest dates known for this main burial activity is found in area A, MS1952–54, Sk15 (Ua–46265), with a posterior density estimated for the time of burial at 5843–5611 cal BCE (95% probability).

The third and last period of concentrated burial activity at Moita do Sebastião is indicated by the 14C dates of three individuals: MS1952–54, Sks 10, 33 in area A (Ua–47978, Ua–46270) and MS19th c., SkCT (TO–135) which precise location is unknown. These three dates are coeval with a posterior density estimated for the time of their burial around 5650–5450 cal BCE. The new 14C dates securely demonstrate the later burial activity at the site as already suggested by a previous date (TO–135, MS19th c, SkCT).

Moita do Sebastião is a large site with high concentration of human burials (MNI 85). The chronological model suggested assumes one general phase of burial activity, with the burials taking place more or less continuously during a period of time, as defined by the start/end of burial activity. In this scenario the model suggests that the burial activity was clustered in three main periods, in a slightly discontinuous fashion, with short hiatuses between them. The burial activity was more frequent between c 5950–5650 cal BCE, with an earlier moment at c 6200–6000 cal BCE and a later cluster at c 5650–5450 cal BCE.

In this model, the burial activity is estimated to have continued for between 469 and 816 years (95% probability), or for 523 and 696 years (68% probability). This estimate suggests a frequency of at least one burial every 10 years, or two burials every two generations, based on the minimum number of individuals recovered at the site (n=85) and assuming the widest span of burial activity of 816 years. If the chronological model considered more than one well defined phase, such as in the hypothetical model 2 (see below, Alternative model), the frequency of burial practice within each phase would have been higher.

If Moita do Sebastião was used as the burial ground of one residential group of hunter-gatherers (n=15 to 17), with a death rate of 0.3 or 0.5 per year (see chapter 2, Hunter-gatherer death rate vs burial population), the burial ground would aggregate in 816 years, c 245 or 408 human burials, respectively. The current MNI (n=85, Jackes and Meiklejohn 2008) accounts for 35% or 21% of this hypothetical burial population. D. Ferembach (1974) calculated a MNI of 136 individuals. In this case, the human remains recovered would account for 56% or 33% of the total burial population. If we consider a smaller span of burial activity, of c 600 years, the current MNIs would represent a larger part of the population, but probably not more than half of the group (table 5.1).
Table 5.1. Representativeness of the archaeological burial population at Moita do Sebastião in relation to the original group. Estimates assume a residential group unit of nomadic foragers of 13 to 17 people (after Binford 2001; Hamilton et al. 2007). Death rate estimates after M. Gurven and H. Kaplan (2007).

<table>
<thead>
<tr>
<th>Death rate/year</th>
<th>Burial activity span</th>
<th>Total burial population</th>
<th>MNI 85</th>
<th>MNI 136</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>816 yrs</td>
<td>245</td>
<td>35%</td>
<td>56%</td>
</tr>
<tr>
<td>0.5</td>
<td>816 yrs</td>
<td>408</td>
<td>21%</td>
<td>33%</td>
</tr>
<tr>
<td>0.3</td>
<td>600 yrs</td>
<td>180</td>
<td>47%</td>
<td>76%</td>
</tr>
<tr>
<td>0.5</td>
<td>600 yrs</td>
<td>300</td>
<td>28%</td>
<td>45%</td>
</tr>
</tbody>
</table>

The proposed model can account for the previous dates on charcoal of unidentiﬁed species (H–2119/1546 and Sa–16, table A3), although one of the dates (Sa–16) has a large margin of error (±350) suggesting a slightly earlier use of the site.

The new ¹⁴C dates introduce an earlier moment of burial activity at Moita do Sebastião. The current posterior density estimated for the start of the burial activity at Moita do Sebastião is 6365–6051 cal BCE (95% probability) which may be slightly earlier than the previous estimate at c 6150 cal BCE (Jackes and Lubell 2012). The new dates support the previous suggestion of M. Jackes and D. Lubell (2012) of a main burial activity between c 5950–5650 cal BCE, which is where most dates cluster. Furthermore, the new data set conﬁrms the later burial activity at the site, already suggested by one previous date (TO–135), estimating the end of the burial activity at 5603–5351 cal BCE (95% conﬁdence).

The burial activity at Moita do Sebastião starts while the estuarine environment is abruptly established in the region (c 6100 cal BCE, van der Schriek et al. 2007) but ends while this apparently favourable ecosystem is still predominant. Also, the proposed model suggests that the burial activity at Moita do Sebastião is coeval with the currently proposed dates for the beginning of the Late Mesolithic in Portugal (Araújo 2015), at c 6350 cal BCE. The burial activity at Moita do Sebastião ends a few centuries before the end of the Mesolithic at c 5250 cal BCE.

Alternative model

As a working hypothesis, a second chronological model could be proposed, by explicitly deﬁning three main periods of burial activity as three distinct phases, with clear boundaries deﬁned for each phase (ﬁg. 5.4). In this model, chronological relations are imposed and the order of the three phases is assumed; clear hiatuses between phases, and duration of phases are deﬁned. However, the archaeological data (i.e., prior beliefs) do not clearly indicate burial activity in three phases. The resolution of the stratigraphic data is low and we know only that the burials were excavated from the basal sand layer, at the bottom of the shell midden. This is not to suggest that the burial activity could not have happened in three distinct phases, but to caution against the statistical manipulation of the data, which, without a strong archaeological basis, can signiﬁcantly mislead representation of the data. Thus, the current archaeological documentation (the prior beliefs) does not securely allow the construction of a robust second model.
Figure 5.4. Hypothetical chronological model 2 for the burial activity at Moita do Sebastião, Tagus valley. Posterior densities estimated for the start and end of the burial activity are 7001–6093 cal BCE (95% probability) and 5597–4800 cal BCE (95% probability), respectively. Phase 1 of burial activity is estimated to have started 6515–6072 cal BCE (95% probability) and ended 6251–5850 cal BCE (95% probability). Phase 2 of burial activity is estimated to have started 5917–5752 cal BCE (95% probability) and ended 5831–5686 cal BCE (95% probability). Phase 3 of burial activity is estimated to have started 5712–5482 cal BCE (95% probability) and ended 5609–5333 cal BCE (95% probability). Observe that the current archaeological data does not acknowledge the construction of a model that explicitly assumes three distinct phases of burial activity. Model-definition command files in appendix, Tagus valley, Moita do Sebastião, Hyp. Model 2, Marine 1.
Cabeço da Arruda, Tagus valley

The chronological model proposed for the burial activity at Cabeço da Arruda is presented in chapter 4 and is based on 15 $^{14}$C measurements on the human remains of 14 individuals. This is a large site with a large number of human burials (MNI 110) in a complex stratigraphy. Nevertheless, the current set of dates can be considered representative of the assemblage:

1. The samples from the nineteenth century assemblages (n=5), for which precise location in the midden is unknown, were selected randomly (Lubell et al. 1994). The $^{14}$C measurements are consistent, with one exception (TO–356, individual N) which presents a more recent date than the other four samples.
2. The material now dated from the 1937 and 1964 excavations was selected according to the position of the burials in the shell midden, and despite the lack of dates from the upper layers, this set represents a comprehensive stratigraphic coverage.
3. Overall, the $^{14}$C measurements obtained for the three groups of samples, nineteenth century, 1930s and 1960s are consistent and can be analysed as one series.

Chronological relationships of the burial areas

The chronology of the material excavated in the nineteenth century, in 1937 and 1964 overlaps in time. However, the material excavated in the nineteenth century generally presents more recent dates. The $^{14}$C data indicates that the different spatial areas are synchronic. Also, the chronological sequence suggests that the burial activity took place continuously.

Burial activity: duration, start/end, frequency

The earliest burial activity at Cabeço da Arruda is represented by the two $^{14}$C dates available for CAR1937, Sk6. This individual was excavated at c 0.80 metres above the basal sand, and c 3.80 m from the top of the midden (Cardoso and Rolão 1999–2000, 178). Despite doubts expressed about the early date of this burial (Jackes and Meiklejohn 2004; Jackes and Lubell 2012) it remains the earliest burial known at Cabeço da Arruda, even after being recently re-dated (Jackes et al. 2014). The posterior density estimated for the time of burial is $6133–5852$ cal BCE (95% probability), obtained by combining the two dates available (Beta–127451 and AA–101343). The combined calibrated date range is $6223–5912$ cal BCE (95% confidence, fig. 4.13) which is slightly older but consistent with the single calibration of the new measurement (AA–101343) which presents a calibrated date range of $6205–5811$ cal BCE (95% confidence) (fig. 5.5). However, the combined calibrated date range is not as old as the original date (Beta–127451), the calibrated date range for which is $6413–5996$ cal BCE (95% confidence) (fig. 5.6), mostly due to its large margin of error ($\pm 100$). Nevertheless, the $^{14}$C data available for this
individual indicates an earlier burial activity, which according to M. Jackes and D. Lubell (2012) was expected to be no earlier than 5750–5650 cal BCE.

**Figure 5.5.** Probability density function for the calibration of sample AA–101343 (Jackes et al. 2014) from bone collagen of CAR1937, Sk6. The calibrated measurements for this sample indicate that the probability density estimated for the death of individual 6 is 6205–5811 cal BCE (95% confidence) or 6066–5899 cal BCE (68% confidence).

**Figure 5.6.** Probability density function for the calibration of sample Beta–127451 (Cunha and Cardoso 2002–03; Cunha et al. 2003) from bone collagen of CAR1937, Sk6. The calibrated measurements for this sample indicate that the probability density estimated for the death of individual 6 is 6413–5996 cal BCE (95% confidence) or 6288–6063 cal BCE (61% confidence).
This earlier burial (CAR1937, Sk6) is followed by the main period of burial at Cabeço da Arruda, where most ¹⁴C dates cluster (n=9), indicating that burial activity was more frequent between c 6000–5600 cal BCE (fig. 5.7). Burials excavated from all areas fall into this time span, suggesting that when the burial practice was more frequent, the extent of the burial area was as large as the total burial area known at Cabeço da Arruda. Burial practice is frequent after the burial of CAR1937, Sks 10, 9, 3 (Ua–46275, Ua–46274, Ua–46273) and CAR1964, Sk4 (Ua–47976) followed by CAR1937, Sk1 (Ua–46272). CAR1937, Sk2 (Ua–47975), CAR19th c., Sks III, A (TO–360, TO–354), and CA–00–02 (1960s area, TO–10216) are coeval within this main activity. The later burials of this main activity are indicated by the ¹⁴C dates of two individuals: CAR19th c., Sk 42 and D (TO–359, TO–355) (table 5.2).

Figure 5.7. Chronological model for the burial activity at Cabeço da Arruda, calibrated using marine 1 diet values. Shade: highlights the period of most frequent burial activity at the site c 6000–5600 cal BCE.
Table 5.2. Cabeço da Arruda, Tagus valley: stratigraphy and burial activity at the site.

<table>
<thead>
<tr>
<th>Individual/Lab no.</th>
<th>Stratigraphy</th>
<th>Reference</th>
<th>Post. density estimate cal BCE, 95% prob.</th>
<th>Burial activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, 19th c./TO–356</td>
<td>Upper layers (based on sediment matrix)</td>
<td>Jackes and Lubell 2012</td>
<td>5464–4963</td>
<td>Latest</td>
</tr>
<tr>
<td>CA-00-01/TO–10217</td>
<td>Upper layers</td>
<td>Roksandic 2006</td>
<td>5602–5287</td>
<td>Late</td>
</tr>
<tr>
<td>42, 19th c./TO–359</td>
<td>Basal sand</td>
<td>Jackes et al. 2013</td>
<td>5827–5495</td>
<td>Main–Late</td>
</tr>
<tr>
<td>D, 19th c./TO–355</td>
<td>Basal sand</td>
<td>Jackes et al. 2013</td>
<td>5734–5428</td>
<td>Main–Late</td>
</tr>
<tr>
<td>III, 19th c./TO–360</td>
<td>Basal sand</td>
<td>Jackes et al. 2013</td>
<td>5972–5511</td>
<td>Main</td>
</tr>
<tr>
<td>A, 19th c./TO–354</td>
<td>Basal sand</td>
<td>Jackes et al. 2013</td>
<td>5902–5617</td>
<td>Main</td>
</tr>
<tr>
<td>1, 1937/Ua–46272</td>
<td>c 1.40 m from basal sand</td>
<td>Cardoso and Rolão 1999–2000, 178</td>
<td>5975–5696</td>
<td>Main</td>
</tr>
<tr>
<td>3, 1937/Ua–46273</td>
<td>c 1.20 m from basal sand</td>
<td>Cardoso and Rolão 1999–2000, 178</td>
<td>5993–5745</td>
<td>Main</td>
</tr>
<tr>
<td>2, 1937/Ua–47975</td>
<td>c 0.85 m from basal sand</td>
<td>Cardoso and Rolão 1999–2000, 178</td>
<td>5905–5640</td>
<td>Main</td>
</tr>
<tr>
<td>9, 1937/Ua–46274</td>
<td>c 0.30 m from basal sand</td>
<td>Cardoso and Rolão 1999–2000, 179</td>
<td>5998–5748</td>
<td>Main</td>
</tr>
<tr>
<td>10, 1937/Ua–46275</td>
<td>c 0.25 m from basal sand, under skeleton 9</td>
<td>Cardoso and Rolão 1999–2000, 179</td>
<td>6049–5798</td>
<td>Main</td>
</tr>
<tr>
<td>CA-00-02/TO–10216</td>
<td>Basal sand (1960s area)</td>
<td>Roksandic 2006</td>
<td>5914–5621</td>
<td>Main</td>
</tr>
<tr>
<td>4, 1964/Ua–47976</td>
<td>Basal sand</td>
<td>Roche 1974</td>
<td>6021–5766</td>
<td>Main</td>
</tr>
<tr>
<td>6, 1937/R_Combine: AA–101343 Beta–127451</td>
<td>c 0.80 m from basal sand</td>
<td>Cardoso and Rolão 1999–2000, 178</td>
<td>6133–5852</td>
<td>Early</td>
</tr>
</tbody>
</table>

The only date securely attributed to the upper layers of the shell midden corresponds to the later occurrence of burial activity at Cabeço da Arruda (TO–10217, individual CA–00–01, 5602–5287 cal BCE, 95% probability) which is in good agreement with the remaining 14C measurements from Cabeço da Arruda.

Individual N (nineteenth century) is the latest burial known at the site. It presents a much more recent date (TO–356, 5464–4951 cal BCE, 95% probability) and is in poor agreement with the remaining dates available, suggesting an episode of later burial activity at the site. Its exact location and depth are unknown, although the enveloping sediment seems to correspond to the characteristic matrix of the upper layers (Jackes and Lubell 2012). More dates from the upper layers could eventually clarify this relatively later burial activity, but unfortunately the only
material securely identified from these upper layers, excavated in 1965 was mixed
with material recovered in 1964 from the bottom of the midden.

Like Moita do Sebastião, Cabeço da Arruda is a large site with a high concentra-
tion of human burials (MNI 110). The chronological model suggested assumes one
general phase of burial activity. The burials take place continuously during a period
of time, as defined by the start/end of burial activity, and are more frequent between
c 6000–5600 cal BCE, with earlier and later burial episodes.

In this model, the burial activity is estimated to have continued for between 557
and 1093 years (95% probability), or for 682 and 918 years (68% probability). This
estimate suggests a frequency of at least one burial every 10 years, or two burials
every two generations, based on the minimum number of individuals recovered at
the site (n=110) and assuming the widest span of burial activity of 1093 years.

If Cabeço da Arruda was used as the burial ground of one residential group of
hunter-gatherers (n=15 to 17), with a death rate of 0.3 or 0.5 per year (see chapter
2, Hunter-gatherer death rate vs burial population), the burial ground would aggregate in
1093 years, c 328 or 547 human burials, respectively. The current MNI (110)
accounts for 34% or 20% of this hypothetical burial population. If we accept, as
discussed, that the MNI could be higher than 170 individuals, the human remains
recovered would account for c 52% or 31% of the total burial population. If we
consider a smaller span of burial activity, of c 800 years, the current MNIs would
represent a larger part of the population, but probably not more than half of the
group (table 5.3).

Table 5.3. Representativeness of the archaeological burial population at Cabeço da Arruda in relation to
the original group. Estimates assume a residential group unit of nomadic foragers of 15 to 17 people (after

<table>
<thead>
<tr>
<th>Death rate/year</th>
<th>Burial activity span</th>
<th>Total burial population</th>
<th>MNI 110</th>
<th>MNI 170</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>1093 yrs</td>
<td>328</td>
<td>34%</td>
<td>52%</td>
</tr>
<tr>
<td>0.5</td>
<td>1093 yrs</td>
<td>547</td>
<td>20%</td>
<td>31%</td>
</tr>
<tr>
<td>0.3</td>
<td>800 yrs</td>
<td>240</td>
<td>46%</td>
<td>71%</td>
</tr>
<tr>
<td>0.5</td>
<td>800 yrs</td>
<td>400</td>
<td>28%</td>
<td>43%</td>
</tr>
</tbody>
</table>

The proposed model can account for three (Sa–197, Beta–152956, and Beta–
271927) of the five previous dates on non-human material (table A4). Two of these
samples are on unidentified species of charcoal. One was collected by J. Roche in
the 1960s from the lower layers (Sa–197) and it has a relatively recent date (5977–
4721 cal BCE, 95% confidence). The second date (Beta–271927) was recently
measured from charcoal inside the crushed skull of a child excavated in the
nineteenth century (Jackes et al. 2013). This charcoal presents a very similar date to
the measurement obtained for the articulated dog (Canis familiaris) found at Cabeço
da Arruda (Beta–152956), the calibrated date range for which is 6023–5851
cal BCE (95% confidence). A third date on unidentified charcoal (TO–10215,
6426–6100 cal BCE, 95% confidence) is slightly older than the range proposed in
the model, which could be the result of old wood effect (Jackes et al. 2014). A more recent date, also on unidentified charcoal (Sa–196) collected by J. Roche from the upper layers in the 1960s indicates a more recent activity at the site, with a calibrated date range of 4706–3196 cal BCE (95% confidence), but its association with the burials is unknown.

The new ^14C dates strengthen the chronology of the main period of burial activity between c 6000–5600 cal BCE. The new dates also support the previous estimates for the start and end of the burial activity at the site. The time span for the use of the site for burial practices is not altered but refined. The posterior density estimated for the start of the burial activity at Cabeço da Arruda is 6270–5918 cal BCE (95% probability), during the first few centuries of the Late Mesolithic in Portugal, when the estuarine environment is well established in the region (c 6100 cal BCE, van der Schriek et al. 2007). The posterior density estimated for the end of the burial activity is 5424–4843 cal BCE (95% probability) suggesting that the burial activity at Cabeço da Arruda ends as saltmarshes gradually contracted (c 5555 cal BCE, van der Schriek et al. 2007). This latest period of burial activity at the site, represented by the date of one later burial (CAR19th c., SkN, TO–356), overlaps with the end of the Late Mesolithic (c 5250 cal BCE) and the Early Neolithic in Portugal (c 5500–4500 cal BCE, Carvalho 2010).

Alternative model

As a working hypothesis, a second chronological model could be proposed by explicitly defining the main phases of burial activity in relation to the stratigraphic sequence. The stratigraphic data of the relative position of the burials could be included as the prior beliefs (or, the archaeology in a Bayesian Model) for the construction of a chronological model. In this model, individual CA–00–02 (TO–10216) and CAR1964, Sk4 (Ua–47976), in the bottom of the shell midden, would inaugurate the burial activity at the site. CA–00–01 (TO–10217) c 2 metres from the bottom would be included in a last phase of activity (fig. 5.8). The burials found at different depths could be grouped in one or two middle phases, according to their stratigraphic position. However, the calibrated date ranges and the posterior density estimates (model 1, fig. 4.14) show that depth and antiquity of the burial are not entirely correlated. This is the case for CA–00–02 (TO–10216) found in the base of the midden. This burial in the basal sand, presents a relatively more recent ^14C date than CAR1937, Sk6 (Beta–127451, AA–101343) which was found 0.80 metres from the base, as well as more recent than CAR1937, Sk3 (UA–46273) at 1.20 metres from bottom. Other dated burials, however, seem to follow a vertical chronology, with individual CA–00–01 (TO–10217) at 2 metres from the bottom presenting one of the most recent dates known at the site. However, without any further information, such as the description of the stratigraphic layers, the depth of the burial cannot be assumed to be indicative of relative chronology.
Chronology of burial activity: implications for the local setting, Tagus valley

The chronology of the burial activity proposed for the shell midden sites of the Tagus valley is based on the data available for the sites under study, which are also the largest sites in the region: Moita do Sebastião and Cabeço da Arruda. For a more robust analysis of the local setting, I introduce in this section a supplementary data set of the published 14C dates on human bone collagen from the neighbouring site Cabeço da Amoreira. The data available for the other sites with human remains at the Tagus valley is extremely limited and does not allow further observations at this level.

The new 14C dates suggest that the first human burials in the Muge region were placed at Moita do Sebastião between 6365–6051 cal BCE (posterior density estimate for the start of burial activity, 95% confidence) as indicated by the burial of MS1952–54, Sks 9, 1. These are followed closely by the burial of CAR1937, Sk6 at Cabeço da Arruda on the other margin of the river, indicating the start of the activity at the site at 6270–5918 cal BCE (posterior density estimate for the start of burial activity, 95% confidence).

This earlier period of burial activity is followed by the most frequent period of burial practice in the Muge region. The burial activity concentrates in time and space at Moita do Sebastião and Cabeço da Arruda between c 6000–5600 cal BCE. The burial activity is frequent and synchronous in both sites (fig. 5.9).
Figure 5.9. Chronological models for the burial activity at Moita do Sebastião and Cabeço da Arruda, calibrated using marine 1 diet values. Shade: highlights the period of most frequent burial activity c 6000–5600 cal BCE.
The data is less robust for Cabeço da Amoreira (tables A5, A6) but here, the burial activity is less frequent (fig. 5.10) and apparently less continuous when compared with Moita do Sebastião and Cabeço da Arruda. The oldest human remains known at Cabeço da Amoreira were excavated in 2000 (CAM–00–01, TO-11819–R) on the basal sand layers of the site (Jackes and Lubell 2012; Meiklejohn et al. 2009a). The posterior density estimated for the time of this burial is 6048–5702 cal BCE (95% probability) which is coeval with the beginning of the frequent burial activity at both Moita do Sebastião and Cabeço da Arruda. However, another measurement from the same context of human remains presents a much later date (CAM–00–01, TO–10218) (Roksandic 2006) with a posterior density estimate of 5508–5224 cal BCE (95% probability). These disparate dates suggest mixing in the deposit, possibly taphonomic. A single burial from Cabeço da Amoreira (burial 2011.1) is coeval with the main period of burial activity at Moita do Sebastião and Cabeço da Arruda, although in its later stages. This burial was excavated from the upper layers of the midden (Wk–32143, Bicho et al. 2013) and presents a posterior density estimate of 5878–5633 cal BCE (95% confidence).

Figure 5.10. Chronological model for the burial activity at Cabeço da Amoreira, calibrated using marine 1 diet values. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, Tagus valley, Cabeço das Amoreira, Model 1, Marine 1.
The burial activity continues between c. 5600–5400 in the three sites but it is less frequent. The activity apparently ends at Moita do Sebastião, continuing episodically at Cabeço da Arruda and Amoreira. The last burials at Arruda and Amoreira are coeval with the gradual contraction of estuarine habitats (starting c. 5500 until 3800 cal BCE, van der Schriek et al. 2007). After the regional establishment of an open landscape in the region around 5000 cal BCE (van der Schriek et al. 2007) these sites are no longer used for burial practices. It is important to remember that the upper layers of Moita do Sebastião were destroyed just before it was excavated by J. Roche and O.V. Ferreira between 1952–54. Nevertheless, this material represents a strong chronological framework. The nineteenth century excavations at Moita do Sebastião were done before the destruction of the site and these dates are coeval and consistent with the material excavated by J. Roche after the destruction of the top layers. This is further consistent with the suggestion that most nineteenth century material was excavated from the basal layers (Jackes and Alvim 2006).

In summary, in the Muge region, the first human burials are placed at Moita do Sebastião, and are immediately followed by a first burial at Cabeço da Arruda on the opposite margin of the river, in the transition between the 7th and 6th millennium cal BCE. During the first half of the 6th millennium cal BCE, between c. 6000–5600 cal BCE, the burial activity is frequent at these two sites, with occasional burials at Cabeço da Amoreira, near Moita do Sebastião. The burial activity ceases at Moita while the estuarine environment is still predominant in the region. It continues at Cabeço da Arruda and Amoreira but in a less frequent fashion. The last burials known were placed in these two sites by the end of the 6th millennium, coinciding with a decline in the tidal influence, gradually shifting from estuarine to a fluvial landscape (van der Schriek et al. 2007, 381). Overall, the burial activity is estimated to have continued in the Muge region for between 773 and 1113 years (95% probability), or for 846 and 1005 years (68% probability) (fig. 5.11).

This updated chronology for the burial activity at the Muge sites in the Tagus valley does not contradict the current chronological framework established for the Late Mesolithic in Portugal (c. 6350–5250 cal BCE, Araújo 2015), but strengthens it.
Figure 5.11. Chronological model for the burial activity at Moita do Sebastião, Cabeço da Arruda and Cabeço da Amoreira in the Tagus valley. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, Tagus valley, Moita do Sebastião, Cabeço da Arruda and Cabeço da Amoreira, Model 1, Marine 1.
Arapouco, Sado valley

**Antiquity of the site**

There is one reliable $^{14}$C date only on human bone collagen from Arapouco (ARA1962, Sk2A, Sac–1560, Cunha and Umbelino 2001). This $^{14}$C date has a probability density estimate of 6232–5713 cal BCE (95% confidence) which is consistent with a previous measurement on shells from the middle layers excavated in 1961–62 with a calibrated date range of 6374–5706 cal BCE (95% confidence) (table A8), and confirms the early chronology of the site. The association of these shells with the human burials is unknown.

**Burial activity: duration, start/end, frequency**

Current $^{14}$C data does not allow the estimation of duration, start/end, and frequency of the burial activity at Arapouco. This is a large site with a MNI of 32, and despite the poor collagen preservation at this site further $^{14}$C measurements should be tried in the future.

Cabeço das Amoreiras, Sado valley

The chronological model proposed for the burial activity at Cabeço das Amoreiras is presented in chapter 4 and is based on three $^{14}$C measurements on human remains. Despite the low number of dates this model can be considered representative of this assemblage, because the eight individuals recovered from this site (one of which is represented by an isolated cranium) were found in one stratigraphic layer (4, brownish sand) and lie in very close proximity.

**Antiquity of the site**

The new $^{14}$C dates do not confirm the antiquity of the burial activity at Cabeço das Amoreiras suggested by the burial previously dated (Beta–125110, individual 5).

**Burial ground during the Neolithic?**

New measurements reveal a later use of the site for burial purposes, and suggest that the burial episodes were spread over time. Despite the apparent scattering, all dates introduced in the model show good agreement and the model did not consider any outliers. The measurements on human bone collagen strongly indicate that the burial activity is a Mesolithic phenomenon.

The proposed model can account for the previous dates on non-human material (table A10). The measurement on shells (Q–AM85B2b, layer 2b, structure B) with a calibrated date range of 5476–5221 cal BCE (95% confidence) is coeval with the latest burial date available (Ua–47973, CAMS1958, Sk4). The measurement on unidentified charcoal (Q–AM85B2a, layer 2a, structure B) is relatively recent (5199–4707 cal BCE, 95% confidence). This charcoal was collected in the same structure as the dated shells, and without further data this sample should be
considered with caution. This later date on charcoal fits well with the few fragments of Neolithic ceramic found at this site (Diniz 2010), but this does not match the burial activity at the site.

**Burial activity: duration, start/end, frequency**

CAMS1958, Sk5 (Beta–125110) is the earliest burial known at the site with a posterior density estimate of \(6156–5914\) cal BCE (95% probability) (fig. 5.12). The latest use of the site for burial practice is represented by CAMS1958, Sk4 (Ua–47973) with a posterior density estimate of \(5483-5329\) cal BCE (95% probability), dated several centuries after the first burial at the site. The start and end of the burial activity at Cabeço das Amoreiras, represented by the dates of these two burials, is well framed in the currently proposed dates for the Late Mesolithic in Portugal (c 6350–5250 cal BCE; Araújo 2015).

The six to eight burials known at Cabeço das Amoreiras were excavated in a small area of c 25 m². The human remains were undisturbed and it was expected that these burials would be coeval in time. The new \(^{14}\)C results are surprising, showing a long duration of burial activity between \(487\) and \(744\) years (95% probability). At Cabeço das Amoreiras, burials were not frequent but the practice continued over a long period of time. It is also interesting that the burials were found undisturbed in a small area which was apparently used for one episodic burial every 100 years, or over four generations.

![Figure 5.12. Cabeço das Amoreiras, Sado valley: site plan and \(^{14}\)C dates.](image)

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Chapter 5

Vale de Romeiras, Sado valley

The chronological model proposed for the burial activity at Vale de Romeiras is presented in chapter 4 and is based on only two $^{14}$C measurements on human remains. Unfortunately, several samples submitted for analyses did not yield enough collagen or presented results that did not assure the quality of the measurements. This is a very small number of measurements compared with the MNI (26) buried in this site. Nevertheless, these are the first successful $^{14}$C dates obtained on human bone collagen from Vale de Romeiras, and although new measurements should be tried in the future, the preliminary model presented here provides valuable indications about the burial activity at the site.

Burial activity: duration, start/end, frequency

The earliest period of burial activity known at Vale de Romeiras is represented by the burial of the VR1959, Sk19 (Ua–46972) placed on top of the basal sand, isolated and apparently outside the area of the shell midden (fig. 5.13). The posterior density estimate for this burial is $6593–6370 \text{ cal BCE (95\% probability)}$ and indicates an early use of the site for burial practices. The second date (Ua–47983, VR1959, Sk9) is several centuries later, with a posterior density estimate of $5625–5475 \text{ cal BCE (95\% probability)}$. This burial is in the shell midden area and it was excavated also in the basal layer. These two $^{14}$C measurements indicate a long duration of burial activity of $779$ to $1074 \text{ years (95\% probability)}$ but it is unknown if the burial activity was more frequent during some periods of time or scattered over a long period. Despite the apparent scattering, the two dates introduced in the model show good agreement and the model did not indicate any outliers.

If the burial activity was scattered over time, this estimate suggests a frequency of not more than two burials every two generations, based on the MNI (26) recovered at the site and assuming the widest span of burial activity of 1074 years. However, the spatial relations of the burials and the homogeneity of the burial modes seem to indicate otherwise. The burial frequency was likely higher during certain period(s) of time, but further dates are required to support this hypothesis.

The start of the burial activity at Vale de Romeiras is represented by the burial of VR1959, Sk19 ($6593–6370 \text{ cal BCE, 95\% probability}$) which is slightly earlier than the currently proposed dates for the Late Mesolithic in Portugal (c 6350–5250 cal BCE). The end of the burial activity is represented by the burial of VR1959, Sk9 ($5625–5475 \text{ cal BCE, 95\% probability}$) which is well positioned in the chronological framework of the Late Mesolithic.

Previous $^{14}$C measurements on non-human samples from shells recovered from the middle layers (Arnaud 2000) suggested an early use of the site, presenting calibrated date ranges of $6416–6081 \text{ cal BCE (ICEN–150)}$ and $6370–6076 \text{ cal BCE (ICEN–146) (95\% confidence)}$ (table A11). Unfortunately, the relation of these samples to the human burials is unknown.
Coeval group of burials?

It has been suggested that the burials at Vale de Romeiras were possibly coeval, based on the spatial arrangement of the burials, organized in a semicircle. Also, because of the assumed small size of the site, it was suggested that this place was used as burial ground for the neighbouring site Cabeço do Pez (Arnaud 1989).

The 14C measurements indicate that the burials at Vale de Romeiras do not represent one coeval group, contra earlier suggestions (Arnaud 1989, 621) of a synchronic burial ground. However, these dates do not invalidate the earlier suggestion, which should be reformulated, to focus on possible synchronic burial subgroups within the burial ground. The chronological relationship with Cabeço do Pez is discussed below in Chronology of burial activity: implications for the local setting, Sado valley.

Unexpected modern 14C date of a child

A third successful 14C measurement on human bone from this site (Ua–46968, VR1959, Sk8) revealed a surprising calibrated date range of 1445–1632 cal CE (95% confidence) (table A2) falling into the early modern period in Europe. For this reason this measurement was not included in the model with the two Mesolithic dates. This individual is a child of 3–4 yrs ± 12 months and was interred in the centre of the burial area in the second layer (grey soil with shells) (fig. 5.13). A bone from this child was previously measured for 14C dating but did not yield results (Cunha et al. 2002, 189). The recent sample (Ua–46968) of a tibia passed all
quality checks and the quality of the measurements was further confirmed by the laboratory.

Despite the very unusual practice, it is probably not so strange that a local child of this time could be buried in a place like this. These inland sites have large concentrations of shells, and human bones are found occasionally on the surface. Local populations would have known about these places, possibly recognized them as ancient burial grounds, and incorporated them in local legends and mysticism. In Portugal, in the fifteenth and sixteenth centuries, and until the mid-nineteenth century, the dead were buried in religious buildings, and very few burials took place outside these precincts. In rural areas, such as Vale de Romeiras, the majority of the burials took place inside churches, and the open air burial of the poor who died in charitable hospitals for example, was viewed as a great indignity (Queiróz and Rugg 2003). The burial of this child in this most unusual place suggests a deviant practice of possibly a non-Christian minority which at the time were highly persecuted groups (Medina 2004). Nevertheless, it would be interesting to obtain a new measurement on this individual in order to confirm this most unusual episode.

Cabeço do Pez, Sado valley

The chronological model proposed for the burial activity at Cabeço do Pez is presented in chapter 4 and is based on five $^{14}$C measurements on human remains. Two samples are from area T.A, two are from area T.B, and one is from an isolated burial (fig. 5.14). This is a relatively low number of samples when compared with the MNI (n=32–36) buried in the site. Nevertheless, the four samples represent a good spatial coverage of both areas T.A and T.B (1956) where most individuals are closely placed. Also, the results obtained for the $^{14}$C measurements are remarkably consistent, except for the sample collected from the individual buried outside these two main clusters (Ua–46930, CP1956, Sk2), which presents a much later date.

Chronological relationship of the burial areas and isolated burials

The four $^{14}$C measures obtained from the two main areas (T.A and T.B, 1956) are coeval and present a calibrated date range of c 5700–5500 cal BCE (95% confidence), indicating a concentration in time and space of the burial activity at Cabeço do Pez.

One sample was collected from one of the three burials (CP1956, Sk2, Ua–46930) isolated outside the two main areas. The burial of this 1.5–2 year old child indicates a more recent burial activity at the site with a posterior density estimate of 4461–4266 cal BCE (95% probability). The chronology of this burial is a strong argument supporting the already suggested interpretation (Arnaud 2000, 32) of Cabeço do Pez as a shell midden developing during the Late Mesolithic with Neolithic episodes yet to be clearly defined.
Figure 5.14. Cabeço do Pez, Sado valley: site plan and $^{14}$C dates.
Burial activity: duration, start/end, frequency

When the 14C dates are plotted without the later date of Neolithic chronology (Ua–46930, CP1956, Sk2), the model indicates that the Mesolithic duration of the burial activity is remarkably short. In this case, the posterior density estimated for the duration of the burial activity is between 0 and 123 years (95% probability), or 0 and 58 years (68% probability) (figs. 5.15–17; table 5.4). If the burial of CP1956, Sk2 (Ua–46930) is included in the model, the posterior density estimated for the duration of the burial activity is between 1192–1412 years (95% probability), or 1246 and 1359 years (68% probability) (as presented in chapter 4).

The posterior density estimated for the start of the burial activity at Cabeço do Pez is coeval with the currently proposed dates for the Late Mesolithic in Portugal (c 6350–5250 cal BCE).

At Cabeço do Pez, during the Mesolithic, the burial activity concentrates in a very short period of time. The areas in use during the Mesolithic are located in two main clusters, T.A and T.B, where at least 24 burials were excavated. The few isolated burials could be of Neolithic chronology, as suggested by CP1956, Sk2, but this hypothesis must be confirmed with further data. At the moment, and assuming that the areas T.A and T.B were used during the Mesolithic for an estimated maximum time span of 123 years, it may be assumed that there was at least one burial every 5 years, indicating a high frequency of burial practice at the site.
Analysis and Synthesis of the Results

Figure 5.16. Duration of burial activity at Cabeço do Pez derived from the chronological model run without Ua–46930, CP1956, Sk2, calibrated with values for marine 1 diet. Posterior density estimated for the duration of the burial activity is between 0 and 123 years (95% probability), or 0 and 58 years (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Figure 5.17. Start and End of burial activity at Cabeço do Pez derived from the chronological model run without Ua–46930, CP1956, Sk2, calibrated with values for marine 1 diet. Posterior density estimated for the start of the burial activity is 5826–5578 cal BCE (95% probability) or 5706–5631 cal BCE (68% probability). Posterior density estimated for the end of the burial activity is 5678–5446 cal BCE (95% probability) or 5649–5565 cal BCE (68% probability). Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively.

Table 5.4. Posterior density estimates for the dates of archaeological events (Start/End) and the duration of burial activity at Cabeço do Pez. Data derived from model described in fig. 5.15.

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Modelled (cal BCE)</th>
<th>Modelled (cal BCE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marine 1</td>
<td>Marine 1</td>
</tr>
<tr>
<td>Posterior density estimate</td>
<td>(68% probability)</td>
<td>(95% probability)</td>
</tr>
<tr>
<td>Start of burial activity</td>
<td>5706–5631</td>
<td>5826–5578</td>
</tr>
<tr>
<td>End of burial activity</td>
<td>5649–5565</td>
<td>5678–5446</td>
</tr>
<tr>
<td>Span of burial activity, duration</td>
<td>0–58 yrs</td>
<td>0–123 yrs</td>
</tr>
<tr>
<td>Overall model agreement (Aoverall)</td>
<td>122%</td>
<td>122%</td>
</tr>
</tbody>
</table>
Chapter 5

The $^{14}$C measurements on human bone are consistent with the previous dates on shell samples excavated from the middle layers in 1983 (Arnaud 1989) with a calibrated date range of 5750–5494 cal BCE (Q–2497) and 5518–5299 cal BCE (Q–2496) (95% confidence) (table A12). The relation of these shell samples with the burials is unknown.

At Cabeço do Pez, the burial activity during the Mesolithic is short but frequent between 5826–5578 and 5678–5446 cal BCE (95% probability), with a frequency of one burial every five years. The data indicates that the site was also used during the Neolithic for burial purposes, as indicated by the date of the isolated burial CP1956, Sk2. The later activity at the site needs further research and the dating of CP1956, Sks 1, 3 also outside the two main clusters may eventually clarify this later episodic and apparently spread out burial activity. Nevertheless, the current model seems to be representative of the burial activity at Cabeço do Pez with one main period during the Late Mesolithic and a more episodic activity during the Neolithic.

If Cabeço do Pez was used as the burial ground of one residential group of hunter-gatherers (n=15 to 17), with a death rate of 0.3 or 0.5 per year (see chapter 2, Hunter-gatherer death rate vs burial population), the burial ground would aggregate in 123 years, c 37 or 62 human burials, respectively. The current lowest MNI (32) accounts for 87% or 52% of this hypothetical burial population (table 5.5). This estimate allows that some individuals may be buried in the site much later (maximum MNI 36).

### Table 5.5. Representativeness of the archaeological burial population at Cabeço do Pez in relation to the original group. Estimates assume a residential group unit of nomadic foragers of 15 to 17 people (after Binford 2001; Hamilton et al. 2007). Death rate estimates after M. Gurven and H. Kaplan (2007).

<table>
<thead>
<tr>
<th>Death rate/year</th>
<th>Burial activity span</th>
<th>Total burial population</th>
<th>MNI 32</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>123 yrs</td>
<td>37</td>
<td>87%</td>
</tr>
<tr>
<td>0.5</td>
<td>123 yrs</td>
<td>62</td>
<td>52%</td>
</tr>
</tbody>
</table>

Várzea da Mó, Sado valley

One human burial was excavated at this site (VM1959, Sk1). The burial of this individual has a probability density estimate of 5345–5071 cal BCE (95% confidence), which is coeval with the later stages of the currently proposed dates for the Late Mesolithic in Portugal (c 6350–5250 cal BCE).

A $^{14}$C date on a sample of shells (ICEN–273, table A13) recovered from the middle layers excavated in 1959, has a calibrated date range of 6067–5892 cal BCE (95% confidence) and indicates an earlier use of the site. The relation of this deposit of shells and the human burial is unknown.
Analysis and Synthesis of the Results

Chronology of burial activity: implications for the local setting, Sado valley

The chronology of the burial activity proposed for the shell midden sites of the Sado valley is based on the data available for: Arapouco, Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó (fig. 5.18). The $^{14}$C data available for Poças de S. Bento (MNI 15) consists of one measurement on human bone of uncertain calibration (Ua–425, PSB1986, Skull) and several non-human samples (table A14). The chronological interpretation of the burial activity at this site is limited, but the data is included here for a more robust analysis at the level of the local setting.

The new $^{14}$C dates suggest that the first human burials in the Sado valley were placed at Vale de Romeiras, as indicated by the burial of VR1959, Sk19 (Ua–47983, $6593–6370 \text{ cal BCE, 95\% probability}$). This is an isolated early date (fig. 5.18) followed by burials at Arapouco (ARA1962, Sk2A, Sac–1560, $6232–5713 \text{ cal BCE, 95\% confidence}$) and at Cabeço das Amoreiras (CAMS1958, Sk5, Beta-125110, $6156–5914 \text{ cal BCE, 95\% probability}$).

These earlier burials are followed by the most active period of burial practice in the Sado valley. Between c 5750–5500 cal BCE the burial activity is frequent at Cabeço do Pez, and is coeval with the burials of VR1959, Sk9 (Ua–47983) in the neighbouring site of Vale de Romeiras, and with the burial of CAMS1959, Sk7 (Ua–47974) at Cabeço das Amoreiras.

The only burial known at Várzea da Mó (VM1959, Sk1, Ua–46310) is also the last burial of Mesolithic chronology known at the Sado valley (5345–5071 cal BCE, 95% confidence). This burial is later than any known Mesolithic burial activity in the valley, but future data from Vale de Romeiras and Poças de S. Bento may eventually change this scenario.

Cabeço do Pez is also used for burial practices during the Neolithic. This also seems to be the case at Poças de S. Bento (Larsson 2010). At Cabeço do Pez, this is suggested by the burial of a child, outside the main burial areas, presenting a posterior density estimate of $4461–4266 \text{ cal BCE (95\% probability)}$, coeval with the early stages of the Middle Neolithic in Portugal (c 4500–3500 cal BCE, Neves and Diniz 2014). At Poças de S. Bento, burial practices coeval with the Neolithic are indicated by the $^{14}$C of a skull excavated in 1986 in the basal sand (Larsson 2010). The calibration of this measurement is unreliable due to the lack of stable isotopic measurements. However, its calibrated date range should be around 4400–3800 cal BCE (95% confidence), depending on the higher or lower offset (see chapter 2, Poças de S. Bento).
In summary, in the Sado valley, the first human burial is placed at Vale de Romeiras in the very early stages of the Late Mesolithic. Only a few centuries later, new burials take place at Arapouco and Cabeço das Amoreiras, also isolated chronologically. The most frequent period of burial activity takes place between c 5750–5500 cal BCE with burials mainly at Cabeço do Pez, but also at Vale de Romeiras and Cabeço das Amoreiras. After c 5500 the burial activity is less frequent, and one burial is known at Cabeço das Amoreiras, followed by the last burial of Mesolithic chronology at Várzea da Mó.
There is a lack of dates for Arapouco which could arguably strengthen the chronology of the earlier phases of burial activity in the valley. Also, further 14C dates at Vale de Romeiras could clarify the chronology of this site, suggested to be the Cabeço do Pez burial ground (Arnaud 1989, 621).

This updated chronology for the burial activity at these four sites does not contradict the current chronological framework established for the Late Mesolithic in Portugal (c 6350–5250 cal BCE; Araújo 2015), rather it strengthens it. Nevertheless, Cabeço do Pez presents the interesting case of two moments of burial activity: one during the Mesolithic and one coeval with the early stages of the Middle Neolithic in Portugal. Further dates on the isolated burials found in this site could potentially strengthen the case for the Neolithic use of the site for burial practice. This is possibly also the case at Poças de S. Bento, but the 14C data on human remains is insufficient for further analysis of the burial activity at the site.

Tagus vs Sado
At both Tagus and Sado valleys, the burial activity is more frequent between c 6000 and 5500 cal BCE. This is well attested by the burial frequency during this time period at Moita do Sebastião (c 6000–5600 cal BCE), Cabeço da Arruda (c 5900–5700 cal BCE), and Cabeço do Pez (c 5600 cal BCE). Based on the spatial distribution of the burials and on the homogeneity of the burial modes, I suggest that this could also be the case at Arapouco and Vale de Romeiras, although at present there are few 14C measurements to confirm this hypothesis.

In both valleys, we find early episodes of human burial activity, during the very first phases of the Late Mesolithic in Portugal (c 6350 cal BCE). The earliest human burial known in any of these shell middens (VR1959, Sk19, 6593–6370 cal BCE) is found at Vale de Romeiras in the Sado valley. Early burials are found also at Moita do Sebastião in the Tagus valley, although with slightly later posterior density estimate (MS1952–54, Sk9, 6218–5998 cal BCE; MS1952–54, Sk1, 6218–5998 cal BCE). These first episodes of burial activity are followed by the earliest burials known at Arapouco (Sado, ARA1962, Sk2A, 6232–5713 cal BCE), Cabeço das Amoreiras (Sado, CAMS1958, Sk5, 6156–5914 cal BCE) and Cabeço da Arruda (Tagus, CAR1937, Sk6, 6133–5852 cal BCE).

Overall, the sites are used for burial practices more or less synchronously. The one exception is Várzea da Mó at the Sado valley, with one burial known, coeval only with the later burial activity at Cabeço da Amoreira and Cabeço da Arruda in the Tagus valley.

After c 5500 cal BCE, the frequency of burial practice decreases dramatically, in both the Tagus and Sado valleys. At this time period, the burial activity seems to be more active at Cabeço da Amoreira and Cabeço da Arruda in the Tagus valley, with two coeval burials known at the Cabeço das Amoreiras and Várzea da Mó in the Sado valley.

In both valleys, certain sites such as at Moita do Sebastião and Cabeço da Arruda in the Tagus valley and Cabeço do Pez in the Sado valley, show frequent
and continuous burial activity over a relatively short period of time. Other sites, such as Cabeço da Amoreira in the Tagus valley or Cabeço das Amoreiras at Sado, present a more scattered activity pattern along with lower frequency of burials, with a more or less continuous burial activity over a long period of time. Arapouco and Vale de Romeiras in the Sado valley present a high spatial concentration of human burials, however, the current chronological data do not allow further observations at this level.

Burial activity is a Late Mesolithic phenomenon at both the Tagus and Sado valleys. Two exceptions are presented by the burial of a child at Cabeço do Pez (CP1956, Sk2, 4461–4266 cal BCE), and one adult (?) at Poças de S. Bento (PSB1986, Skull, c 4400–3800 cal BCE) which are coeval with Middle Neolithic groups in Portugal. Another interesting case of the later use of these sites for human burial is given by the early modern burial of a child at Vale de Romeiras (VR1959, Sk8, 1445–1632 cal CE).

In terms of chronological patterns, the burial activity at the Tagus and Sado valleys is coherent, although much more frequent at Moita do Sebastião and Cabeço da Arruda in the Tagus valley, possibly related to differential demography.

This updated chronology for the burial activity at these sites does not contradict the current chronological framework established for the Late Mesolithic in Portugal, rather it strengthens it.
Figure 5.19. Chronological model for the burial activity at the Tagus (Muge) and Sado valleys. For each of the dates two distributions have been plotted, one in outline which is the result produced by the scientific evidence alone, and a solid one which is based on the chronological model used. Calibrated ranges of 95% and 68% probability are given by the lower and higher square brackets respectively. The large square brackets (left) and the OxCal keywords define the overall model. Model-definition command files in appendix, Tagus and Sado valleys, human remains, Model 1, Marine 1.
Isotopic signatures: defining the people in each burial place

Moita do Sebastião, Tagus valley

At Moita do Sebastião, the human collagen samples (n=21/no. individuals=18) display stable isotope values ranging between −18.4‰ and −15.3‰ (−16.9 ± 0.7‰, mean ± SD) for carbon, and +9.0 to +14.0‰ (+11.1 ± 1.3‰) for nitrogen (n=20/no. individuals=18) (table 5.6). These values are indicative of the consumption of a mixture of marine-estuarine and terrestrial food resources, although with significant intra-individual variation among some individuals. Some individuals were sampled more than once and present slightly different stable isotope values. However, if the multiple measurements (Umbelino 2006) are excluded, the ranges remain the same and the means are not statistically different: −17.0 ± 0.8‰ for δ¹³C and +11.0 ± 1.4‰ for δ¹⁵N. For consistency in the case of multiple sets of values, the discussion is based on the individual values obtained in the course of this study (Ua–number).

The highest δ¹⁵N values derive from three individuals: MS19th c., SkCT; 1952–54, Sks 22, 25. Two are children under two years old (Sks 22, 25) and their elevated δ¹⁵N values (+12.2, +14.0) may be explained as a result of bioenrichment from breast milk consumption (Fogel et al. 1989). However, individual CT is an adult male (Mary Jackes, pers. comm.) and his high δ¹⁵N value (+13.4) is clear outlier to the Moita do Sebastião series. The mean δ¹⁵N value calculated without these three individuals is +10.6 ± 1.0‰ presenting slightly smaller standard deviation, however, still moderately high.

The δ¹³C and δ¹⁵N values fluctuate over time and do not follow any particular tendency (figs. 5.20, 5.21). The earliest burials at Moita do Sebastião (MS1952–54, Sks 9, 1) present equivalent stable isotope values (table 5.6), also consistent with the mean values of the series. The δ¹³C values derived from the individuals buried during the main period of burial activity (n=13) are consistent with the mean values of the series and present small intra-individual variation (−16.9 ± 0.5‰). The δ¹⁵N values present larger standard deviation and indicate moderate intra-individual variation (+11.1 ± 1.4‰). As discussed, the highest δ¹⁵N values are derived from the two children in the group (MS1952–54, Sks 22, 25) possibly due to a breastfeeding effect. However, even when these two individuals are excluded from the group the standard deviation is still moderately high (+10.7 ± 1.0). The latest period of burial activity at the site is represented by three individuals (MS19th c., SkCT; 1952–54, Sks 10, 33). Two of these individuals (Sks 10, 33) present slightly lower δ¹³C values indicating a group with higher consumption of terrestrial foods. In contrast, the values derived from individual CT are obtained from marine-estuarine sources. This distinct isotopic profile (MS19th c., SkCT) presents the highest set of values for δ¹³C and δ¹⁵N among the adults.

Overall, the intra-individual variation at Moita do Sebastião is low to moderate suggesting that the people buried in this place had a fairly similar pattern of protein
consumption. Towards the end of the burial activity the isotopic signatures are more heterogeneous and the individuals buried during this later stage present not only the lowest but also the highest $\delta^{13}$C values of the series. The new $\delta^{13}$C value obtained for MS1952–54, Sk10 (–18.2, Ua–47978) is slightly lower than the previous value available for this same individual (–16.6, Umbelino 2006). While the latter value is not in contrast with most of the series, the new value is. This difference could be explained by contamination of the sample or other difficulties during the measuring process. The C:N ratio for the new measurement (Ua–47978, C:N=3.4, $\delta^{13}$C= –18.2) is acceptable but it is at the limit of the quality parameter (2.9–3.4/3.6) (see chapter 3, Reliability of the isotopic measurements). Unfortunately, the C:N parameter is not available for the earlier measurements of this skeleton (Umbelino 2006), and for this reason the new measurements are those used in the discussion of the results.

One $^{14}$C measurement (Beta–127499, Cunha and Cardoso 2002–03; Cunha et al. 2003) was excluded from this study because the only $\delta^{13}$C value available was obtained on an AMS instrument during the radiocarbon dating process making the calibration of this $^{14}$C date highly uncertain. Nevertheless, the original AMS measurement of –16.8‰ for carbon (Beta–127499), is in line with the current isotopic series for Moita do Sebastião suggesting possible low offset from an isotope-ratio mass spectrometry (IRMS) measurement, which must be confirmed with future measurements.
Table 5.6. Moita do Sebastião, Tagus valley: chronology and stable isotope values ($\delta^{13}C$ and $\delta^{15}N$) of human bone collagen. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements (IRMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual</strong></td>
<td><strong>Age</strong></td>
</tr>
<tr>
<td>33, 1952–54</td>
<td>Adult</td>
</tr>
<tr>
<td>10, 1952–54</td>
<td>Adult, 35–50 yrs</td>
</tr>
<tr>
<td>15, 1952–54</td>
<td>Adult, 25–35 yrs</td>
</tr>
<tr>
<td>30, 1952–54</td>
<td>Adult</td>
</tr>
<tr>
<td>18, 1952–54</td>
<td>Adult</td>
</tr>
<tr>
<td>17, 1952–54</td>
<td>Adult</td>
</tr>
<tr>
<td>22, 1952–54</td>
<td>Non-adult</td>
</tr>
</tbody>
</table>

*continued...*
| 5, 1952–54 | Adult | ♂ | Ua–47977 | 7138±42 | 5972–5672 | –16.9, this study |
| 31, 1952–54 | Adult | ♀ | Ua–46269 | 7141±40 | 5979–5718 | –17.4, this study |
| 34, 1952–54 | Adult, old | ♂ | Ua–46271 | 7236±41 | 5991–5734 | –16.3, this study |
| 25, 1952–54 | Non-adult | n/d | Ua–46268 | 7243±45 | 5998–5736 | –16.2, this study |
| 29, 19th c. | Adult | ♀ | TO–133 | 7200±70 | 6017–5707 | –16.9, Lubell et al. 1994 |
| 1, 1952–54 | Adult | n/d | Ua–46263 | 7483±48 | 6218–5998 | –17.0, this study |
| 9, 1952–54 | Adult | ♂ | Ua–46264 | 7621±50 | 6292–6023 | –17.0, this study |
Figure 5.20. Moita do Sebastião, Tagus valley: variation of $\delta^{13}C$ (‰) over time (cal BCE, 95% probability) of 21 samples of human bone collagen from 18 individuals. Individuals 10 (circle), 15 (triangle) and 31 (open square) have two sets of $\delta^{13}C$ values.

Figure 5.21. Moita do Sebastião, Tagus valley: variation of $\delta^{15}N$ (‰) over time (cal BCE, 95% probability) of 20 samples of human bone collagen from 18 individuals. Individuals 10 (circle) and 31 (open square) have two sets of $\delta^{15}N$ values. The non-adults are indicated by grey square.
Cabeço da Arruda, Tagus valley

At Cabeço da Arruda, the human collagen samples (n=16/no. individuals=14) display stable isotope values ranging between –19.0‰ and –15.3‰ (–17.3 ± 1.0‰) for carbon, and +9.5 to +12.0‰ (+11.0 ± 0.9‰) for nitrogen (n=16/no. individuals=14) (table 5.7). These values are indicative of the consumption of a mixture of marine-estuarine and terrestrial food resources, although with chronological and intra-individual variation. Some individuals were sampled more than once and present slightly different stable isotope values. However, if the multiple measurements (Umbelino 2006) are excluded, the ranges remain the same and the means are not statistically different: –17.4 ± 1.0‰ for δ¹³C and +10.9 ± 0.9‰ for δ¹⁵N. For consistency in the case of multiple sets of values, the discussion is based on the individual values obtained in the scope of this study (Ua–number).

The δ¹³C variation over time is not linear and does not follow any particular tendency (fig. 5.22). The δ¹³C values are more homogeneous during the early/main burial activity and more heterogeneous within the main/later burials. In comparison, the δ¹⁵N variation is more homogeneous over time (fig. 5.23). The earliest burial at Cabeço da Arruda (CAR1937, Sk6) presents a slightly higher marine-estuarine diet component than the mean values of the series. Stable isotope values derived from the individuals (n=11) buried during the main period of burial activity are consistent with the mean values of the series and present moderate intra-individual variation. Isotopic signatures are –17.6 ± 0.8‰ and +10.8 ± 0.9‰ for carbon and nitrogen, respectively. The individuals with the oldest dates in this group present coherent δ¹³C values and slight variation regarding the δ¹⁵N values. Following burial episodes, samples dating to between c 5800–5700 cal BCE present the greatest intra-individual variation, suggesting a heterogeneous diet among these individuals. One adult male (CAR19th c., SkA) presents the lowest δ¹³C value (–19.0‰) paired with a relatively high δ¹⁵N value (+12.2‰). This set of values is unusual at Cabeço da Arruda and suggests a significant consumption of freshwater foods. Alternatively, these values could be explained as the result of contamination of the sample, showing an anomalous negative value for carbon paired with a more positive value for nitrogen (see chapter 3, Reliability of the isotopic measurements).

However, the problem of contamination is difficult to confirm because the values of carbon and nitrogen are in the normal ranges, although outlier to the series. Also, the C:N ratio was reported to be within the accepted quality range (Lubell et al. 1994, 204), although the precise values were not published. Thus, without further data, this set of values is accepted, and the hypothesis of a diet rich in freshwater foods is put forward as a possible explanation for this particular isotopic profile. The last episode of burial activity at the site is represented by one old adult male (CAR19th c., SkN). The stable isotopes derived from this individual are the highest at Cabeço da Arruda and are clearly indicative of a high intake of marine-estuarine foods.

Intra-individual variation at Cabeço da Arruda is moderately high, particularly after c 5800 cal BCE. While most individuals present δ¹³C values between
c –16.5‰ and –18.0‰, a smaller group presents highly variable values outside this range. This suggests that some of the individuals buried at Cabeço da Arruda had fairly different patterns of protein consumption, contributing to the isotopic heterogeneity represented at the site.
# Table 5.7. Cabeço da Arruda, Tagus valley: chronology and stable isotope values (δ¹³C and δ¹⁵N) of human bone collagen. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements (IRMS)</th>
</tr>
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<td>Individual</td>
<td>Age</td>
</tr>
<tr>
<td>-----------</td>
<td>-----</td>
</tr>
<tr>
<td>CA–00–01, 2000</td>
<td>Non-adult</td>
</tr>
<tr>
<td>D, 19th c.</td>
<td>Adult</td>
</tr>
<tr>
<td>42, 19th c.</td>
<td>Adult, 20–24 yrs</td>
</tr>
<tr>
<td>2, 1937</td>
<td>Adult</td>
</tr>
<tr>
<td>CA–00–02, 2000</td>
<td>n/p</td>
</tr>
<tr>
<td>1, 1937</td>
<td>Adult</td>
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continued…
Table 5.7. continued

<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>Sex</th>
<th>Sample Code</th>
<th>Age Mean ± SD</th>
<th>Age Range</th>
<th>Reference</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>3, 1937</td>
<td>Adult</td>
<td>♂</td>
<td>Ua–46273</td>
<td>7198±40</td>
<td>5993–5745</td>
<td>10.1, this study</td>
<td>Main</td>
</tr>
<tr>
<td>9, 1937</td>
<td>Adult</td>
<td>n/d</td>
<td>Ua–46274</td>
<td>7200±41</td>
<td>5998–5748</td>
<td>10.6, this study</td>
<td>Main</td>
</tr>
<tr>
<td>4, 1964–65</td>
<td>Adult</td>
<td>n/d</td>
<td>Ua–47976</td>
<td>7261±45</td>
<td>6021–5766</td>
<td>9.7, this study</td>
<td>Main</td>
</tr>
<tr>
<td>10, 1937</td>
<td>Adult</td>
<td>♂</td>
<td>Ua–46275</td>
<td>7263±46</td>
<td>6049–5798</td>
<td>11.4, this study</td>
<td>Main</td>
</tr>
</tbody>
</table>
Figure 5.22. Cabeço da Arruda, Tagus valley: variation of $\delta^{13}C$ (‰) over time (cal BCE, 95% probability) of 16 samples of human bone collagen from 14 individuals. Individuals 10 (triangle) and 1 (circle) have two sets of $\delta^{13}C$ values.

Figure 5.23. Cabeço da Arruda, Tagus valley: variation of $\delta^{15}N$ (‰) over time (cal BCE, 95% probability) of 16 samples of human bone collagen from 14 individuals. Individuals 10 (triangle) and 1 (circle) have two sets of $\delta^{15}N$ values.
Cabeço da Amoreira, Tagus valley

Material from Cabeço da Amoreira was not sampled or analysed in the scope of this study. However, the published data are important resources for comparison with the data from Moita do Sebastião and Cabeço da Arruda, allowing a more robust analysis of the local setting.

At Cabeço da Amoreira, the human collagen samples of 14C dated individuals display stable isotope values ranging between −20.1‰ and −15.8‰ (−17.0 ± 1.8‰) for carbon (n=5), and +8.2 to +13.9‰ (+11.8 ± 2.5‰) for nitrogen (n=4) (tables 5.8, 5.9, figs. 5.24, 5.25). If all isotopic data is included, dated and non-dated, the mean value is −16.4 ± 1.5‰ for carbon (n=9), which is very similar to the mean value obtained for the 14C dated individuals only. In the case of δ15N (n=8), the standard deviation for the whole data set is slightly lower +12.0 ± 1.7‰, although still high. This apparently high intra-individual variation depends on the values derived from one individual, who presents the lowest isotopic values in the series. The isotopic signature for this individual (CAM–01–01, bone 139) indicates a full terrestrial diet in contrast to the remaining measurements of the series which present a balanced consumption of marine-estuarine and terrestrial foods. If this set of values is excluded the stable isotope values for the series range between −16.9‰ and −15.8‰ for carbon and +11.9 and +13.9 for nitrogen. The mean values for the dated series are very similar when all values are taken into account, dated and non-dated: −16.3 ± 0.5‰ (n=4) or −16.0 ± 0.6‰ (n=8) for carbon and +13.0 ± 0.8‰ (n=3) or +12.6 ± 0.7‰ (n=7) for nitrogen.

The intra-individual variation at Cabeço da Amoreira is relatively low suggesting that the people buried in this place had a fairly similar pattern of protein consumption. One individual (CAM–01–01, bone 139) is an outlier and presents a radically different isotopic signature suggesting a very different pattern of protein consumption.

Table 5.8. Cabeço da Amoreira, Tagus valley: stable isotope values (δ13C and δ15N) of human bone collagen without associated 14C date. Samples are sorted so that the lowest δ13C values are on the top of the column.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements (IRMS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>Age</td>
</tr>
<tr>
<td>7, 1930–33</td>
<td>Adult</td>
</tr>
<tr>
<td>4, 1930–33</td>
<td>Adult</td>
</tr>
<tr>
<td>8, 1930–33</td>
<td>Adult, mature</td>
</tr>
<tr>
<td>6, 1930–33</td>
<td>Adult, mature</td>
</tr>
</tbody>
</table>
Table 5.9. Cabeço da Amoreira, Tagus valley: chronology and stable isotope values ($\delta^{13}$C and $\delta^{15}$N) of human bone collagen. CAM–00–01, TO–11819–R replaces the previous measurements TO–10218 (Meiklejohn et al. 2009a). Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Lab no.</th>
<th>$^{14}$C Age BP</th>
<th>Post. density estimate (95% probability)</th>
<th>$\delta^{13}$C ($%o$)</th>
<th>$\delta^{15}$N ($%o$)</th>
</tr>
</thead>
</table>
Figure 5.24. Cabeço da Amoreira, Tagus valley: variation of $\delta^{13}C$ (‰) over time (cal BCE, 95% probability) of 5 samples of human bone collagen from 5 individuals.

Figure 5.25. Cabeço da Amoreira, Tagus valley: variation of $\delta^{15}N$ (‰) over time (cal BCE, 95% probability) of 4 samples of human bone collagen from 4 individuals.
Isotopic signatures and implications for the local setting, Tagus valley

Overall, the isotopic signatures for the individuals buried in the shell middens of the Tagus valley show low to moderate intra-individual variability. The profiles reflect the consumption of a mixture of marine-estuarine and terrestrial resources, suggesting the consumption of foods that could have been collected by the shores of the estuary near the shell midden sites, as well as the intake of terrestrial foods that could have been collected in the immediate vicinity of the sites and/or further inland. In fact, the isotopic signatures are derived mostly from terrestrial foods, plants and animals. Few individuals (c n=8) derive their isotopes from the intake of 50% or more of marine-estuarine food sources. These results are in agreement with previous trace element studies suggesting an overall inter-site homogeneity, characterized by a mixed and diverse diet, based on marine-estuarine and terrestrial resources including a range of faunal and floral foods (Umbelino 2006).

Samples from individuals dating to the main period of burial activity at the Tagus valley are homogenous, and most individuals present similar isotopic signatures. The values become more heterogeneous towards the end of the activity (figs. 5.26, 5.27). Interestingly, only two individuals stand out as clear outliers to the general pattern:

- one adult male buried at Cabeço da Arruda (CAR19th c., SkA, 5902–5617 cal BCE) has a signature usually associated with considerable intake of freshwater fish supplemented with terrestrial sources of protein ($\delta^{13}C = -19.0\%o$, $\delta^{15}N = +12.2\%o$);
- one adult buried at Cabeço da Amoreira (CAM–01–01, bone 139, 5613–5296 cal BCE) has a typical terrestrial signature ($\delta^{13}C = -20.1\%o$, $\delta^{15}N = +8.2\%o$).
Chapter 5

Figure 5.26. Moita do Sebastião, Cabeço da Arruda and Cabeço das Amoreiras, Tagus valley: bone collagen δ¹³C over time (cal BCE, 95% probability). At the Tagus valley, the main period of burial activity is homogenous in terms of dietary sources, and most individuals present similar isotopic signatures. Towards the end of the activity the values become more heterogeneous. Dashed outline: the two outliers of the series (CAR19th c., SkA; CAM–01–01, 139). Individuals MS1952–54, Sks 10 (open square), 15 (grey square with outline), 31 (grey square), and CAR1937, Sks 1 (open triangle), 10 (grey triangle with outline) have two sets of δ¹³C values.

Figure 5.27. Moita do Sebastião, Cabeço da Arruda and Cabeço das Amoreiras, Tagus valley: bone collagen δ¹⁵N over time (cal BCE, 95% probability). Dashed outline: the two outliers of the series (CAR19th c., SkA; CAM–01–01, 139). Individuals MS1952–54, Sks 10 (open square), 31 (grey square), and CAR1937, Sks 1 (open triangle), 10 (grey triangle with outline) have two sets of δ¹⁵N values.
When the isotopic data is analysed over time the homogeneity of the profiles becomes more evident. During the earliest period of burial activity (fig. 5.28, map 1), the individuals buried at Moita do Sebastião (n=2) and Cabeço da Arruda (n=1) present equivalent isotopic signatures (−16.9 ± 0.2‰ for carbon and +10.7 ± 0.2‰ for nitrogen), indicating no inter-site variability at the isotopic level.

At the start of the main burial activity at the Tagus valley (fig. 5.28, map 2) there is a moderate variation in the trophic levels of the foods consumed, as suggested by the nitrogen values (+9.7‰ to +12.2‰, +10.9 ± 1.1‰). In every case the intra-individual variation is lower than +2.0‰. At Moita do Sebastião, MS19th c., Sk22 consumed marine-estuarine foods on average one trophic level higher than MS19th c., Sk29. The δ15N enrichment is just +1.8‰, which is lower than the estimated trophic level enrichment of nitrogen for mammals (2 to 4‰, see chapter 3, Stable isotope analysis of carbon and nitrogen). Similarly, at Cabeço da Arruda the isotopic signatures suggest that CAR1937, Sk10 consumed marine-estuarine foods on average one trophic level higher than CAR1937, Sk4, however the δ15N enrichment is just +1.7‰. At the start of the main burial activity at the Tagus valley the intra-individual carbon variability is low, and carbon values range from −17.4‰ and −16.1‰ (−16.8 ± 0.5‰) at the three sites. Overall, the inter-site variability is low to moderate and only two individuals present an average consumption of foods from different trophic levels, as indicated by the nitrogen enrichment (+2.5‰) between MS19th c., Sk22 (adult female, −16.1‰/+12.2‰) and Cabeço da Arruda 4 (adult, 17.1‰/+9.7‰).

During the main period of burial activity the isotopic signatures are fairly consistent and the intra-individual variability is low to moderate. For the benefit of comparison I divided this main period into two maps (fig. 5.29, maps 3 and 4), although the division is artificial because most of these individuals are probably contemporaneous and could be represented on one map. In map 3, the isotopic values derived from Moita do Sebastião (n=7) range from −17.4‰ and −16.2‰ (−16.7 ± 0.4‰) for carbon, and +9.3‰ to +14.0‰ (+11.7 ± 1.5‰) for nitrogen. As discussed, the large standard deviation observed for the nitrogen values is derived from two children possibly benefiting from breastfeeding, and without their values the range is +9.3‰ to +11.9‰ (+11.0 ± 1.1‰). Nevertheless, there is a moderate variability between three adult males. One adult indicates the average consumption of protein from lower trophic levels (MS1952–54, Sk5; δ15N= +9.3‰). The other two adults (MS19th c., Sk24; 1952–54, Sk34; δ15N= +11.9‰) show an average intake of protein one trophic level higher (+2.6‰) than the latter individual. At Cabeço da Arruda (n=7), the isotopic values range from −19.0‰ and −16.6‰ (−17.5 ± 0.8‰) for carbon and +9.5‰ to +12.2‰ (+10.5 ± 0.7‰) for nitrogen. One adult male (CAR19th c., SkA) presents an odd isotopic profile (δ13C= −19.0‰, δ15N= +12.2‰) in relation to this series. If his values are excluded, the isotopic values display a shorter range from −17.9‰ and −16.6‰ (−17.3 ± 0.5‰) for carbon and +9.5‰ to +11.2‰ (+10.5 ± 0.7‰) for nitrogen.
Figure 5.28. Maps 1 and 2 represent temporal moments of burial activity at the Tagus valley and display the $^{14}$C dated human burials at each site. The burials are identified by skeleton number, excavation year, $^{14}$C date (cal BCE, 95% probability), $\delta^{13}$C, and $\delta^{15}$N.
Figure 5.29. Maps 3 and 4 represent temporal moments of burial activity at the Tagus valley and display the $^{14}$C dated human burials at each site. The burials are identified by skeleton number, excavation year, $^{14}$C date (cal BCE, 95% probability), $\delta^{13}$C, and $\delta^{15}$N.
As observed at Moita do Sebastião, at Cabeço da Arruda there is also a moderate variability between three individuals, one indicating the consumption of protein from lower trophic levels (CAR1937, Sk2; \(\delta^{15}N = +9.5\%\)) while two individuals (CAR19th c., SkIII; 1937, Sk1; \(\delta^{15}N = +11.2\%\)) present an average intake of protein of a higher trophic level, although the increase is only +1.7\% (trophic level increase, 2 to 4\%). If the values of the two breastfeeding children at Moita do Sebastião (MS1952–54, Sks 22, 25) and the outlier at Cabeço da Arruda (CAR19th c., SkA) are excluded, the inter-site variability is low (–17.1 ± 0.5\% for carbon and +10.7 ± 0.9\% for nitrogen). The variability observed for the nitrogen values remains moderate due to the low values derived from one individual at each site (MS1952–54, Sk5; \(\delta^{15}N = +9.3\%\) and CAR1937, Sk2; \(\delta^{15}N = +9.5\%\)), confirming once again the low intra-individual variability between the burial places.

Overall, the individuals buried at Moita do Sebastião and Cabeço da Arruda present similar isotopic signatures and the deceased could belong either to the same group or to different groups deriving their isotopes from similar sources. As discussed, one individual presents an odd isotopic profile (CAR19th c., SkA, adult male, \(\delta^{13}C = –19.0\%\), \(\delta^{15}N = +12.2\%\)), possibly derived from an important consumption of freshwater foods, suggesting a different environment where this individual would have spent most of his time over the last years of his life. Likewise, the burials represented in map 4 present low \(\delta^{13}C\) inter-site variation ranging from –17.9\% and –16.0\% (–17.0 ± 0.6\%). The variation of \(\delta^{15}N\) is higher (9.5\% to 13.9\%; +11.0 ± 1.6\%) mainly due to the values derived from a child buried at Cabeço da Amoreira (burial 2011.1). If these values are excluded the range is smaller from +9.5\% to +11.8\% (+10.4 ± 0.9\%), but still moderate due to the difference between MS1952–54, Sk17 (\(\delta^{13}C = –16.8\%\), \(\delta^{15}N = +9.5\%\)) and CAR19th c., Sk 42 (\(\delta^{13}C = –17.2\%\), \(\delta^{15}N = +11.8\%\)) derived from foods of one trophic level higher (+2.3\%).

The overall homogeneity observed so far changes during the later stages of burial activity (fig. 5.30, map 5), as indicated by the larger isotopic variability. At Moita do Sebastião (n=3) the isotopic values range from –18.4\% and –15.3\% (–17.3 ± 1.7\%) for carbon and +9.0\% to +13.4\% (11.0 ± 2.2\%) for nitrogen. This heterogeneity derives from two distinct signature groups buried in the site. One is represented by two individuals with a range from –18.2\% to –18.4\% (–18.3 ± 0.1\%) for carbon and +9.0\% to +10.5\% (+9.8 ± 1.1\%) for nitrogen. A second group is represented by one individual with higher values both for carbon (–15.3\%) and for nitrogen (+13.4\%). At Cabeço da Arruda (n=2) the variability is low (\(\delta^{13}C = –18.5 ± 0.6\%\), \(\delta^{15}N = +10.4 ± 0.1\%\)) and similar to one of the groups buried at Moita do Sebastião. At Cabeço da Amoreira (n=2) the inter-individual variability is much higher (–18.0 ± 3.0\%, 10.6 ± 3.3\%). Here, one individual presents a clearly marine-estuarine diet (\(\delta^{13}C = –15.8\%\), \(\delta^{15}N = +12.9\%\)) while the other individual derives its isotopes from terrestrial sources (\(\delta^{13}C = –20.1\%\), \(\delta^{15}N = +8.2\%\)). Each individual presents similar isotopic signatures to the two groups identified at Moita do Sebastião.
During this later period of burial activity there are two distinct isotopic signatures representing different dietary groups buried in these sites. One group (n=4) was buried at Moita do Sebastião and Cabeço da Arruda and derived their isotopes from a mixture of atmospheric and aquatic reservoirs but with a high intake of terrestrial foods (mixed, high terrestrial). The other main group (n=2), buried at Moita do Sebastião and Cabeço da Amoreira also depended on mixed reservoirs but the intake of marine foods was higher (mixed, high aquatic), and in contrast with the other group. A possible third group is represented by one individual buried at Cabeço da Amoreira, which could be considered an outlier to the series due to its low carbon values clearly indicative of a full terrestrial diet. Despite their differences, the two main groups were coherent with the ecology of the sites. The latter individual was clearly an outlier, possibly from inland origin. The two dietary groups (mixed, high terrestrial and mixed, high aquatic) were found at Moita do Sebastião in distinct areas within the burial ground. The mixed, high terrestrial group (MS1952–54, Sks 10, 33) was buried in the area excavated in the 1950s while the mixed, high aquatic individual (MS19th c., SkCT) was buried in the nineteenth century area. Likewise, at Cabeço da Amoreira the individuals with distinct isotopic signatures were excavated from two different areas. The outlier CAM–01–01 (139) was excavated at the J. Rolão area (c 20–60 cm below present day surface, Roksandic 2006), while the burial 2011.2 with the mixed, high aquatic diet was found in
the current excavation area on the top of the midden. During this later phase at Cabeço da Arruda, the dominant signature corresponds to the *mixed, high terrestrial* diet also found at the 1950s area at Moita do Sebastião.

The very last burials known in the valley present coherent isotopic signatures of a mixed diet with high intake of aquatic foods \( n=2, \delta^{13}C = -16.1 \pm 1.1\%o, \delta^{15}N = +12.4 \pm 0.1\%o \) (fig. 5.31, *map 6*). Interestingly, the individual with the highest intake of aquatic foods was buried at Cabeço da Arruda, and presents a signature which is in contrast with the *mixed, high terrestrial* profile of previous burial episodes (fig. 5.30, *map 5*).

![Map 6](image)

*Figure 5.31.* Map 6 represents temporal moments of burial activity at the Tagus valley and display the \(^{14}C\) dated human burials at each site. The burials are identified by skeleton number, excavation year, \(^{14}C\) date (cal BCE, 95\% probability), \(\delta^{13}C\), and \(\delta^{15}N\)

Overall, the isotopic signatures derived from Moita do Sebastião, Cabeço da Arruda, and Cabeço da Amoreira are indicative of the consumption of a mixture of marine-estuarine and terrestrial resources. These results are consistent with the ecology of the area where the sites are located, and suggest that a significant portion of the protein consumed could be obtained locally. As discussed, two burials are clear outliers to this pattern and may suggest that these individuals were originally from elsewhere. The overall homogeneity of the stable isotope profiles indicates that the people buried in these places derived their protein from similar sources, but it is difficult to establish if these individuals belong to one or various groups, based on the current isotopic data. The people buried in these places were
very likely consuming resources collected nearby the sites, as indicated by the intake of marine-estuarine sources. However, in most cases, more than half of the protein consumed is derived from terrestrial food sources which could have been obtained from elsewhere, nearby or at some distance.

There is a slight shift during the latest period of burial activity regarding the isotopic signatures. Instead of one homogeneous dietary group, the people buried in these sites during the later phases, present two distinct isotopic profiles, representing two dietary groups. One group is possibly more local and is buried at Moita do Sebastião and Cabeço da Amoreira (mixed, high marine-estuarine, c 50% of protein from nearby the shell middens). The other group presents a predominantly inland pattern of food consumption (mixed, high terrestrial, deriving much less from the immediate area of the shell middens), and is represented by individuals buried at Cabeço da Arruda and also at Moita do Sebastião.

Only two burials are clear outliers. One was at Cabeço da Arruda during the main period of burial activity and the other at Cabeço da Amoreira during the later phases. These are individuals whose isotopic signatures do not match the main patterns. This could be explained by personal food preferences or social impediments. Another possible explanation is that these individuals derived their protein from other environments and were possibly “external” to the main group(s) identified, but were nevertheless, provided with a permanent place in these burial grounds (see discussion in chapter 6).

Arapouco, Sado valley

At Arapouco, the human collagen samples (n=12/no. individuals=12) display stable isotope values ranging between −17.9‰ to −16.1‰ (−17.0 ± 0.5‰) for carbon, and +11.0‰ to +13.0‰ (+12.2 ± 0.4‰) for nitrogen, which are indicative of the consumption of a mixture of marine-estuarine and terrestrial food resources. These results are in agreement with previous trace element analysis (n=8). Trace elements indicated high intake of marine protein (rich in zinc), as indicated by the high Zn/Ca ratio, balanced by significant consumption of vegetables, as indicated by the Mg/Ca index and Ba ratio (ORBa) (Umbelino 2006; Umbelino and Cunha 2012).

The lack of reliable 14C data available for Arapouco does not allow comparisons over time. However the intra-individual variation is small indicating that the people buried at Arapouco shared a similar pattern of protein consumption.

As discussed, one skeleton wrongly labelled as skeleton 5 from Arapouco was sampled for isotopic analysis by M. Fontanalls-Coll and colleagues (2014). The provenience of this individual is unknown, but I suggest, based on the visual analysis of the sediment, that this skeleton could be from Cabeço do Pez. The values for the mislabelled individual (δ13C= −20.0‰; δ15N= +9.0‰, Fontanalls-Coll et al. 2014) indicate the consumption of a full terrestrial diet which is in contrast with the mixed diet observed for the burial population of Arapouco.
Cabeço das Amoreiras, Sado valley

Stable isotope values derived from most individuals (n=9/no. individuals=4) buried at Cabeço das Amoreiras indicate consumption of foods primarily from terrestrial sources. This is supported by the analysis of trace elements (n=2) which suggested high consumption of vegetables complemented with a medium intake of terrestrial animals as indicated by the ratio of Ba (ORBa) validated by the Mg/Ca and V indexes (Umbelino 2006; Umbelino and Cunha 2012). One mature adult male (CAMS1958, Sk6) is exceptional to this pattern and presents the highest set of isotopic values (δ¹³C= –16.0‰, δ¹⁵N= +13.4‰), indicating an important intake of marine-estuarine protein in contrast with the remaining individuals buried at Cabeço das Amoreiras. When CAMS1958, Sk6 is excluded from the series (n=9/no. individuals=4), the intra-individual variation is smaller and the mean values are −19.1 ± 0.6‰, instead of −18.8 ± 1.1‰ for carbon and +9.2 ± 0.8‰, instead of +9.6 ± 1.5‰ for nitrogen.

Some individuals were sampled more than once and present slightly different stable isotope values (table 5.10), but are statistically coherent. For consistency, the Ua–number values were preferred in the analysis over time. Over time (n=3), the δ¹³C variation is generally small (−19.7 ± 0.6‰) but moderate when considering the δ¹⁵N values (+8.4 ± 1.0‰) where there is a small decrease over time (figs. 5.32, 5.33).

The individuals buried at Cabeço das Amoreiras present a consistent isotopic signature, particularly when considering the long time span of burial activity. As discussed, one individual (CAMS1958, Sk6) presents the exception to this pattern and indicates a very different pattern of protein consumption. Unfortu-

nately it remains undated.

Table 5.10. Cabeço das Amoreiras, Sado valley: chronology and stable isotope values (δ¹³C and δ¹⁵N) of human bone collagen. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Identification of the human remains</th>
<th>Measurements (IRMS)</th>
</tr>
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<tr>
<td>Ind.</td>
<td>Age</td>
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<td>4, 1958</td>
<td>Adult</td>
</tr>
<tr>
<td>7, 1958</td>
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<td></td>
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</table>
Figure 5.32. Cabeço das Amoreiras, Sado valley: bone collagen δ¹³C over time (cal BCE, 95% probability). Individuals 5 (open square), and 7 (grey square) have multiple δ¹³C values.

Figure 5.33. Cabeço das Amoreiras, Sado valley: bone collagen δ¹⁵N over time (cal BCE, 95% probability). Individuals 5 (open square), and 7 (grey square) have multiple δ¹⁵N values.
Vale de Romeiras, Sado valley

The isotopic signature for Vale de Romeiras (n=10/no. individuals=7) is clearly terrestrial. These results are supported by previous trace element analysis (n=10) suggesting the high consumption of vegetables supplemented by a relatively low intake of terrestrial animals as indicated by the ratio of Ba (ORBa) validated by the Mg/Ca and V indexes (Umbelino 2006; Umbelino and Cunha 2012). The mean value for all isotopic measurements is \(-19.2 \pm 0.7\%o\) (n=10) for carbon and \(+9.5 \pm 0.9\%o\) (n=9) for nitrogen.

Some individuals were sampled more than once and present slightly different stable isotope values (table 5.11), but are generally statistically consistent. In one case (VR1959, Sk9) the values are less consistent (\(\delta^{13}C= -20.5\%o, \delta^{15}N= +7.7\%o\) vs \(\delta^{13}C= -18.7\%o, \delta^{15}N= +9.6\%o\)), but remain within the range of a terrestrial isotopic signature. For consistency, the Ua–number values were preferred in the analysis over time. Unfortunately, the sample size for the analysis over time is limited (n=2). The \(\delta^{13}C\) variation is insignificant \((-20.4 \pm 0.2\%o\) and slightly higher when considering the \(\delta^{15}N\) values \(+8.2 \pm 0.7\%o\) where there is a small decrease over time (figs. 5.34, 5.35). Nevertheless, the individuals buried at Vale de Romeiras present a consistent isotopic signature, particularly when considering the long time span of the burial activity. However, this pattern should be tested with a larger sample.

Table 5.11. Vale de Romeiras, Sado valley: chronology and stable isotope values (\(\delta^{13}C\) and \(\delta^{15}N\)) of human bone collagen. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Ind.</th>
<th>Age</th>
<th>Sex</th>
<th>Lab no.</th>
<th>(^{14}C) Age BP</th>
<th>Post. density estimate (95% prob.)</th>
<th>(\delta^{13}C) (%)</th>
<th>(\delta^{15}N) (%)</th>
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<tbody>
<tr>
<td>9, 1959</td>
<td>Adult</td>
<td>♂</td>
<td>Ua–47983</td>
<td>6625±51</td>
<td>5625–5475</td>
<td>-20.5, this study 18.7, Guiry et al. 2015</td>
<td>7.7, this study 9.6, Guiry et al. 2015</td>
</tr>
<tr>
<td>19, 1959</td>
<td>Adult, 20–35 yrs</td>
<td>♀</td>
<td>Ua–46972</td>
<td>7640±55</td>
<td>6593–6370</td>
<td>-20.2, this study 19.8, Guiry et al. 2015</td>
<td>8.7, this study 9.1, Guiry et al. 2015</td>
</tr>
</tbody>
</table>
Figure 5.34. Vale de Romeiras, Sado valley: bone collagen $\delta^{13}$C over time (cal BCE, 95% probability). Individuals 9 (grey square), and 19 (black square) have two sets of $\delta^{13}$C values.

Figure 5.35. Vale de Romeiras, Sado valley: bone collagen $\delta^{15}$N over time (cal BCE, 95% probability). Individuals 9 (grey square), and 19 (black square) have two sets of $\delta^{15}$N values.
Cabeço do Pez, Sado valley

At Cabeço do Pez, the human collagen samples (n=13/no. individuals=9) display stable isotope values ranging between –20.7‰ and –17.2‰ (–19.3 ± 0.7‰) for carbon, and +6.7‰ to +13.5‰ (+9.8 ± 1.5‰) for nitrogen (tables 5.12, 5.13). When considering the 14C dated individuals (n=5) and the Ua–number values, in the case of individuals with more than one set of measurements, the range of values is maintained, but the standard deviation for the nitrogen values increases (+11.0 ± 2.7‰).

Overall, the δ13C variation is small to moderate, while the intra-individual variation of δ15N values is high (figs. 5.36, 5.37). The highest δ15N values derive from three individuals, two adults (CP1956, Sk5 5, 27), and one isolated child (CP1956, Sk2). Individuals 2 and 5 have two sets of measurements (this study; Fontanals-Coll et al. 2014; Guiry et al. 2015), and individual 27 was sampled four times (this study; Fontanals-Coll et al. 2014; Guiry et al. 2015; Umbelino 2006).

Table 5.12. Cabeço do Pez, Sado valley: stable isotopes values (δ13C and δ15N) without associated 14C date. Samples are sorted so that the lowest δ13C values are at the top of the column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Lab no.</th>
<th>δ13C (‰)</th>
<th>δ15N (‰)</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>n/a</td>
<td>–20.0</td>
<td>9.3</td>
<td>Fontanals-Coll et al. 2014</td>
</tr>
<tr>
<td>B, 1959</td>
<td>Adult</td>
<td>n/d</td>
<td>n/a</td>
<td>–19.8</td>
<td>8.2</td>
<td>Fontanals-Coll et al. 2014</td>
</tr>
<tr>
<td>13, 1956</td>
<td>15–23 yrs</td>
<td>♂</td>
<td>7768.3</td>
<td>–19.7</td>
<td>8.9</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>14, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>7762.3</td>
<td>–19.7</td>
<td>8.5</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>6, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>6894.3</td>
<td>–19.6</td>
<td>9.2</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>8, 1956</td>
<td>Adult, young</td>
<td>♂</td>
<td>7761.3</td>
<td>–19.5</td>
<td>8.8</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>15 (?), 1956</td>
<td>Adult</td>
<td>♂</td>
<td>6891.3</td>
<td>–19.5</td>
<td>8.7</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>26, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>7760.3</td>
<td>–19.5</td>
<td>8.7</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>17, 1956</td>
<td>Non–adult, 5–7 yrs</td>
<td>n/d</td>
<td>n/a</td>
<td>–19.4</td>
<td>9.3</td>
<td>Fontanals-Coll et al. 2014</td>
</tr>
<tr>
<td>24, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>7759.2</td>
<td>–19.4</td>
<td>8.9</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>21, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>n/a</td>
<td>–19.3</td>
<td>9.2</td>
<td>Fontanals-Coll et al. 2014</td>
</tr>
<tr>
<td>25, 1956</td>
<td>Adult, mature</td>
<td>♂</td>
<td>7764.3</td>
<td>–19.3</td>
<td>8.6</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>20, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>7758.2</td>
<td>–19.2</td>
<td>9.7</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>19, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>7763.3</td>
<td>–19.2</td>
<td>8.8</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>16, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>7767.3</td>
<td>–18.9</td>
<td>9.6</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>1, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>6893.3</td>
<td>–18.5</td>
<td>10.2</td>
<td>Guiry et al. 2015</td>
</tr>
</tbody>
</table>
Table 5.13. Cabeço do Pez, Sado valley: chronology and stable isotope values ($\delta^{13}C$ and $\delta^{15}N$) of human bone collagen. Samples are sorted so that the most recent dates are at the top of the column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Lab no.</th>
<th>$^{14}$C Age BP</th>
<th>Post. density estimate (95% probability)</th>
<th>$\delta^{13}C$ (%)</th>
<th>$\delta^{15}N$ (%)</th>
<th>Burial activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 1956</td>
<td>Non-adult, 1.5–2 yrs</td>
<td>n/d</td>
<td>Ua–46930</td>
<td>5579±41</td>
<td>4461–4266</td>
<td>−19.1, this study</td>
<td>11.5, this study</td>
<td>Late</td>
</tr>
<tr>
<td>5, 1956</td>
<td>Adult, 35–50 yrs</td>
<td>♀</td>
<td>Ua–46931</td>
<td>6791±43</td>
<td>5711–5536</td>
<td>−18.3, this study</td>
<td>13.0, this study</td>
<td>Main</td>
</tr>
<tr>
<td>27, 1956</td>
<td>Adult</td>
<td>♂</td>
<td>Ua–46934</td>
<td>6734±51</td>
<td>5705–5510</td>
<td>−19.7, this study</td>
<td>13.5, this study</td>
<td>Main</td>
</tr>
<tr>
<td>9, 1956</td>
<td>Adult</td>
<td>n/d</td>
<td>Ua–46932</td>
<td>6780±48</td>
<td>5726–5552</td>
<td>−19.8, this study</td>
<td>10.4, this study</td>
<td>Main</td>
</tr>
<tr>
<td>11, 1956</td>
<td>Adult</td>
<td>♂♀</td>
<td>Ua–46933</td>
<td>6788±46</td>
<td>5733–5566</td>
<td>−20.7, this study</td>
<td>6.7, this study</td>
<td>Main</td>
</tr>
</tbody>
</table>
Figure 5.36. Cabeço do Pez, Sado valley: variation of $\delta^{13}$C (‰) over time (cal BCE, 95% probability) of 11 samples of human bone collagen from 5 individuals. Individuals 2 (grey square), 5 (open circle), 9 (open square), and 27 (grey square with outline) have multiple $\delta^{13}$C values.

Figure 5.37. Cabeço do Pez, Sado valley: variation of $\delta^{15}$N (‰) over time (cal BCE, 95% probability) of 10 samples of human bone collagen from 5 individuals. Individuals 2 (grey square), 5 (open circle), 9 (open square), and 27 (grey square with outline) have multiple $\delta^{15}$N values. The possible anomalous $\delta^{15}$N value of +13.5‰ obtained for individual 27 (this study) is not displayed.
In the case of CP1956, Sk5 (5711–5536 cal BCE, 95% probability), the two different sets present moderate deviations but both indicate a relatively significant consumption of marine protein, c 30 to 40 ± 10%, placing this individual in an outlier position. On the other hand, the four sets available for CP1956, Sk27 (5705–5510 cal BCE, 95% probability) are consistent in terms of δ¹³C values but the high δ¹⁵N value obtained in this study (+13.5‰) seems to be anomalous when considering the consistent values from the other three measurements with a mean value of +10.1 ± 0.4‰. Thus, when this possibly anomalous value is excluded, the δ¹⁵N values obtained for CP1956, Sk27 are no longer eccentric to the series. The two sets of values for CP1956, Sk2 are more consistent and its slightly deviant position in the series can be explained by the recent date obtained for this 1.5–2 year old child (4461–4266 cal BCE, 95% probability) coeval with Middle Neolithic groups in Portugal. Also, its relatively high nitrogen value could suggest a breastfeeding effect. If this was the case, the δ¹⁵N value for the mother of this child could be estimated to be between +8.5‰ and +10.5‰ by lowering 1 to 3‰ (Katzenberg et al. 1996) from the bioenriched δ¹⁵N value for the child. In this case, the δ¹³C values derived from this child reflect the diet of his/her mother and indicate the consumption of terrestrial foods, which is in clear continuity with the isotopic signatures observed during the Late Mesolithic at Cabeço do Pez.

One adult (CP1956, Sk11) presents the lowest set of values in the series (δ¹³C= −20.7‰; δ¹⁵N= +6.7‰) indicative of a terrestrial diet based primarily on low trophic level food sources, such as vegetables. Although its ¹⁴C date (5733–5566 cal BCE, 95% probability) is consistent with the main burial activity in the site, its isotopic signature places this individual in an outlier position.

As discussed, three individuals buried at Cabeço do Pez present different patterns of protein consumption (CP1956, Sks 2, 5, 11). Two are adults buried during the main activity of the site. One of these adults presents a mixed diet of terrestrial resources complemented by protein of marine-estuarine origin (CP1956, Sk5). The other adult (CP1956, Sk11), indicates a full terrestrial diet, but based exclusively on plants. The third individual is a child (CP1956, Sk2) buried at Cabeço do Pez several centuries after the main burial activity at the site, and its outlier position derives possibly from a breastfeeding effect. When these three outliers (CP1956, Sks 2, 5, 11) are excluded, as well as the possibly anomalously high δ¹⁵N value obtained for CP1956, Sk27 (+13.5‰), the intra-individual variation is smaller and the isotope values range between −20.0‰ to −18.5‰ (−19.4 ± 0.4‰) for carbon, and +8.2‰ to 10.6‰ (+9.3 ± 0.7‰) for nitrogen, which are indicative of a typical terrestrial food diet.

The strong terrestrial component observed in the isotopic signatures derived from most individuals buried at Cabeço do Pez is supported by previous trace element studies (n=11). Trace element analysis indicates high consumption of vegetables, such as tubers, legumes and fruits, supplemented with medium consumption of animal food sources (Umbelino 2006; Umbelino and Cunha 2012). As discussed, two individuals, buried during the main period of burial activity, are clearly eccentric to this pattern. While one individual follows the terres-
trial diet but largely from vegetarian sources, the other individual presents a mixed
diet of terrestrial sources supplemented with a medium consumption of marine-
estuarine sources of protein. Both signatures contrast with the whole series of
Cabeço do Pez.

Two \(^{14}\text{C}\) measurements on individual 4 (Beta–125109 and Sac–1558, Cunha and
Umbelino 2001) were excluded from this study because the two \(\delta^{13}\text{C}\) values
available were obtained on an AMS instrument during the radiocarbon dating
process making the calibration of this \(^{14}\text{C}\) date highly uncertain. Nevertheless, one
of these original AMS measurements is \(-19.3\%\) for carbon (Sac–1558) and is in
line with the current isotopic series for Cabeço do Pez, suggesting a low offset
from an isotope-ratio mass spectrometry (IRMS) measurement, which must be
confirmed with future measurements. The second measurement \((-22.6\%\),
Beta–125109) presents a greater offset and remains unreliable for calibration and
dietary analysis.

Várzea da Mó, Sado valley

The only human burial known at Várzea da Mó presents an isotopic signature
derived from terrestrial sources as indicated by the values \(-20.5\%\) for carbon and
+8.1\% for nitrogen.

Poças de S. Bento, Sado valley

Poças de S. Bento was not sampled or analysed in the scope of this study. However, the published data are important resources for comparison with the
studied material from the Sado valley, allowing a more robust analysis of the local
setting.

At Poças de S. Bento, the human collagen samples \((n=9/no. \text{ individuals}=8)\)
display stable isotope values ranging between \(-17.9\%\) and \(-16.9\%\) \((-17.4 \pm 0.3\%)\)
for carbon, and +11.7 to +12.8\% \((+12.3 \pm 0.4\%)\) for nitrogen (table 5.14), which
are indicative of the consumption of a mixture of marine-estuarine and terrestrial
food resources. These results are in agreement with previous trace element analysis
\((n=6)\) showing the highest Zn/Ca ratio in the Sado series explained by significant
intake of marine protein, such as fish and crustaceans (Umbelino 2006; Umbelino
and Cunha 2012).

The lack of reliable \(^{14}\text{C}\) data available for Poças de S. Bento does not allow
comparisons over time. However, the intra-individual variation is small indicating
that the people buried at Poças de S. Bento shared a similar pattern of protein
consumption (fig. 5.38).
Table 5.14. Poças de S. Bento, Sado valley: stable isotopes values ($\delta^{13}$C and $\delta^{15}$N) without associated $^{14}$C date. Samples are sorted so that the lowest $\delta^{13}$C values are at the top of the column.

<table>
<thead>
<tr>
<th>Individual</th>
<th>Age</th>
<th>Sex</th>
<th>Bone</th>
<th>Lab no.</th>
<th>$\delta^{13}$C (‰)</th>
<th>$\delta^{15}$N (‰)</th>
<th>C:N</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>5, 1960</td>
<td>Adult</td>
<td>♂</td>
<td>Long bone 999.33.3</td>
<td>6897.3</td>
<td>–17.9</td>
<td>12.1</td>
<td>3.3</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>3, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.31.20</td>
<td>6896.6</td>
<td>–17.7</td>
<td>11.8</td>
<td>3.4</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>7, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>n/a</td>
<td>n/a</td>
<td>–17.6</td>
<td>11.7</td>
<td>n/a</td>
<td>Umbelino 2006</td>
</tr>
<tr>
<td>7, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.35.3</td>
<td>7755.2</td>
<td>–17.5</td>
<td>12.1</td>
<td>3.5</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>11, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.40.5</td>
<td>7752.2</td>
<td>–17.4</td>
<td>12.7</td>
<td>3.5</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>1, 1960</td>
<td>Non-adult, 12–15 yrs</td>
<td>n/d</td>
<td>Long bone 999.30.13</td>
<td>6899.3</td>
<td>–17.3</td>
<td>12.2</td>
<td>3.4</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>13, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.42.5</td>
<td>6895.3</td>
<td>–17.0</td>
<td>12.8</td>
<td>3.3</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>12, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.41.1</td>
<td>6898.3</td>
<td>–17.0</td>
<td>12.6</td>
<td>3.3</td>
<td>Guiry et al. 2015</td>
</tr>
<tr>
<td>8, 1960</td>
<td>Adult</td>
<td>n/d</td>
<td>Long bone 999.37.30</td>
<td>7754.3</td>
<td>–16.9</td>
<td>12.5</td>
<td>3.3</td>
<td>Guiry et al. 2015</td>
</tr>
</tbody>
</table>
Isotopic signatures and implications for the local setting, Sado valley

The isotopic signatures of carbon and nitrogen derived from the sites of the Sado valley present two dietary groups. One group derived its stable isotopes from a mixture of terrestrial foods complemented by c 40 ± 10% of protein from marine-estuarine sources, and was buried in the western sites of the Sado valley, at Arapouco and Poças de S. Bento. The other main dietary group derived its isotopes from a full terrestrial diet, and was buried in the eastern side of the valley in the sites of Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó (fig. 5.39).

The intra-individual variation within each site is generally small suggesting that the people interred in each burial ground shared a fairly homogeneous pattern of protein consumption. Few individuals are noted as real outliers, and are found only at the eastern sites:

- one undated adult male at Cabeço das Amoreiras (CAMS1958, Sk6) presents a mixed diet with significant intake of protein from marine-
estuarine sources ($\delta^{13}C = -16.0\%o$, $\delta^{15}N = +13.4\%o$), which is in contrast with the remaining individuals in this burial ground;

- one adult female at Cabeço do Pez (CP1956, Sk5, 5711–5536 cal BCE) presents a relatively significant intake of marine-estuarine resources supplemented by the consumption of terrestrial foods ($\delta^{13}C = -18.3\%o$, $\delta^{15}N = +13.0\%o$, this study; $\delta^{13}C = -17.2\%o$; $\delta^{15}N = +12.4\%o$, Guiry et al. 2015);

- also at Cabeço do Pez, another adult deviates from the general pattern (CP1956, Sk11, 5733–5566 cal BCE) due to its possibly exclusive vegetarian diet, as suggested by the very low isotopic values ($\delta^{13}C = -20.7\%o$; $\delta^{15}N = +6.7\%o$).

Figure 5.39. Sado valley: correlation between the $\delta^{13}C$ (‰) and $\delta^{15}N$ (‰) values of 66 samples of human bone collagen from 53 individuals. The inter-site variation suggests that the burials grounds were used distinctively by at least two populations. One main group was defined in the west, characterized by an isotopic profile indicative of a mixed diet (Arapouco and Poças de S. Bento). The second main group was defined in the eastern sites where individuals with typical terrestrial diet buried their dead (Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó). The outliers of the series are indicated with a modified notation: CAMS1959, Sk6 (open diamond), CP1956, Sks 5 (open triangle), and 11 (grey triangle). CP1956, Sk2 (dashed outline) is a child, possibly breastfeeding, and coeval with the early stages of the Middle Neolithic in Portugal.
At the Sado valley, while the intra-site variation is small, suggesting a homogeneous dietary population buried in each site, the inter-site variation indicates that the burial grounds were used distinctively by at least two populations. One main group was defined in the west, characterized by an isotopic profile indicative of a mixed diet, and used Arapouco and Poças de S. Bento as their burial grounds. The second main group was defined in the eastern sites, where individuals with a typically terrestrial diet buried their dead, and used Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó as their burial grounds. The individual isotopic profiles overlap within the two main dietary groups and it is speculative to distinguish eventual subgroups, which could represent different communities using specifically determined burial ground(s) in particular, as was briefly suggested before (Fontanals-Coll et al. 2014, 544).

Unfortunately, the $^{14}$C data available is limited for the western sites (figs. 5.40, 5.41). Nevertheless, it seems that the groups in the west and those in the east used the sites simultaneously, as demonstrated by the earliest burials known in the valley, from both the western (Arapouco) as well as the eastern sites (Cabeço das Amoreiras) (fig. 5.18).

I suggested that the skeleton wrongly labelled as skeleton 5 from Arapouco could be a burial from Cabeço do Pez. The assignment of this burial to Cabeço do Pez is based on the visual analysis of the sediment within the individuals preserved in paraffin blocks at MNA (Arapouco, Cabeço das Amoreiras, and Cabeço do Pez). Thus, it is unknown if the sediment could also match that of the individuals buried at the neighbouring site Vale de Romeiras. The isotopic values of the mislabelled individual ($\delta^{13}$C = –20.0‰, $\delta^{15}$N = +9.0‰; Fontanals-Coll et al. 2014) indicate the consumption of a full terrestrial diet which is in contrast to the mixed diet observed for the burial population of Arapouco, but matches the signature profiles of both Cabeço do Pez and Vale de Romeiras. I sampled this skeleton (adult female, Ua–46939, table A2) for $^{14}$C dating, and the calibrated date range for the time of her burial is 5787–5634 cal BCE (95% confidence) which is consistent with the main burial activity at Cabeço do Pez.

The distinct isotopic profiles noted between the western and eastern groups are coherent with the zooarchaeological evidence. While fish remains of marine-estuarine species are relatively abundant at Arapouco and Poças de S. Bento in the west (Arnaud 1989; Marques-Gabriel 2015), mammal bones are more frequent at Cabeço das Amoreiras, Vale de Romeiras, and Cabeço do Pez (Arnaud 1989; Rowley-Conwy 2015). Fish remains are also found at Cabeço das Amoreiras, but in much lesser quantity than in the western sites, and without species predominantly marine, such as those of shark families such as the Triakidae and the Lamnidae found at Arapouco and Poças de S. Bento (Marques-Gabriel 2015). Unlike Arapouco, mammal remains are relatively abundant at Poças de S. Bento, in particular rabbits (Rowley-Conwy 2015).
**Figure 5.40.** Sado valley: bone collagen $\delta^{13}C$ over time (cal BCE, 95% probability). CAMS1958 Sks 5 (open diamond), 7 (grey diamond), VR1959 Sks 9 (grey square), 19 (black square), CP1956 Sks 2 (dashed outline), 5 (open triangle), 9 (grey triangle), 27 (grey triangle with outline) have multiple $\delta^{13}C$ values.

**Figure 5.41.** Sado valley: bone collagen $\delta^{15}N$ over time (cal BCE, 95% probability). CAMS1958 Sks 5 (open diamond), 7 (grey diamond), VR1959 Sks 9 (grey square), 19 (black square), CP1956 Sks 2 (dashed outline), 5 (open triangle), 9 (grey triangle), 27 (grey triangle with outline) have multiple $\delta^{15}N$ values.
The distinct food choices noted between the western and eastern groups seem to follow a geoecological pattern (figs. 5.42, 5.43). People buried in the western sites would have easier access to marine resources, not only because the estuary was probably richer in marine foods where Arapouco is located, but also because of the accessibility to the coast by boat. The location of the other western site, Poças de S. Bento, in a relatively inland area c. 3 kilometres from the river, remains an apparently odd choice. In this case, the populations buried here would get an important part of their food outside the immediate area of this site. In the eastern side of the valley, the terrestrial signatures observed could be explained if the local environment was less rich in marine foods in this portion of the valley. Also, it can be suggested that the individuals buried at the eastern sites derived most of their carbon and nitrogen from other ecosystems, either in the valley, which was probably rich in terrestrial resources and/or elsewhere. Interestingly, despite the important component of shells of aquatic molluscs, in these eastern sites as well, its consumption by the burial population seems to be low and occasional.

![Figure 5.42. Sites with human remains at the Sado valley: minimum number of individuals (MNI), mean $\delta^{13}C$ (%) and $\delta^{15}N$ (%) values, and respective standard deviations derived from human bone collagen. The burial populations of the western-most sites display isotopic signatures indicative of the consumption of a mixture of terrestrial and marine-estuarine resources. In contrast, the people buried at the eastern sites generally present isotopic values consistent with diets derived entirely from terrestrial sources. Two individuals with a mixed diet of marine-estuarine and terrestrial foods were buried at the eastern sites where the burial populations present a full terrestrial diet. One of these individuals was buried at Cabeço das Amoreiras (CAMS1958, Sk6)
but unfortunately remains to be dated. This mature adult male was buried in the centre of the burial area and could be one of the earliest burials in the site. If this were the case, this individual would be contemporaneous with the population buried in the western site of Arapouco, presumably from the same dietary group. The other dietary outlier is found at Cabeço do Pez (CP1956, Sk5). This mature adult female was buried during the period of main activity at the site and despite being contemporaneous with most burials she presents a dietary pattern of terrestrial sources of protein, complemented by the intake of marine-estuarine foods, which is in contrast with the full terrestrial profile of the site. This burial (5711–5536 cal BCE, 95% probability) is more recent than the only burial known at Arapouco, but it is contemporaneous with the use of the Poças de S. Bento, in the west (table A14), with an overall similar dietary profile (δ¹³C = −17.4 ± 0.3; δ¹⁵N = +12.3 ± 0.4). As a working hypothesis it could be suggested that CP1956, Sk5 was originally from the western dietary group, possibly from the site of Poças de S. Bento.

Tagus vs Sado

Current isotopic data suggests that the protein sources of choice vary regionally and possibly culturally. The isotopic signatures are consistent with the zooarchaeological evidence, and suggest that the dietary patterns were influenced and reflected the geography and ecology of the sites where the individuals were buried. Overall, while the isotopic signatures from the Tagus sites present a balanced intake of marine-estuarine and terrestrial foods, the individuals buried in the Sado sites can be grouped into two isotopic populations (figs. 5.43, tables 5.15, 5.16). The isotopic population characterized by a mixed diet of terrestrial and marine-estuarine resources was typically buried at the western sites. The population deriving their isotopes mainly from terrestrial sources was buried at the eastern sites of the valley.

This isotopic contrast between the individuals buried in the Tagus valley and the western sites of the Sado valley, with those buried in the eastern portion of the Sado valley (fig. 5.44), suggests that these burial grounds were used by at least two major regional and/or cultural groups of hunter-gatherers. One is defined by the consumption of a mixture of marine-estuarine and terrestrial foods in the west, and the other in the east deriving their protein from terrestrial sources. However, while the dietary profiles in each site of the Sado valley remained highly homogeneous over time, the sites of the Tagus valley became more heterogeneous during the later episodes of the burial activity. At the later stages of burial activity at the Tagus valley, two dietary groups were buried in each site, both with a mixed diet, but while one group had a high marine intake the other group relied on a greater quantity of terrestrial sources.
Figure 5.43. Individuals buried in the Tagus and Western Sado valleys derived their isotopes from a mixed diet of terrestrial and marine-estuarine resources (M) while the people buried in the East Sado obtained their protein from terrestrial food sources (T).
In both valleys just a few individuals stand out as outliers. In two cases, the individuals present isotopic signatures not found in any other of the sites analysed. This is the case for the first clear isotopic outlier found at Cabeço da Arruda in the Tagus valley (CAR19th c., SkA, 5902–5617 cal BCE) which presents a freshwater signature not comparable with any other individual. Likewise, one individual buried at Cabeço do Pez (CP1956, Sk11, 5733–5566 cal BCE) has no isotopic parallel, and although it presents a clear terrestrial diet in agreement with the site’s profile, this is the only signature that could be derived from an entirely vegetarian diet.

Most commonly, the outliers present isotopic signatures that are coherent with the dominant profile observed in other sites. This is the case for the second outlier found at the Tagus valley at Cabeço das Amoreiras (CAM–01–01, bone 139, 5613–5296 cal BCE), which presents a clear terrestrial signature, comparable with the individuals buried at both Vale de Romeiras (9, 5625–5475 cal BCE) and Cabeço...
Chapters 5

das Amoreiras (7, 5620–5481 cal BCE) in the Sado valley. However, without further analyses this correlation is not possible to establish as individuals with a similar terrestrial signature could be originally from any other region. Likewise, the only outlier known at Cabeço da Amoreira in the East Sado, presents a mixed isotopic signature particularly coherent with the profiles of the West Sado as indicated by the high nitrogen value. Similarly, one adult female buried at Cabeço do Pez (CP1956, Sk5, 5711–5536 cal BCE) with the only mixed signature known in this burial ground could be originally from any of the western populations.

Figure 5.44. Tagus and Sado valleys: correlation between the $\delta^{13}$C (‰) and $\delta^{15}$N (‰) values from human bone collagen samples.

In summary:

- The individuals buried in the sites of the Tagus valley derive their isotopes from mixed sources of terrestrial and marine-estuarine origin.
- At the Sado valley, the individuals buried in the western sites derive their isotopes from mixed sources of terrestrial and marine-estuarine...
origin while those buried in the eastern sites obtained their protein from terrestrial food sources.

- The distinct isotopic profiles found in the western and eastern sites of the Sado valley suggest that different groups were using distinct sites to bury their dead.
- The few isotopic outliers in each site suggest that these distinct groups were rarely mixed.
- The isotopic profile of each site at the Sado valley remains homogenous over time while at the Tagus valley there is increased intra-site heterogeneity during the later episodes of burial activity in the region. The profiles remain characterized by the consumption of mixed sources, but one group is more dependent on marine foods (mixed, high marine-estuarine) while the other obtains their protein mainly from terrestrial sources (mixed, high terrestrial).
- The analysis does not indicate any particular pattern associated with age or sex of the individual, which is possibly in part due to the poor preservation of the material which increases the difficulties of accurate estimates.

The treatment of the dead: synthesis of the archaeothanatological analysis

Archaeothanatological analysis was carried out on a total of 82 individuals: 33 were excavated at the Tagus valley, and 49 at the Sado valley. For the material from the Tagus valley, the analysis was particularly limited and constrained by the nature and availability of the source material. In several cases the observations were restricted to a few parts of the skeleton. Often, the analysis relied on indirect observations only, such as the descriptions of the excavators. Despite the difficulties, it was possible to obtain sufficient data supporting general observations regarding the treatment of the dead, even when detailed analysis was constrained. The sample for the Sado valley is better documented. The data set represents slightly less than half of the burials known in the region, but the consistency of the results indicates that the sample is representative of the assemblage. Observations supporting the reconstruction of the treatment of the dead at the Tagus and Sado valleys are presented in chapter 4.

Overall, the mortuary practices identified in the burial grounds of both valleys are comparable, with strong similarities. The analysis suggests some intra- and inter-site variations but these are minor and do not affect the overall pattern of the treatment of the dead.

The cadavers were typically interred in individual grave features soon after death, and retained their anatomical integrity (individual primary deposits). In several cases the diagnostic criteria are unclear. However, in most cases the general
topography of the skeletal elements in the features strongly indicates that the corpses were placed in the graves before degradation of the labile joints, supporting the interpretation of burials in primary position.

The secondary nature of the deposits was rare, and presumably absent in most sites. These subtle practices, when detected, involved the manipulation of a few selected bone elements. In only two cases (CAMS1958, Sk2; VR1959, Sk9), both found in the Sado valley, is the data sufficient to support the hypothesis of secondary deposition of skeletal elements related to post-depositional manipulation of the cadavers, although neither of the cases is conclusive. At the Tagus valley, one case (MS1954–54, Sk23) described by the excavators as the isolated cranium of a child deposited in a pit, is suggestive of a secondary deposition. Unfortunately, the low resolution of the source material for the Tagus sites does not allow further observations at this level. It is possible that contexts with disarticulated human remains, containing for example just a few elements of the skeleton, were not documented in the same detail as the complete burials. This could have been the case for the nineteenth century excavations, but it is unlikely for the fieldwork done in the twentieth century. The historical documentation shows a thorough recovery system always when human remains were found, which is also detected in the painstaking recovery of microliths, even the very small lithic debris.

In rare cases, the analysis confirms the multiple nature of primary deposits containing the remains of two individuals. These striking episodes of double burials are well attested at Arapouco (ARA1961, Sks 11, 12) by the synchronous deposit of a adult female and a three year old child, and at Cabeço do Pez (CP1956, Sks 9, 10) by the deposit of two adults.

In every burial ground, the bodies were normally laid on the back, with the upper limbs arranged close to the body, and with the lower limbs in flexion at various degrees, with the feet often placed towards the buttocks. In one case only (MS1952–54, Sk9) were the lower limbs placed in complete extension. The knees of the cadavers lying in the features were directed forwards, upwards or towards the right or left side. In rare cases the knees were directed downwards (CAMS1958, Sk7; VR1959, Sks 12, 19). The practice of laying the cadaver on the lateral side was unusual in most sites. At Arapouco only, was this a common alternative. Placement on the lateral side was further noted in two burials only at Vale de Romeiras, and a possible one at Moita do Sebastião. This practice was presumably absent elsewhere.

The size and shape of the grave features were rarely described by the excavators. Archaeothanatological analysis suggests that the cadavers were placed in pits dug into the ground, just wide enough to contain the body. The construction of these simple features was possibly dependent on the planned burial position. However, it is clear that in most cases the design of the grave had significant impact on the position of the cadaver. Clumping of the body was common, particularly at the level of the lower limbs which were commonly placed in contraction. At some sites (Moita do Sebastião, Cabeço da Arruda, Arapouco, and Cabeço das Amoreiras), the grave features were somewhat wider allowing a
relatively expanded position of the cadaver, at the level of the upper or the lower body. This was particularly common at Moita do Sebastião. In contrast, at Vale de Romeiras the graves were notably narrow, and the cadavers were frequently compressed, with their skeletons becoming hypercontracted in the feature. This phenomenon is noted in two cases at Arapouco, and in one case at Cabeço do Pez, but was apparently absent at Cabeço das Amoreiras. Hypercontraction of the body is also noted at Cabeço da Arrudda in at least three cases, but at Moita do Sebastião this is occasionally noticed at the level of the lower limbs only, as the result of the clumping of these elements.

Normally, the pressures observed on the bodies in the features can be explained as the result of the physical limits of the pit. A few cases at Moita do Sebastião (19th c., Sk10; 1952–54, Sks 9, 30), Arapouco (1961, Sks 6, 11, 12), and Cabeço das Amoreiras (1958, Sk7), suggest that there might have been extra support offered by some kind of soft container, such as a light wrapping of the cadaver at the time of the burial. The low resolution of the source material available for Cabeço da Arruda does not allow further observations at this level. At the other sites, the wrapping hypothesis is unlikely.

The floor of the graves tended to be uneven and sloping from the upper to the lower end of the feature, and often towards one side. Typically, the head was in a more elevated position than the trunk and pelvic region. Unfortunately, the fragmented state of most of the material does not allow detailed observations of skeletal elements that could clarify aspects of the original position of the body in the feature, in relation to the characteristics of the bottom, such as in the case of bodies placed in a half-sitting position.

After the placement of the cadaver in the grave, the feature was covered with sediment providing a filled space of decomposition. In several cases, the analysis indicates rapid penetration of fluid sediment provided by a sand rich environment. Arapouco at the Sado valley presents several good examples of rapid penetration of sediment and the hourglass effect was often detected. In several cases the documentation is unclear and/or the diagnostic criteria are not preserved. In every case however, movement of the bones is limited suggesting that decomposition of the cadaver occurred underground in a sediment-filled environment. A few cases suggest mixed spaces of decomposition (ARA1961, Sks 6, 12; VR1959, Sks 5, 6) by the formation of secondary empty spaces outside the volume of the cadaver within an overall filled environment. The analysis of these features suggests the existence of perishable material inserted in the grave along with the cadaver. Some of these elements may have functioned as a cushion placed behind the upper body (ARA1961, Sk6; VR1959, Sk6), while other elements were possibly placed in front of the upper body (VR1959, Sk5). One exceptional case (ARA1961, Sk12) suggests the existence of an element functioning as a container, such as a pouch or a basket accommodating the body. As discussed, neither of these interpretations are conclusive but they strongly suggest the existence of other elements in the graves, placed along with the cadaver.
Typically, the cadavers lie underground and undisturbed in their graves. Some skeletons were found disturbed in the feature, possibly due to the disposal of a new cadaver. The practice of *reduction* of the skeletal elements of an individual to accommodate the burial of a new cadaver was presumably common at Moita do Sebastião. This practice was also noted at Cabeço da Arruda, and possibly at Vale de Romeiras. These gestures, rather than suggesting disrespect towards the principle of integrity of the body, strongly indicate the continued preference of certain areas for the burial of the dead.

In rare cases the data suggest the post-depositional manipulation of selected bone elements in association with secondary deposits of skeletal elements. One further case that may suggest post-depositional manipulation of the cadavers is ARA1961, Sk11. The skull (cranium and mandible) of this adult female was missing from the feature. As discussed in chapter 4, it is unclear if this was a case of disturbance or deliberate removal of the skeletal element. However, it is interesting to entertain the hypothesis, although not possible to confirm it, that the isolated cranium found at Cabeço das Amoreiras (CAMS1958, Sk2) could belong to this female buried at Arapouco.

The main principles governing the mortuary practices at the Tagus and Sado valleys are remarkably consistent and homogeneous, as suggested by the archaeo-thanatological analysis.

Few cases present deviant elements, but exceptional instances were noted in almost every site. Despite the common core characteristics of burial practices, the data indicate some particulars that may distinguish practices carried out in the different burial grounds. Site specificities are apparently not consistent with any specific trend over time, but further chronological data may refine this observation. These are noted particularly at the level of the characteristics of the grave features, as well as in the initial position of the cadavers, and can be briefly outlined as follows:

- At Arapouco, the bodies were often placed on the lateral side with the limbs in flexion arranged close to the body. While this position was not the most common at the site, the lateral placement of the body was rare, and largely absent in other burial grounds.
- The individuals buried at Cabeço das Amoreiras (MNI 8) were predominantly mature adult males (n=4). The remaining individuals were two juveniles, one represented by its cranium, and another adult (male or female), the sex of which could not be determined. At other sites, the burial populations were representative of natural populations.
- While at all sites most cadavers were placed in constrained grave pits, this aspect was particularly striking at Vale de Romeiras. At Vale de Romeiras, the bodies were normally laid in very small pits in contracted positions, with the limbs nested on the upper body and the feet forced towards the buttocks.
- In slight contrast, at Moita do Sebastião, while the lower limbs were often placed in a constrained position with the feet forced towards the
buttocks, the lower limbs were possibly never rotated towards the upper body.

- At Cabeço da Arruda and Cabeço do Pez the analysis did not reveal any particular characteristic of the initial position of the bodies or the grave features, most likely due to the low resolution of the source material.

These are slight variations on a common theme. Further analyses of this material may provide additional elements about subtle and particular practices in the different burial grounds.

Overall, the mortuary programme at the Tagus and Sado valleys was consistent and based on strong common principles indicating a shared mindset on the treatment of the dead (fig. 5.45).

Figure 5.45. This illustration presents several typical elements observed in the burials at the Tagus and Sado valleys. The cadavers were normally laid on the back with the upper limbs placed close to the body and the lower limbs in contraction with the feet forced towards the buttocks. The floor of the graves tended to be sloping. The head of the cadaver was often rotated forwards and downwards towards the body. The physical limits of the feature had a significant impact on the final arrangement of the body in the feature. The wall-effects and consequent pressures are visible in the contracted position of most skeletons and can be explained as the result of the design of the grave.

(Drawing by Susanna Berglund)
PART THREE: DEATH IN PLACE

Riddaren: Då är levandet en orimlig fasa. Ingen människa kan leva med Döden för ögonen och vetskapen om alltings intighet.

Döden: De flesta människor reflekterar varken över Döden eller intigheten.

Riddaren: En dag står de ju ändå på livets yttersta näs.

Döden: Ja den dagen…

(Bergman 1957)
Introduction to part three

The human remains analysed in this dissertation provide concrete archaeological evidence for an interpretation of the significance of burial activity at the sites of the Tagus and Sado valleys, as outlined in the beginning of this study. Mortuary evidence offers a strong basis for inferences about broad historical processes and explanations about the human engagement with death in particular, with a focus on the burial phenomenon. The narrative of this dissertation is built on the archaeological data obtained in the course of this study under three main lines of enquiry:

- the reconstruction of the mortuary gestures,
- the chronological framework of the burial activity,
- and the definition of the people buried in these places by the identification of their dietary choices.

To provide additional evidence supporting the central arguments in this dissertation, I call upon further empirical data, such as studies of lithic technology, faunal evidence, palaeoecological analyses, osteological analyses, and palaeodemography.

Empirical evidence is evaluated through the lens of theory and concepts that relate most closely to the aspects of mortuary behaviour of interest in this dissertation:

- the manipulation of human remains,
- the places for the dead,
- and the (re)construction of social memories in mortuary ritual context.

The arguments supporting the analysis of the mortuary practices in the context of site formation processes are justified in a historical framework, on the basis of the concepts of place, social memory, and mortuary ritual practice, as presented in chapter 2. The explicit use of this framework allows us to link the actions of the people using these sites to the materiality of their mortuary practices recovered in the archaeological context. The use of these concepts is twofold. First, they frame the human impact on the formation and maintenance of these burial grounds. Second, and additionally, they allow inferences about the significance of mortuary practices and attitudes towards death on these people.

In the last part of this dissertation, I return to the central themes of this research: death, memory, and place. I evaluate the empirical evidence by tracing the boundaries of the mortuary phenomenon under study, in terms of practice, time, space, and people. Then, I discuss this particular engagement with death, in terms of the significance of the formal practice of human burial in dedicated spaces, and its relation to the formation and maintenance of these shell midden sites. Based on the empirical evidence available, I suggest an interpretation of the sites at the Tagus and Sado valleys by stitching together the spheres of death, memory and
place with the thread of historical agency in hunter-gatherer communities. In the final section of this thesis, *Conclusion: on the history of death and the last hunter-gatherers of the south-western Iberian Peninsula*, I recapitulate the central arguments in this dissertation and emphasize the need for broad examination of the history of human relationships with death in the chrono-cultural periods that frame the Late Mesolithic in the south-western Iberian Peninsula.
Chapter 6
The Places for the Dead as Places of Shared Narratives: Discussion

Introduction

Archaeological evidence indicates a strong core set of common practices associated with the treatment of the cadaver during the Late Mesolithic at the Tagus and Sado valleys. This is illustrated by the attitudes towards the body after death, which is particular to these regions, by contrast with contemporaneous sites in the Iberian Peninsula (Peyroteo Stjerna, forthcoming). In this dissertation, I suggest that the burial activity at the Tagus and Sado valleys is a significant historical practice with a central role in the formation and maintenance of these sites, rather than a peripheral activity resulting from the practical need to dispose a cadaver. The reasons supporting the structural significance of the burial activity at these sites can be outlined as follows:

- The topographical placement of the dead within the landscape of the living is a central aspect in the social dynamics of the last hunter-gatherers of the Tagus and Sado valleys.

- Hunter-gatherer communities were structured within specific social scenarios in a historically situated world view. At the Tagus and Sado valleys, people were bound by shared social and historical practices, including the formation and maintenance of burial grounds.

- The formation and maintenance of burial grounds is a primary means of history making. Burial practices are non-literary depositional narratives of an historical process. The burial of the dead in these burial grounds was an act of historical consciousness, and was motivated by the encounter and interaction with other bands frequenting the same environments.

- Social practices such as death rituals are acts of cultural production with a powerful memory aid. Mortuary ritual practices had a central role in the formation and maintenance of these sites as meaningful social environments.

- Death rituals in general and burial practice in particular played a central role in the life of these hunter-gatherers, and in developing a sense of community within the landscape as well as maintaining the social ties in both life and death.
These reasons support the argument for the structural significance of the burial activity at the Tagus and Sado valleys. They are articulated from the evidence obtained in the course of this study: radiocarbon and isotopic evidence, and archaeothanatological data. Studies of lithic technology (Araújo 1995–97; Diniz and Nukushina 2014; Marchand 2001, 2005; Nukushina 2012; Roche 1967, 1972), faunal evidence (Detry 2003, 2007; Lentacker 1986, 1994; Marques-Gabriel 2015; Rowley-Conwy 2015), palaeoecological analyses (Mateus and Queiróz 1993; van der Schriek et al. 2007), palaeodemographic data, and osteological analysis of human remains (Cunha and Umbelino 1995–97; Jackes, forthcoming; Jackes and Meiklejohn 2008), provide further empirical evidence supporting my arguments.

The shell middens of the Tagus and Sado valleys have been interpreted as hunter-gatherer territorial claims to establish control over economic resources (Arnaud 1989, 621). This is a compelling explanation; however, this approach does not address the question of the significance of mortuary ritual practices in the formation and maintenance of these places (Peyroteo Stjerna 2015). A broad and widely used argument to explain mortuary contexts in relation to the people under study, was presented by Saxe (1970) and Binford (1971), and links mortuary treatment to social structure (see chapter 1). In this view, the treatment of the dead reflects the dimensions of the social persona, such as age, sex, social rank and affiliation (Binford 1971). In this framework, death rituals are interpreted as indicative of the complexity of the social structure, and understood as claims of corporate groups to resources and territories (Saxe 1970). The merit of these explanations of the burial phenomenon lies in their simplicity, applicability to a diversity of empirical evidence, and general independence of chronological and spatial boundaries. However, these explanations tend to emphasize certain elements, such as the analysis of funerary architecture and grave goods, interpreting the elaboration of mortuary practices as representative of the complexity of a given society, which correlation is speculative in most cases.

In the following sections, I evaluate the empirical data at the level of the burial practice, Burial as the chosen way of treating the cadaver: boundaries of the phenomenon, and at the level of the spaces dedicated to these burials, Death in place. These two scales, the burial and the burial ground, are discussed further within an historical framework, based on the concepts of place, social memory, and mortuary ritual practice. In the following section, Places of mortuary narratives, I aim to explicitly connect these theoretical concepts to the materiality of the mortuary practices of the hunter-gatherers under study. Following this, I suggest an explanation for the significance of the burial practices at the Tagus and Sado valleys. This interpretative scenario is based on the arguments listed above supported by multiple lines of archaeological evidence.
Burial as the chosen way of treating the cadaver: boundaries of the phenomenon

Treatment of the dead

During the Late Mesolithic at the sites of the Tagus and Sado valleys, the burial of the cadaver was a typical way of dealing with the body of the deceased. The cadavers were placed in individual grave features, soon after death, while retaining their anatomical integrity. After laying the body in the grave, the feature was immediately covered with sediment. The metamorphosis of the cadaver through the process of decomposition occurred largely underground. The physical transformation of the individual was hidden from the sphere of the living, and the bodies remained undisturbed in the subterranean world. Transformation was concealed, but the dead were afforded a common and permanent location within the landscape of the living, in an accessible open air place. The placement of the body in the grave pit was careful and meticulous. The last image of the deceased was lifelike and faithful to what the individual looked like when he/she was alive in a position of repose. For the hunter-gatherers of the Tagus and Sado valleys, burial of the cadaver in a dedicated place for the dead was a common practice. While we cannot know their intentions, or why this was the chosen way of dealing with the dead, some aspects can be considered that distinguish the practice of primary burial in dedicated common burial grounds from other mortuary practices, which seem to be particularly significant to these sites:

- relevance of the integrity of the body;
- transformation of the cadaver was hidden from the living and happened underground;
- lifelike position and last image of the deceased before concealment in the grave feature;
- the dead were afforded a common and permanent place in the landscape of the living, in an open air and accessible place.

Unusual practices, such as the placement of more than one individual in the grave feature, or the occasional post-depositional manipulation of skeletal elements, did not affect the principles governing burial practice at these sites. Exceptional instances highlight central aspects about the proper way of dealing with the cadavers. The double burial identified at Arapouco (ARA1961, Sks 11, 12) is a striking example of the significance of the lifelike position of the deceased in the grave. The young woman and child in this feature were not just disposed of simultaneously in the grave. The adult was placed holding the child on her body and the pair were clearly arranged in a realistically lifelike position (see chapter 4). This unusual case demonstrates the considerable effort from the living to stage the dead in a familiar way. Likewise, the few post-depositional manipulations of the identified cadavers, presumably happen after decomposition of most soft tissue.
Chapter 6

These are exceptional instances and demonstrate the significance of the principle of hidden metamorphosis of the cadaver. On occasion, manipulation of skeletal elements seems to have been related to processes of reduction. The episodes of reduction could be used to argue against the principle of the relevance of the integrity of the body. However, this type of handling was unusual in most sites, and could be explained by ill marked graves and consequent unintentional manipulation of the remains. Here, the practice of reduction suggests the relevance of these particular places for the burial of the dead, without intentional disrespect towards the principle of the integrity of the body.

Chronological and spatial boundaries

The way of dealing with the cadaver in the Tagus and Sado valleys contrasts with earlier and contemporary practices known from other regions in the Iberian Peninsula (Peyroteo Stjerna, forthcoming). In the Early Mesolithic, the presence of human remains was more common in cave or rock shelter contexts, a pattern that decreases in occurrence through time during the Mesolithic. Yet this practice was not abandoned when open air sites became the most common option for the disposal of human remains. At the same time, during the Late Mesolithic in Iberia, there was an increment of sites with human remains accompanied by the intensification of burial practice. Nevertheless, the statistical increase of burial practice in open air sites in the Peninsula is due to the material from the Tagus and Sado valleys; without these sites the data for both Early and Late Mesolithic does not differ (Peyroteo Stjerna, forthcoming). Burial as a mortuary practice was known in the Iberian Peninsula but it was never a common practice until the Late Mesolithic in these two river valleys.

This is a Late Mesolithic phenomenon which in the Iberian Peninsula was clustered in the Tagus and Sado valleys. Overall, these sites were used for burial activity more or less synchronously. In both the Tagus and Sado valleys, burial activity was more frequent between c 6000 and 5500 cal BCE. In both valleys, there were early episodes of human burial activity, during the very first phases of the Late Mesolithic in Portugal, around 6350 cal BCE. After c 5500 cal BCE, the frequency of burial practice decreases dramatically, in both valleys, with a few last episodes not later than c 5000 cal BCE contemporaneous with several Early Neolithic sites in Portugal. Two apparent outliers are presented by the burial of a child at Cabeço do Pez, and one individual at Poças de S. Bento, in the Sado valley, around 4300 cal BCE, both coeval with Middle Neolithic sites in Portugal. The burials of Neolithic chronology require further research to understand their significance in these sites. At present, other than the calendrical date, nothing in the graves indicates that these individuals are Neolithic and not hunter-gatherers.

Death rituals observed at the sites of the Tagus and Sado valleys are materialized in the practice of human burial in dedicated burial grounds. This singular engagement with death is contemporaneous with the reconfiguration of the settlement pattern and other cultural changes that define and distinguish the Early and
Discussion

the Late Mesolithic in Portugal (Araújo 2015). During both periods, archaeological sites are located in places corresponding to the innermost areas of palaeoestuaries. However, while in the Early Mesolithic the sites were scattered throughout the territory by small rivers, in the Late Mesolithic the settlement pattern was clustered in the large estuaries of the Atlantic period, such as in the Tagus and Sado, which were newly occupied during this later phase. The concentration of people in very specific regions has no parallel in the Early Mesolithic, when highly mobile groups probably of small single-family units, moved regularly between the littoral and the interior regions in logistic and short-term residential camps (Araújo 2012, 2015).

As pointed out by A. C. Araújo (2015) the convergence of people to the confined and ecologically rich new estuarine environments of the Atlantic have certainly triggered many of the Late Mesolithic behaviours, such as the use of long-term residential sites, the new lithic technology, and a new attitude towards death.

Current explanations for the reconfiguration of the settlement pattern from the Early to the Late Mesolithic (Bicho et al. 2010; Zilhão 2003) are based on palaeoclimatic evidence which indicates significant changes in the local ecosystems around 8200 years ago, c 6250 BCE (Mateus and Queiróz 1993; van der Schriek et al. 2007). The earliest 14C dates at the Tagus and Sado valleys correspond to the start of burial activity in some of the sites. These are the first moments of occupation of these sites, c 6350 cal BCE (fig. 6.1), and are coeval with environmental changes in Portugal and elsewhere. In fact, at the Tagus valley where the palaeogeography and palaeoenvironment are well known, the burial activity is more frequent between c 6000–5600 cal BCE, coinciding with the rapid establishment of inner estuarine tidal mudflat and saltmarsh environments c 6100 cal BCE (van der Schriek et al. 2007). While the chronological match between environmental changes and the new settlement pattern is not a coincidence, the particular social mechanisms allowing this territorial and social reconfiguration remain unclear (Araújo 2015).

Likewise, the processes leading to the decrease of burial activity around 5500 cal BCE, at both the Tagus and Sado valleys, are not well established, and in this case, the environmental factors seem to play a less important role. The decrease of burial activity in the two valleys is coeval with the first phase of the Early Neolithic in Portugal, between c 5500–5300 cal BCE (Carvalho 2010). It coincides with environmental changes well documented in the Tagus valley, defined by the contraction of estuarine habitats, between c 5500–3800 cal BCE, and the establishment of an open landscape around c 5000 cal BCE (van der Schriek et al. 2007). In this case, the socio-cultural explanation for the end of the phenomenon, defined by the expansion of the Neolithic life style, seems to be more compelling, because despite the decline of the environmental conditions, the estuarine environment in the Tagus valley was still productive and the same mix of habitats remained until c 3800 cal BCE (van der Schriek et al. 2007). Palaeoenvironmental reconstruction of the Sado valley is under study (Costa et al. 2015; Freitas et al. 2013), and the spatial and temporal extension of the marine influence on the valley remains unclear. However, preliminary data seem to indicate that the less frequent
use of the Sado sites is not correlated to a palaeoenvironmental event (Diniz and Arias 2012).

Figure 6.1. Chronological data for the burial activity in the Tagus and Sado valleys plotted with two major events: palaeoclimatic change 8200 years ago (c 6250 BCE) and the onset of the Neolithic in Portugal.
The living and the dead

Clustering of the settlement pattern observed from the Early to the Late Mesolithic was the outcome of the convergence of small and highly mobile groups to an apparently more confined territory, broadly concentrated in the large estuaries of the Tagus and Sado valleys. This shift brought together small groups probably organized in single families (Araújo 2015) which then lived side by side. The organization of these groups in the new territories is poorly understood, and it is unclear whether these groups merged, at least partially, or if they remained autonomous. Traditionally, the hunter-gatherers of the Tagus and Sado valleys have been studied as two independent groups. This divide exists primarily from the segmented research history of these sites (see chapter 2). Research teams focused on one or the other valley, and centred their efforts on particular sites, to the detriment of long-range aspects of the archaeology of the last hunter-gatherers. In the following sections, I discuss the evidence supporting the unity of the populations frequenting the sites of the Tagus and Sado valleys, and the contrasting data suggesting that autonomous groups lived side by side and buried their dead in neighbouring burial grounds.

Seasonal model of settlement pattern

Early interpretations of the settlement pattern at the Sado valley (Arnaud 1989) were based on the concept of logistic movement (Binford 1980) applied to multiple lines of evidence, such as faunal remains, material culture, and site location. In this model, most of the population living in the valley moved seasonally between large base camps, occupying one site during the spring/summer (e.g., Poças de S. Bento), and moving to another, just a few kilometres away (fig. 2.3), for the autumn/winter (e.g., Cabeço do Pez), while making short incursions to smaller temporary camps for specialized activities. This explanation for the settlement pattern in the Sado valley was a preliminary model based on limited data which needed further evidence for its validation, refinement or rejection (Arnaud 1989), but so far, no other model was so well systematized. The sites of the Tagus valley were never interpreted in such explicit manner and have been broadly referred to as long-term residential sites of semi-sedentary hunter-gatherer groups; based on the generally large size of the sites, the high number of human burials in each site, and the several structures identified only at Moita do Sebastião which have been interpreted as postholes and storage pits, thus suggesting a permanent domestic use of the site (Roche 1972).

Faunal analyses are somewhat contradictory. While some authors emphasize the seasonal use of the sites within each valley (Lentacker 1986; Marques-Gabriel 2015, 312; Rowley-Conwy 2015), it has also been noted that the evidence may indicate a year-round use of the sites. The non-seasonal use of the sites was pointed out by A. Lentacker (1986, 22) in her study of the Tagus assemblages. Lentacker identified seasonal patterns of some species, but emphasized that the remains of mammals such as wild rabbit, red deer, and wild boar, possibly representing all age-
categories, could indicate visits to the sites throughout the year, instead of stays during particular seasons. This pattern was supported further by the study of shell remains at the sites of the Sado valley carried out by M. Deith (Arnaud 1990, 440) which indicated that shellfish were collected in the autumn/winter at all sites, by contrast with the suggestion of sites specialized in spring/summer vs autumn/winter activities. Conversely, and like the seasonal model proposed by J. Arnaud (1989) for the Sado valley, a broad zooarchaeological model advanced for the Portuguese Late Mesolithic sites suggested short seasonal movement between summer and winter base camps, and radial incursions out from each to logistic camps (Rowley-Conwy 2015). In this model, based on the differential representation of skeletal parts, P. Rowley-Conwy (2015) suggested that Cabeço da Arruda was possibly a winter hunting camp across the Muge River from the base camps of Moita do Sebastião and Cabeço da Amoreira, where hunting parties camped and prepared deer carcasses for transport back across the river to the base camps. According to this author, the data seemed also to accommodate the alternative hypothesis that the Muge sites may not have been occupied in the summer. At the Sado valley, the faunal analysis suggested that the eastern sites which are located relatively more inland, such as Vale de Romeiras and Cabeço do Pez, were used in the winter, while in the summer, the groups moved west using Arapouco as a logistic fishing camp, and Poças de S. Bento as a rabbit hunting site (Rowley-Conwy 2015).

Seasonal models imply that the burial activity followed a cyclical movement, and the deceased were buried wherever the group was stationed at the time. In this scenario, the populations having access to a variety of foods throughout the year, from marine-estuarine to terrestrial origin, should present individual isotopic signatures indicative of a more or less balanced intake of protein from seasonal reservoirs. More significantly, the itinerancy between the sites, with the burial of the deceased occurring according to the location of the group would result in low inter-site variability at the level of the dietary patterns of the burial population, which does not seem to be the case at least at the Sado valley, as discussed below.

**Dietary patterns**

**Tagus valley**

At the Tagus valley, isotopic data of carbon and nitrogen shows low to moderate inter-site and intra-individual variability suggesting that the people buried in the valley derived their protein from similar sources. The analysis over time indicates a general homogeneity of the isotopic signatures suggesting a balanced consumption of marine-estuarine and terrestrial foods. This pattern changes during the later episodes of burial activity, when two dietary groups (*mixed, high terrestrial* and *mixed, high marine-estuarine*) were buried at Moita do Sebastião and Cabeço da Amoreira, while apparently at Cabeço da Arruda only one of these groups (*mixed, high terrestrial*) was buried. The pattern is confirmed with the last burial known at Cabeço da Arruda presenting a contrasting profile, similar to those of *mixed, high*
*marine-estuarine* signatures found at Moita do Sebastião and Cabeço da Amoreira in preceding burial episodes. The heterogeneity noted towards the last phases of burial activity is identified in all sites and each burial ground accommodates individuals from both dietary groups (*mixed*, *high terrestrial* and *mixed*, *high marine-estuarine*), further supporting the similar patterns in the use of these sites for burial practice.

The dietary patterns observed in the Tagus valley suggest similar sources of protein consumption varying only in proportion during the later phases. In either case, the foods could be obtained locally in the estuarine environment and/or from inland territories. Current dietary data is not conclusive in terms of possible differences between the groups buried in each site. Further analyses on other isotopic elements, such as strontium or barium may identify different geographic patterns (Burton et al. 2003; Price et al. 2002) within this population, which could potentially clarify similarities and differences that are masked at present.

**Sado valley**

Dietary patterns observed at the Sado valley are somewhat surprising and do not conform to current seasonal models for the settlement pattern in the region. Unlike the sites at the Tagus valley, the inter-site variability at the Sado valley is high, indicating that the people buried in this valley derived their protein from different sources. In contrast, the intra-site variability is low, suggesting that the people in each burial ground shared similar patterns of protein consumption.

The burial populations in the western sites of the Sado valley, at Arapouco and Poças de S. Bento, present a dietary pattern similar to those buried in the Tagus valley, indicating the balanced consumption of marine-estuarine and terrestrial foods. However, this is not the case in the eastern portion of the valley, where the burial populations at Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó derived their protein from a full terrestrial diet. Interestingly, this dual dietary pattern is coherent with the zooarchaeological evidence, which indicates a significant consumption of marine-estuarine sources in the western sites while the remains of terrestrial foods dominate the inventories of the eastern sites (Arnaud 1989). The dualism found in the faunal remains is one of the pillars of the seasonal models, proposing that most of the population would live in the eastern hunting sites during the autumn/winter, moving to the west in the spring/summer when the marine-estuarine environment was more productive. The isotopic data of the human remains suggests otherwise. Dietary patterns of the burial populations indicate a division of the valley, which is not only geographic and ecological but also according to the population. The burial grounds of the west (Arapouco and Poças de S. Bento) were used by populations with a similar mixed dietary pattern while the burial grounds of the east (Cabeço das Amoreiras, Vale de Romeiras, Cabeço do Pez, and Várzea da Mó) were used by populations with a full terrestrial diet. Dietary patterns and zooarchaeological evidence are in agreement and suggest a strong territorial pattern of people using the western sites exclusively while another group was concentrated in the eastern portion of the valley.
At the Sado valley, dietary patterns remain consistent over time strengthening the population segmentation of the territory, both in terms of food catchment areas and burial grounds. Current isotopic data is not clear in terms of possible differences between subgroups in the west and in the east, and further analyses should be pursued. At the Sado valley, the isotopic evidence of carbon and nitrogen shows that distinct groups were using these sites not only simultaneously but with clear territorial borders, one defined in the west and the other defined in the east. Despite the dietary differences, the association of aquatic shells with the burial grounds remains a common trait, in the east and in the west (see below Cemeteries and shell middens in the Tagus and Sado valleys).

**Lithic analyses**

Occasionally, the archaeological material from the two valleys was investigated from a broad perspective (Arnaud 1987; Carvalho 2009). When the valleys are compared some striking aspects emerge. One remarkable difference is related to the choices of raw material. People at the Tagus valley worked with regional flint (Araújo 1993; Cardoso 2004; Carvalho 2003, 2008; Zilhão 2000), while people at the Sado valley used local raw material (Pimentel et al. 2015) with generally poor knapping properties (Araújo 1995–97; Arnaud 1989, 2000; Diniz and Nukushina 2014; Marchand 2001; Nukushina 2012). The Tagus region is rich in sources of quality flint for knapping; however, this raw material was not transported to the Sado valley, c 100 kilometres away. The choice of raw material indicates no movement of stone resources from one valley to the other, supporting the idea of self-contained valleys with separate groups clustering towards one or the other region. Another striking difference between the valleys lies in the procurement strategies of lithic raw material. While at the Tagus valley, flint with good knapping properties was obtained at a regional level, not at the immediacies of the sites, at the Sado valley the choice of materials was micro-local, with the use of pebbles of siliceous slates, chert, jasper, and quartz found in close proximity to the sites, although with inferior knapping quality (Pimentel et al. 2015).

The use of rock from the immediate vicinity is consistent with the local lithic production well documented at the Sado valley sites. All lithic studies are unanimous that all stages of the chaîne opératoire are present in the site’s assemblages, suggesting that lithic tools were produced, used, and discarded at the site (Araújo 1995–97; Diniz and Nukushina 2014; Marchand 2001; Nukushina 2012). The presence of all stages of the chaîne opératoire of lithic production seems also to be the case at the Tagus sites (Marchand 2001).

While the local tool production does not contradict the seasonal models, the proposed specialized character of the sites seems more difficult to uphold, based on current lithic evidence. In the seasonal scenario, the lithic tools should present a certain degree of specialization and heterogeneity, at least between the logistic sites, which does not seem to be the case. In the Sado valley, recent lithic studies (Diniz and Nukushina 2014; Pimentel et al. 2015) challenged the specialized character of the sites as proposed in the seasonal models. This is the case of Arapouco, which
has been interpreted as a specialized fishing camp (Arnaud 1989, 2000; Rowley-Conwy 2015) due to its downstream location, and relative abundance of marine-estuarine fish remains in relation to other sites in the valley (Marques-Gabriel 2015; Rowley-Conwy 2015). Lithic analysis presents an unspecialized toolkit dominated by multitasking tools, such as retouched flakes (69%) among other “common fond” tools (end-scrapers, denticulated flakes, and others), which seems inconsistent with the specialized interpretation of the site (Diniz and Nukushina 2014). The analysis suggests that this pattern of tool production cannot be explained by constraints of the raw material, and specialized tools could be produced using the available rock. The raw material used at Arapouco for the production of these flakes is predominantly siliceous rocks, of equal or better quality than the raw material used at Cabeço das Amoreiras, which was mainly used for the production of specialized tools such as geometric microliths (Nukushina 2012; Pimentel et al. 2015). So far, the specialization of the lithic industry has not been verified in other sites either (Nukushina 2012). Lithic studies demonstrate and confirm the use of locally available rock but most significantly, they indicate that the raw material used in each site is different, suggesting a preference for rock available in the immediate vicinity (Pimentel et al. 2015).

The frequency of retouched tools, such as geometric microliths, is a common trait at the Late Mesolithic sites (Araújo 2003; Arnaud 1987; Carvalho 2009). Their typological frequency has been used to determine the relative chronology of the sites (Roche 1972), or to suggest particular functions for each site (Arnaud 1989; Marchand 2001). The most common microlith is the trapeze. These are dominant in the assemblages of Moita do Sebastião and Cabeço da Arruda in the Tagus valley (Roche 1967, 1972), and Arapouco, Poças de S. Bento, and possibly Vale de Romeiras in the Sado valley (Araújo 1995–97; Diniz and Nukushina 2014; Nukushina 2012). Triangles are predominant only at Cabeço da Amoreira in the Tagus valley. These are residual at Moita do Sebastião and Cabeço da Arruda (Roche 1972), and at all the Sado sites (Nukushina 2012, 78). Segments are abundant in the assemblages of the eastern portion of the Sado valley, at Cabeço das Amoreiras, Cabeço do Pez, and Várzea da Mó (Marchand 2001; Nukushina 2012), but are rare at the Tagus valley, found in the assemblages of Cabeço da Amoreira only. While there is some chronological patterning, with the trapezes being more common in the sites with earlier dates, and the triangles and segments in the sites with the most recent dates, this variability does not clearly support arguments towards different functions of the sites, which in fact seem typologically and technologically homogeneous. At present, the typological and technological data are insufficient and future comparative analyses of the assemblages are necessary to clarify and understand homogeneity and heterogeneity in the lithic material of both valleys.

**Other data**

Other lines of evidence provide additional elements for the analysis of the burial populations in the sites at the Tagus and Sado valleys. In this section I summarize
and evaluate central aspects of various osteological analyses and palaeodemographic data from both valleys, along with preliminary observations about objects of adornment recovered at the Tagus sites. These data highlight aspects of heterogeneity between the sites, further supporting the hypothesis of autonomous groups living side by side and burying their dead in neighbouring burial grounds.

Tagus valley

Osteological analysis of the skeletal material from Moita do Sebastião and Cabeço da Arruda presents several elements suggesting heterogeneity between the populations of each site, which can be outlined as follows:

- Individuals buried at Cabeço da Arruda present a higher fertility rate than those at Moita do Sebastião, as suggested by the reconstruction of demographic profiles analysed in terms of population growth (or decline) and fertility (Jackes and Meiklejohn 2008). According to these authors, this difference suggests an expanding population at Cabeço da Arruda while the values from Moita do Sebastião are aligned with a typical hunter-gatherer population with a slow growth rate.

- The burial population at Cabeço da Arruda contains a higher number of older adults than at Moita do Sebastião, suggesting a greater life expectancy at Cabeço da Arruda (Jackes, forthcoming).

- Dental wear is stronger in the individuals buried at Moita do Sebastião than in those at Cabeço da Arruda (Jackes, forthcoming).

- Frequency of dental caries is higher at Moita do Sebastião than at Cabeço da Arruda. In contrast with the material from Cabeço da Arruda, at Moita do Sebastião caries are common at late adolescence, and older adults present very high levels of caries (Jackes 2009, forthcoming).

- Bone cortex is on average thinner in the osteological series of Cabeço da Arruda than in the series of Moita do Sebastião (Jackes, forthcoming; Jackes and Meiklejohn 2008, 218). These authors suggested that this could be explained by lower activity levels of the population buried at Cabeço da Arruda and/or by the consumption of high oxalic acid and salt rich plants, which could be found in the estuary, suggesting high reliability on foods found in the immediacies of the site (Jackes, forthcoming; Jackes and Meiklejohn 2008, 218).

According to M. Jackes and C. Meiklejohn (2008), the different patterns observed between Moita do Sebastião and Cabeço da Arruda seem to suggest higher levels of sedentism of the latter population. In this scenario, differential sedentism could explain the higher fertility levels noted at Cabeço da Arruda, as well as the indicators of reduced physical activity and the eventual higher reliance on local plants (Jackes, forthcoming; Jackes and Meiklejohn 2008). This scenario remains hypothetical, and further research should clarify the suggested model of divergent sedentism levels between the populations of Moita and Arruda. While the isotopic
signatures indicate the consumption of protein from similar sources, the differential dental wear and caries observed in the assemblages of Moita do Sebastião and Cabeço da Arruda suggests different food habits and/or genetic differences between the burial groups.

Objects of adornment analysed by J. Roche (1959) indicate differential use of these elements, further supporting the idea of heterogeneity between the burial populations at Moita do Sebastião and Cabeço da Arruda, as well as at Cabeço da Amoreira. Pierced shells are abundant at Moita do Sebastião and were found in significant quantities in several graves (MS1952–54, Sks 1, 5, 6, 8, 11, 25). Pierced shells were also found at Cabeço da Amoreira, but were very rare at Cabeço da Arruda, where only three elements were identified. Stone pendants made from raw materials that could be found locally (Roche 1959, 409) were also found but are rare, with four examples known at Moita do Sebastião, two from Cabeço da Amoreira, and possibly one from Cabeço da Arruda. Four teeth found at Cabeço da Amoreira were possibly used as pendants. This type of pendant is unknown at both Moita do Sebastião and Cabeço da Arruda. J. Roche’s (1959) observations suggest a distinction in use of objects of adornment between the individuals buried in the different sites, and while pierced shells are common at Moita do Sebastião, these elements were not used by the individuals buried at Cabeço da Arruda. Unfortunately, comparative observations of the objects of adornment are not available for the sites at the Sado valley.

*Sado valley*

Palaeodemographic analysis of the skeletal material from the Sado valley indicates a common demographic pattern between the populations buried in each site (Umbelino 2006, 146):

- The proportion of adults (c 80%) and non-adults (20%) buried in each site is almost identical (Cunha et al. 2003), with the exception of Várzea da Mó where just one burial of an adult was found.
- Sexual distribution is difficult to determine due to preservation of the material. However, most sites present a balanced number of male and female burials (Arapouco, Vale de Romeiras, and Cabeço do Pez), with the exception of Cabeço das Amoreiras where all adults seem to be male. Sexual determination was not possible at Poças de S. Bento (Cunha and Umbelino 1995–97).
- Age at death is equally difficult to establish but it seems that all sites accommodate non-adults, adults, and individuals over 50 years old (Cunha and Umbelino 1995–97; Cunha et al. 2003).

Frequency of dental caries in the Sado valley series indicates some variation and heterogeneity between the sites, even attending to differential preservation of the material (Cunha et al. 2003) (fig. 6.2). In a sample of 48 individuals, a total of 18 present caries (38%). Arapouco (7/15) and Vale de Romeiras (6/12) present a similar pattern of c 50% of the individuals with caries, despite the marked
differences in the sources of protein consumption. In contrast, at Cabeço do Pez, located next to Vale de Romeiras, only 2 out of 17 individuals had caries (12%). Cabeço das Amoreiras, also with a terrestrial isotopic profile, presents the highest percentage of individuals with caries (3/4, 75%).

Figure 6.2. Burial grounds in the Sado valley with indication of sources of protein (mixed/terrestrial) and frequency of caries (F.C.) of the burial populations.

The combined evaluation of the patterns of dietary sources of protein and frequency of caries for each burial population at the Sado valley, offers some indicators about possible subgroups coexisting within the eastern group defined by the terrestrial protein pattern. Unfortunately, due to poor preservation of the material from Poças de S. Bento, dental analysis has not been possible, and without further data, it remains unclear if the burial populations of the western sites, Arapouco and Poças de S. Bento, correspond to one or more groups. In the eastern group, characterized by the consumption of terrestrial protein, two subgroups emerge: one with high frequency of caries buried at Cabeço das Amoreiras and Vale de Romeiras, and the other with low levels of caries buried at Cabeço do Pez. Despite the common pattern of protein consumption, these subgroups present different patterns of frequency of caries suggesting different food habits and/or genetic differences between the burial groups.

The common demographic pattern and inter-site variability of dietary patterns, seems to support the scenario of different burial grounds being used by particular groups where natural populations were buried according to their group of origin.
Side by side: geographic segmentation of shared landscapes

Several lines of evidence indicate that the burial grounds at the Tagus and Sado valleys were used side by side by different units of hunter-gatherers, suggesting the geodemographic segmentation of the valleys. This term, borrowed from geographical marketing research (see See and Openshaw 2001) is used in this dissertation to express the phenomenon of coexistence of different groups of a population of hunter-gatherers, which contained similar people with similar lifestyles, but who belonged to different units, as suggested by the dietary patterns, the lithic analyses, the objects of adornment, and the osteological evidence presented above.

At the scale of the valleys it is clear that each valley concentrated groups of hunter-gatherers that normally did not move from one valley to the other. The valleys were self-contained, and the different choices of lithic raw materials as well as the distinct procurement strategies observed in each valley are strong indicators of this autonomy and population clustering. The geodemographic segmentation of the valleys is especially clear in the Sado valley but the evidence is less strong for the sites in the Tagus valley.

Sado valley

Overall, the isotopic profiles of the population in each burial ground reflect the zooarchaeological data of the site. This is particularly striking at the Sado valley, where only a few sites present significant quantities of fish remains of marine-estuarine habitats. It is precisely in these sites (Arapouco and Poças de S. Bento) that the burial populations reflect the protein consumption of a mixture of marine-estuarine and terrestrial resources, similar to the pattern identified at the Tagus valley where the sites are particularly rich in aquatic fauna. In contrast, in the eastern sites of the Sado valley, where faunal remains of terrestrial origin are dominant, the burial populations confirm this pattern and present isotopic signatures typical of the high consumption of protein from terrestrial foods.

It may seem a paradox that all these sites are shell middens. Here, the most common species of shellfish are the peppery furrow shell (Scrobicularia plana) and the common cockle (Cerastoderma edule). These molluscs can survive in shallow waters with low salinity levels (Dupont 2011, 197; Gutiérrez-Zugasti 2009, 479, 483) but the impact of their consumption on human isotopic signatures remains unclear. Nevertheless, the concentration of shell remains decreases considerably from West to East, suggesting a very occasional consumption of this type of food in the eastern sites.

The positive correlation between the isotopic profiles of the burial populations and the zooarchaeology of the sites is a strong indicator of a geodemographic segmentation of the Sado valley. It suggests that the human occupation of the valley was divided between the marine-estuarine environment of the western sites and the thresholds of the estuarine system in the eastern sites. Evidence obtained from the analysis of dental caries, discussed above, suggests the presence of two subgroups within the eastern group, further supporting the dietary and/or genetic
geodemographic segmentation of the hunter-gatherer population. The data for the western group is limited and it remains unclear if one or more groups used these sites to bury their dead. The geodemographic segmentation of the Sado valley is evident and indicates that different groups coexisted side by side and buried their dead in neighbouring sites.

**Tagus valley**

The data from the Tagus valley is less explicit, however, several lines of evidence point to geodemographic segmentation, at least to some extent, but also to a modality of aggregation sites.

The isotopic signatures are consistent with the zooarchaeological data and do not indicate any particular pattern that may distinguish the burial populations in each site. Differences in the frequency of dental caries between the people buried at Moita do Sebastião and Cabeço da Arruda suggest different food choices and/or genetic differences. Other osteological observations, such as the higher fertility rate and longer life expectancy rate observed at Cabeço da Arruda, in comparison to Moita do Sebastião, supports the argument further, suggesting that these were in fact two different groups, although their characterization remains unclear. A striking piece of evidence comes from brief observations made by J. Roche (1959) on the objects of adornment, discussed above, showing a marked difference between the two burial populations, with adornments being commonly used at Moita do Sebastião but almost absent at Cabeço da Arruda.

The intra-site heterogeneity of dietary patterns (mixed, high terrestrial and mixed, high marine-estuarine) observed towards the last episodes of burial activity at the Tagus valley suggests a different mode of using the burial grounds. This heterogeneity could be explained if different units were using the same sites, consisting of places of aggregation of hunter-gatherers for the burial of their dead, suggesting that these places were locations of social gathering structured by death rituals.

These interpretative scenarios remain hypothetical and further studies on the human remains recovered from these and other sites at the Tagus valley must be carried out in order to test both the scenario of geodemographic segmentation of the valley, and the suggestion of aggregation sites.

**Shared landscapes**

The populations of the Tagus and Sado valleys coexisted side by side and the people frequenting the sites of one valley were buried in the same valley. The geodemographic segmentation of the valleys is clear in the Sado and likely at the Tagus. In this scenario, different groups used and buried their dead in different sites. In some cases, it is possible that one group used more than one burial ground, but further analyses should be done to clarify this. Current evidence suggests the following scenarios:

- In the Tagus valley, one group used the burial ground of Moita do Sebastião and another group used the burial ground of Cabeço da Arruda. However, towards the end of the burial activity, more than one
dietary group is buried at each site, suggesting a shift to a modality of aggregation places rather than segmentation.

- In the Sado valley, the people using the western sites were normally not buried in the eastern sites, and vice versa.
- At the eastern sites of the Sado valley, one group was buried at Cabeço do Pez, and one or two other groups were buried at Vale de Romeiras and Cabeço das Amoreiras.

Segmentation of Mesolithic territories has been suggested in other areas such as the French Bretagne. The interpretation of this phenomenon was suggested by the analysis of the dietary profiles of the burial populations at Téviec and Hoëdic in which differences suggested that each burial ground was used by different groups (Schulting and Richards 2001, 326).

At the Tagus and Sado valleys, this phenomenon of segmentation is possibly better termed as a phenomenon of shared landscapes between hunter-gatherers. The apparent social splitting of the land was possibly based on the principles of trust, sharing, and exchange that apply to hunter-gatherer relations with the non-human environment and with the human community (see Ingold 1999). Furthermore, in the archaeological record there is no evidence of conflict between these groups, at least on a physical level. Osteological analyses of the Tagus and Sado series show that evidence of trauma is minor and may be explained as the result of daily activities rather than interpersonal violence or warfare (Cunha et al. 2004; Jackes 2004). Thus, current archaeological evidence suggests that the geographical areas of the Tagus and Sado valleys were shared and used simultaneously by several cultural units of hunter-gatherers, and where the dead were buried side by side.

Death in place

Burial ground as the chosen space for the dead

The last hunter-gatherers of the Tagus and Sado valleys placed their dead in open air burial grounds. Through a period of time, people were buried in these sites, mostly in simple individual structures, spatially organized in a more or less complex manner.

Analysis of the representativeness of the archaeological burial population in relation to the original groups, suggests that at Moita do Sebastião and Cabeço da Arruda the MNI does not represent more than 50% of the original group, assuming that one group is buried at each site (see chapter 5). This could be explained if (1) the sites contained several more burials than those that were excavated; (2) half of the group received other mortuary treatment; or, (3) the groups frequenting each site used more than one burial ground. Interestingly, the estimates for both Moita do Sebastião and Cabeço da Arruda are similar and suggest a common
pattern in the mortuary practices. At the Sado valley, the representativeness of the sample is difficult to calculate due to current limits on the estimates of duration of burial activity at some sites. This is the case at Arapouco and at Vale de Romeiras to a certain extent. At Vale de Romeiras, it is possible that the site was used more frequently during a period of time, but at present we have only two $^{14}$C dates separated by a long time span. Nevertheless, at Cabeço do Pez the archaeological population buried during the Late Mesolithic seems to be representative of one original group burying their dead here as the principal way of disposing of the cadaver (see chapter 5), although taking into account that the site is not fully excavated. In contrast, the number of burials at Cabeço das Amoreiras is low (n=8) and if the site has been used by one group only, it could be suggested that most individuals from this group were buried elsewhere, or received another mortuary treatment. The possibility of coexisting mortuary practices is not unusual and it is common that one cultural group has various ways of treating their dead (Ucko 1969). The data is not conclusive and these working hypotheses require further investigation.

As discussed, burial practice was not common in the Iberian Peninsula, neither for previous chronologies nor in contemporaneous sites (Peyroteo Stjerna, forthcoming). Yet it was common mortuary practice in the Tagus and Sado valleys during the Late Mesolithic, from the first episodes of use of the sites. This particular form of dealing with death, by constituting cemeteries, was a central aspect in the life of the last hunter-gatherers of this region, and played a central role in the formation and maintenance of these places. This observation does not exclude other interpretations of further uses of these sites. This observation implies solely that at least part of these sites was used as burial ground over a more or less long period of time, in a more or less continuous manner.

It could be argued that if these were semi-sedentary groups (Arnaud 1987, 1989), this concentration of human burials essentially fulfilled a practical need. These bodies would simply be buried where the person died, as a way of dealing with a decomposing corpse. This practicality was possibly one motivator for this mortuary behaviour. However, the analysis of the treatment of the dead and the chronological and spatial boundaries of the phenomenon suggest that these were highly structured mortuary ritual practices that go beyond the practical need of removing a decomposing corpse.

Processual explanations link these Late Mesolithic cemeteries to hunter-gatherer territorial claims to establish control over economic resources provided by the new environmental conditions in these estuaries (Arnaud 1987, 1989). This is a valid and compelling argument. However, I argue that the economic motivator cannot be sustained on its own. Furthermore, the formation and maintenance of cemeteries in these early chronologies has been regarded as an indicator of social complexity. According to this view, social complexity would be mirrored by mortuary complexity (Binford 1971), as discussed in chapter 1. This may be factual in certain contexts; however, I argue that in these sites this correlation is not necessarily valid, as these cemeteries were not necessarily more complex than other funerary practices that did not engage in the formation of cemeteries.
This particular approach to death, with the development of cemeteries in open air sites, as opposed to a concealed death in caves or in remote places, reveals a relation of death to a daily landscape. Thus, instead of focusing on economic constraints and issues of social complexity, I would like to emphasize the role of mortuary practices in the formation and maintenance of these locations as meaningful places remembered over generations. In this perspective, these locations were not only a repository of economic resources but spaces that held experiences, events, and memories (see Low and Lawrence-Zúñiga 2003), constituting highly productive territories of social and symbolic resources. The commitment of the living to the formation and maintenance of these cemeteries is a positive indicator of the importance of the dead in defining space and place in the long term (Wright 2013, 414). In practice, as the dead are buried in a place, this place is invested with new significance (Nilsson Stutz 2003a, 363), and consciously and/or unconsciously, death played a role in the collective memory of these sites.

A cemetery is more than a place of burial and the site can maintain its funerary function without new burials. The cemetery can be visited, ritual practices can take place, and the site can be maintained as a place of ancestors. But a cemetery can also be forgotten, and remembered again (see Nilsson Stutz 2012). The chronological boundaries for the use of the sites as burial grounds (i.e., for burial practice) are not necessarily the chronological limits of the use of the sites as cemeteries. We can assume however, that these chronological boundaries have, to some extent, some meaning regarding the specific practice of burial. Overall, the sites were used more or less continuously for burial practice between c 500 and 1000 years, and all burial grounds were active between c 6000 and 5500 cal BCE. Moita do Sebastião and Cabeço da Arruda in the Tagus valley and Cabeço do Pez in the Sado valley present frequent and continuous burial activity over relatively short periods of time. This was possibly the case at Arapouco and Vale de Romeiras at the Sado valley, but here the chronological data are more limited. Other sites, such as Cabeço da Amoreira in the Tagus valley or Cabeço das Amoreiras at Sado, present a more scattered activity pattern along with a lower frequency of burials. This could be explained if these sites were used more or less simultaneously by one group using multiple burial grounds, for example Moita do Sebastião and Cabeço da Amoreira used by one group, while Cabeço da Arruda was used by another. Similarly, in the Sado valley, Cabeço das Amoreiras and Vale de Romeiras could have been used by the same group, while Cabeço do Pez was used by another group, as suggested by the dietary patterns discussed above. It is also possible that the lower frequency of burial was due to its use by a smaller group with fewer deaths per year, and/or by a group that visited the site less frequently. Any of these explanations remains temporary until new data can support one or the other hypotheses.

The close proximity of some of the burial grounds, possibly used by different groups, supports the importance of the place of the dead in these locations. The continued use of these sites for the burial of the dead over multiple generations was likely a significant part of the group’s dynamics and a powerful way for a social unit to form and re-form its identity (see Joyce 2003). Furthermore, the isotopic
data suggests strongly that the placement of the dead was not carried out randomly at different burial grounds, but they were buried in “their” place.

Cemeteries and shell middens in the Tagus and Sado valleys

The dead in a daily landscape: residential or non-residential sites?
The relation between the burial grounds and the remaining areas of the sites remains an open question, and the permanent or semi-permanent character of these places as residential sites is still unclear. The placement of the dead in accessible open air burial grounds suggests a relation of death to a daily landscape, but while the funerary function is undeniable, the domestic nature of the sites remains ambiguous.

Since the nineteenth century (Pereira da Costa 1865, 17), these sites have been interpreted as residential places, and the formation of the shell middens was explained as the result of the accumulation of debris (Roche 1972). J. Roche identified and documented several structures at Moita do Sebastião, and also at Cabeço da Amoreira in the Tagus valley (Roche 1964–65; 1972), which he interpreted as residential features alongside burial grounds. In fact, possible residential structures are unknown in most sites, except for several hearths the relation of which to domestic activities is unknown. The presence of all stages of the chaîne opératoire of stone tool production has been used as a strong indicator of the residential nature of the sites (Araújo 1995–97; Marchand 2001). Recent reanalysis of the structures identified by J. Roche at Moita do Sebastião suggests that these structures may have been part of the burial area, rather than domestic features, related to differential areas dedicated to mortuary ritual practices. This reinterpretation of the data, correlating structures with mortuary practices, suggests the monumentalization of the site and emphasizes the ritual character of the place (Alvim 2009–10). The postholes initially interpreted as part of residential structures, are in this scenario interpreted as the remains of a timber structure delimiting the burial area (fig. 6.3).

The reinterpretation is based on detailed spatial analysis of the postholes in relation to the burial area, the irregularity of both size and position of the holes, and on the architectonic fact that if this was a semicircular hut as advanced by J. Roche (1972), it was positioned in an adverse way in relation to the local winds. Other structures, such as pits filled with unopened shells of *Scrobicularia plana* were erroneously interpreted as storage facilities (Roche 1972, 103, 112), while it is well known that shellfish deteriorates very quickly after its collection (Arnaud 1987). Instead of storage facilities for the living, these pits could be interpreted as associated with ritual deposits related to mortuary practices (Alvim 2009–10, 21). Interestingly, some of these pits also contained a significant quantity of flint, constituting some of the highest concentrations found at the site (Alvim 2009–10, 22; Roche 1972). P. Alvim (2009–10) reinterpreted the structures identified and documented by J. Roche, and proposed a new significance for these elements while emphasizing the funerary and ritual function of the site.
Structures like these have not yet been identified at any other site in the Tagus and Sado valleys. This could be explained by the different excavation methods employed by different teams working at these sites in the past. In 1959 at Cabeço do Pez in the Sado valley, J. Roldão identified several structures related to fire activity (*cinzeiros* and *lares*) (MNA, APMH, 2/3/7/3, pp. 1–28, Cabeço do Pez, 23 May to 25 July 1959). The excavator described these as large structures, c. 200 cm x 120 cm, with a depth of 10 to 15 cm, containing a high concentration of ashes and charcoal. The large size of these features suggests a function other than domestic, but their possible relation with the burial activity is unknown. Unfortunately, there is no graphic documentation of these features and they were not described further. The interpretation of these structures is not possible at present, but ongoing exca-
observations in the Sado valley (Arias et al. 2015; Diniz & Arias 2012) may eventually offer new data and perspectives regarding their function.

**Areas reserved for the dead**

Burial of the dead was specific to particular areas within the sites (Larsson 1996, 30). The only exception is Vale de Romeiras in the Sado valley, where the area of the site presumably corresponds to the area of the burial ground (Arnaud 1989). The burial areas were in general relatively small and presented high concentrations of human burials. The site plans and field photographs show that the burials were typically placed in close proximity with little disturbance of previous burials, suggesting knowledge of prior burials in the area (fig. 6.4).

![Figure 6.4. Burials at Arapouco in the Sado valley, lying in close proximity without disturbance. Left, individual 7; top, individual 8, bottom right, individuals 9 and 10. (MNA, APMH, 1961, F373)](image)

**Grave markers**

The spatial organization of the burial grounds suggests the use of grave markers of perishable material which have not been archaeologically identified. Additional indirect evidence comes from the typical crushed crania patterns indicating significant vertical pressure exerted by overlying soil. This is a common pattern in the osteological collections of both the Tagus and Sado valleys. Experimental work has shown that grainy soils such as gravel and sand exert less vertical pressure on the body in the grave when compared with other soils (McGowan and Prangnell 2015). Since fine sand is the main type of soil in these sites, the pressures observed
suggest that a substantial weight of sediment was covering the feature, possibly aided by heaps of shells on top of the grave. Unfortunately, these elements that may be identified stratigraphically were not recorded by the pioneer excavators of the sites, and this hypothesis remains speculative.

**Site formation and burial activity**

Typically, the human burials lie on the sterile sandy layers at the bottom of the shell middens. Few burials are found in middle and upper layers and these are evident only at Cabeço da Arruda (Roche 1974; Roksandic 2006) and Cabeço da Amoreira (Bicho et al. 2013; Roksandic 2006) in the Tagus valley. The formation of the burial areas starts at the basal sands suggesting that the site development is closely related to the use of the place as burial ground. This is strongly supported by $^{14}$C evidence. The human burials present the earliest dates known in the sites, indicating that the beginning of the burial activity predates, or is coeval with the earliest phases of the formation of the shell middens. The deposits of shells seem to accompany the burial activity, at least in the first stages of use of the sites. The relation of the site formation with the burial activity was noted by L. Larsson (1996, 139; 2010, 33–34) during his fieldwork at Poças de S. Bento in the Sado valley:

It is evident from the stratigraphy that the graves were dug before shells were accumulated and in conjunction with the deposition of shells. (Larsson 1996, 130)

Microstratigraphic analyses at Cabeço da Amoreira in the Tagus valley identified different anthropogenic signatures suggesting several sets of depositional practices (Aldeias et al. 2015). These practices consisted of primary depositional activities (e.g., discrete shell tossing events, trampled surfaces, and combustion features), and assemblages in dumped or reworked deposits placed in secondary position. This research is ongoing and further analyses may clarify the nature of the deposits in association with the human burials. This is certainly one way forward to understanding the relationship between depositional practices, burial activity, and site formation processes.

Several lines of evidence indicate that site formation at the Tagus and Sado valleys is correlated with the burial activity. Funerary depositional histories were varied and complex and their significance require further examination. At an elementary level, they can be outlined as follows:

- **Human and shell deposits were synchronous:** the burial of the individual was followed by the deposit of heap(s) of shells freshly brought to the site. Shellfish was consumed in situ and deposited on top of the grave and/or at other areas of the site. In this case the shells are in primary position.

- **Shell deposits precede the human burial:** the interior and/or top of the grave was filled and/or topped with shells previously deposited in the site,
and relocated at the time of the burial. In this case the shells are in secondary position.

**Burials and shells**

At the Tagus valley the association between human burial and shell deposits is evident. Skeletal remains are typically densely covered with a shell matrix, and the sediment filling the grave was saturated with fragments of shells. In some skeletons preserved in blocks it is possible to observe the placement of the cadaver in a shallow pit dug out of the sterile basal sands, and the covering of the body with sediment containing shells, ash and charcoal. In these cases, the sediment was brought from elsewhere in the site, suggesting a secondary position of the shell matrix deposit (fig. 6.5).

![Figure 6.5](image)

*Figure 6.5. Tagus valley, Moita do Sebastião, 1952–54, individual 21. The skeletal remains lie on a yellow sand with few inclusions, and are covered with shell-rich sediment with ashes and charcoal. (Photograph by author at MHNUP)*

At the Sado valley, the association of the human remains with deposits of shells is not always clear. Most burials were found in the basal sand layer below the more compact layer with shells (Arnaud 1989, 621), as indicated by the site profiles. However, some burials seem to be eccentric to this pattern. At Vale de Romeiras, individuals 19 and 21 were found outside the shell midden area (fig. 4.45) in chestnut brown sand (layer 5) without being covered by a layer of shells (fig. 6.6).
Figure 6.6. Profile F–F', Vale de Romeiras, Sado valley. Individuals 19 and 21 lie in the chestnut brown sand (layer 5) at 60 cm and 41 cm deep, respectively. This layer is covered by black soil (layer 3) and the top soil (layer 1). In this part of the site, the grey soil with shells (layer 2) and yellowish clay-like soil (layer 4) were not identified. (Adapted from a photograph by J. P. Ruas. MNA, 1959, D. Sousa, A120-detail)

VR1959, Sk19 is the oldest burial known at both the Sado and Tagus valley (6593–6370 cal BCE, 95% probability) and this shell-free deposition supports the hypothesis of the burial activity preceding the deposits of shells. This is also the case at Poças de S. Bento where several individuals were found outside the shell midden area, although the date of these individuals is unknown. The shell matrix concretion observed on the skeletons excavated at the Sado valley is much less compact when compared with the material from the Tagus valley, where it is absent in several cases. Likewise, the filling of the graves at the Sado valley contained very few shells when compared with the burials at the Tagus.

In both valleys the burials were typically associated with primary or secondary deposits of shells. As discussed, in a few cases at the Sado valley some burials seem to be eccentric to this pattern. Despite the lower concentration of shells at most sites of the Sado valley, shells are an obvious element in all sites, even in those located at some distance from the river, such as Poças de S. Bento, or in the eastern group where the ecological conditions were possibly not as favourable for gathering shellfish. Nevertheless, the accumulation of shells and its association with the human burials is a common feature in both valleys, as it was among other Late Mesolithic hunter-gatherers in Atlantic Europe (e.g., Téviec and Hoëdic in Brittany, France). This common element was definitely not a main food resource in some of these sites but its ubiquity was a common cultural trait.

Shell symbolism

Shellfish is a low caloric food which remains highly appreciated in Portuguese gastronomy. The hard shell element of this animal has throughout human history embodied several symbolic and religious meanings. Some evidence suggests that it is possible that shells had a symbolic meaning also in these burial grounds.

As discussed, shells are commonly found mixed in the filling of the graves. In some cases the filling was different from the bottom of the grave (fig. 6.5). In other cases the presence of shells in the filling is related to the layer where the pit was dug out, with shells already mixed in. Shell heaps were possibly placed on top of the graves, and among other possible functions these heaps were likely to have provided a grave marker. Some evidence strongly suggests that shells were not
mere waste randomly used as sediment. This is particularly well documented at Moita do Sebastião (see chapter 4). Several features had a significant concentration of shells placed in particular areas of the grave. Other cases indicated the preparation of the floor of the grave with a layer of shells before the placement of the cadaver in the feature. In some of these examples the selection of a particular type of shell was evident (Roche 1972).

Shells were used as personal ornament. At the Tagus valley these elements were more common at Moita do Sebastião. Objects of adornment were found at Cabeço da Amoreira, but were very rare at Cabeço da Arruda (Roche 1959). At the Sado valley, the relative frequency of objects of adornment is unknown but it was noted that these elements were used for a long time, possibly from an early age until the death of its user, as indicated by well-worn beads and multiple and consecutive perforations (Mariana Diniz, pers. comm.).

These practices suggest that it is likely that shells were charged with symbolic meanings expressed by the placement of these elements in the burial features, or in close association. Shell symbolism is varied, but its association with water places it in narratives of birth, rebirth, rejuvenation, creation, and cyclical time (Claassen 2011). Bivalve shells present an idea of container, and in some cultures bivalves are viewed as vessels that can hold the soul of the dead and purify the decaying flesh (Ceci 1989). Shell symbolism is attached to individual shells but also to heaps and mounds (Claassen 1996). C. Claassen, an authority in the study of shells in archaeological contexts has further proposed that “to be buried in a matrix of shell, or under a stratum of shell was surely to insure the reincarnation of the individual, the family, and the lineage” (Claassen 2011, 35).

Places for the dead?

Postglacial prehistoric and historic shell-bearing sites exist worldwide in a diverse range of patterns regarding site formation processes and functions. The great variability of archaeological shell-matrix precludes its study as a single phenomenon (Balbo et al. 2011; Claassen 1998; Milner et al. 2007; Roksandic et al. 2014).

The formation of the shell middens in the Tagus and Sado valleys is closely related to the development of burial grounds, as indicated by stratigraphic and radiocarbon evidence. The depositional patterns observed in these sites are the outcome of multiple events and represent numerous overlapping depositional narratives (see Randall 2011, 126). At the Tagus valley, overlapping practices resulted in the formation of mounds, while at the Sado valley the vertical mound formation is much more discreet. Interestingly, at the Sado valley, most sites are located at the top of a hill, by contrast with the location of the Tagus sites on low terraces at the river bank. The formation of the shell middens at the Tagus and Sado valleys is a process and is strongly related to mortuary ritual practices. The formation of these sites can be understood as set of communal practices the significance of which lies in the practices of creation and metamorphosis of the place, rather than on its complete and unitary form (see Kidder 2011).
The creation of places of particular meaning, such as mounds and monuments, and their later interpretation may entail different understandings (Richards 2004). It is possible that the sites at the Tagus and Sado valleys were transformed from ancestral spaces to places of residence, which not may have been synchronous and/or continuous. This is a hypothetical scenario and further research is necessary to evaluate this and other possibilities. Current evidence shows that the sites develop with the formation of burial grounds. Furthermore, the data indicates that these places were not simple locations to access resources, but embodied the social and symbolic foundations of the community.

Following this argument of the significance of the burial grounds in the formation of these sites, one aspect remains intriguing. Several shell middens identified at the Tagus and Sado valleys do not contain human remains. This is however unclear and may be misleading. While some of these sites were destroyed before any archaeological excavation, other sites may have human burials which have not yet been found. The assumption of the existence of shell middens of the same chronology and without human remains in these river valleys remains to be verified.

**Mobility: permanent places for the dead, but also for the living?**

Dietary patterns of protein consumption identified in the different burial grounds reflect a strong connection of the burial population to the ecology of each site. This is particularly striking at the Sado valley where the western and eastern groups present contrasting diets but reflect the ecology of the sites where they are buried. While this may indicate that these sites were used during long periods, it does not exclude the possibility of mobility and exploration and use of other territories.

Several elements seem to suggest significant mobility of these populations. As discussed, the invisibility of domestic structures suggests the use of ephemeral shelters, which is one indicator of residential mobility (Kelly 2013, 91). Despite the local production of geometric microliths, the material culture tends to be non-specialized, and in some sites the predominance of unspecialized toolkits is well documented (Diniz and Nukushina 2014), by contrast with the complex and vast inventories of material culture known for highly sedentary foragers, where the ratio between time and cost of technology is high (Kelly 2013, 122, 123). The raw material procurement pattern observed at the Sado valley shows that only local rocks of immediate access were used for tool production. While the choice of raw material is not a definite argument, it seems to support the scenario of short and temporary visits to the sites. This seems to be the case at the Sado valley, but may not be the same at the Tagus valley. The current data is not conclusive.

While these aspects seem to suggest temporary stays at the sites, the faunal evidence indicates that the sites may have been visited throughout the year (Arnaud 1990; Lentacker 1986). Visits to the sites could have been motivated by factors not related to resources but with other events, such as the death of a member of the group or other related practices. In a scenario of mobile hunter-gatherers burying their dead in particular burial grounds, a few aspects remain intriguing.
First, is the fact that very few archaeological sites are known outside these two regions (Araújo 2003, 2015). The second intriguing aspect is the undisturbed nature of these burials, which were not accessed by scavengers. The bodies were clearly well protected after death and buried properly, even if not in deep pits. These measures seem to have been enough to control the access of rapid scavengers such as vultures, which can surround a body and remove soft tissue in just a few hours, as well as the access of burrowing animals such as the wild boar, with a developed sense of smell able to detect odours underground. Scavengers are less common in settlements where movement and presence of humans curbs their activity. However if the sites were used for temporary activities such as burial and other related practices, it seems extraordinary that the bodies remained undisturbed underground. Forensic data shows that the decomposition process slows down soon after burial. First, because the temperature is cooler underground, and second, because burial decreases insect and animal activity. Further evidence has shown that corpses are normally spared from scavengers and insects when buried at a depth of about one metre (Shkrum and Ramsey 2007, 41), which could explain the undisturbed nature of the burials at the Tagus and Sado valleys, even if the sites were not permanently occupied.

From death to burial

The more or less permanent use of these sites remains an open question, and it may have varied over time and between regions. In any case, and assuming that each burial ground was dedicated to a particular group, it is fair to consider that at least some individuals did not die at the place of burial, and were transported to the burial ground after death (Burns 2007, 7). In this event, would it have been possible to bury the individual while retaining its anatomical integrity as observed in the archaeothanatological analysis, and how far could the body be transported?

To answer this question it is important to understand what happens to the body immediately after death (fig. 6.7). The transformation of the body starts soon after death and is dependent on the environment surrounding the cadaver. Immediate post-mortem changes affecting the cadaver are rigor mortis, livor mortis, and algor mortis. The livor mortis is related to the settling of the blood after circulation stops and becomes evident several hours after death. The algor mortis refers to the temperature change of the body after death in relation to the environment. The rigor mortis refers to the temporary post-mortem contraction of the muscles (Prahlow and Byard 2012, 145; Shkrum and Ramsey 2007). The stage of rigor mortis is particularly relevant to this study, because it affects the manipulation of the body, including removal and transportation (Shkrum and Ramsey 2007), as follows:

- Prior to the onset of rigor mortis, a body can be manipulated to any position.
- Once rigor is established, it will not conform to a new position.
• Rigor mortis may be broken by the manipulation of the body, but if rigor is at the maximum then it does not return. The forceful manipulation of a stiff joint can tear muscles and fracture a long bone weakened by disease (e.g., osteoporosis). If rigidity is not fully established, then it returns to a lesser degree in a particular joint (range 2–8 hours).

Figure 6.7. From death to the burial of the individual: post-mortem changes of the cadaver.

Body rigidity occurs at the level of the involuntary and voluntary muscles and several factors can influence the development of rigor mortis (table 6.1). It starts from the smaller to the largest muscles, and it is fully established in all joints within 2 to 20 hours (mean = 8 ± 1h) after death (Shkrum and Ramsey 2007). Rigor mortis can persist for 24 to 96 hours (mean = 57 ± 14h) but it gradually disappears at the earlier stages of decomposition (Prahlow and Byard 2012, 145; Shkrum and Ramsey 2007).

Table 6.1. Factors that can influence the development of rigor mortis (Shkrum and Ramsey 2007).

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Muscle volume and body habitus</th>
<th>Antemortem muscle contraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased body or environmental temperatures</td>
<td>Increased muscle bulk delays the onset of rigor mortis but the</td>
<td>Related to the position and cause of death.</td>
</tr>
<tr>
<td>decreases the time of onset and resolution of the</td>
<td>rigor will be better developed.</td>
<td></td>
</tr>
<tr>
<td>rigor mortis.</td>
<td>The elderly and infants have rapid progression of rigor but it</td>
<td></td>
</tr>
<tr>
<td></td>
<td>is less developed and disappears more quickly.</td>
<td></td>
</tr>
</tbody>
</table>

The decomposition process consists of progressive break-down and dissolution of the body and starts after the onset of the earliest post-mortem changes (Prahlow and Byard 2012, 145; Shkrum and Ramsey 2007). Decomposition consists of two aspects: autolysis and putrefaction. Both are influenced by environmental factors, temperature in particular. The onset of decomposition depends on a number of variables. In temperate conditions changes begin 24 to 48 hours after death (Shkrum and Ramsey 2007), depending on the season of the year. It has been documented that during the summer, in temperate Mediterranean climates, such as
in Portugal, decomposition changes can become evident just half a day after death (Pinheiro 2006, 97). Decomposition changes involve processes of discoloration, distension, degradation, dissolution (Shkrum and Ramsey 2007), and skeletonization (Pinheiro 2006).

If a buried skeletonized body is found in articulation, it indicates that most of the process of decomposition occurred underground. The body was buried before the break-down of the joints, while retaining its anatomical integrity (Duday and Guillon 2006). Additionally, if the relative position of the skeletal elements indicates that the body was buried in a constrained position, flexed at the level of the hip and knee joints, as typically found in the burial grounds under study, it indicates that the individual was placed in the grave feature before or after rigor mortis. The placement of a cadaver in a constrained position in a pit while still retaining its anatomical integrity could be carried out in the following scenarios:

- If the deceased was *buried before rigor mortis*, meaning that burial took place sometime between the moment of death and the full onset of rigor mortis, in an interval between 0 to 20 hours after death.
- If the deceased was *buried after rigor mortis*, meaning that burial took place at the early stages of decomposition, when rigor mortis lessens and disappears. In a temperate climate, decomposition starts 24 to 48 hours after death, but in warmer seasons it can start earlier.
- It is unlikely that the body was buried while in maximum rigor mortis.

A body protected from scavengers, and from insects to a certain extent, could be buried c 48 hours after death, after rigor mortis, while still retaining its anatomical integrity. However, degradation of the joints starts slightly later, even in the case of the most labile joints. It is suggested that a week or two may not be enough for most connective tissue to break down completely and the skeletal elements would remain articulated (Duday 2009, 75).

**Transportation of the dead**

Moving is costly, and while subsistence and shelter must always be accounted for (Kelly 2013, 101), moving with a cadaver entails other limitations and risks. Archaeothanatological analysis in this study indicates that if the body was transported, it was as a whole, and its transportation required the maintenance of its integrity. This procedure would require a method of transport of the corpse functioning as a carrying device, such as a stretcher where the body could lie, possibly wrapped and bundled up. Structures that may have functioned as carrying devices of corpses are extremely rare in the archaeological record, but there is some evidence of such elements, such as the case of the Mesolithic burial at Korsør Nor in Denmark. The interpretation of this striking burial indicates that the cadaver was wrapped in a bark construction resembling a stretcher (Norling-Christiansen and Brøste 1945, quoted in Nilsson Stutz 2003a, 281), possibly used for carrying the body (National Museum of Denmark 2015).
A small group carrying a human corpse, walking c 3 km/h during 5 h/day could in two days move at least 30 kilometres. This is a conservative estimate, and these groups could certainly move faster, if there were no impediments such as terrain, weather constraints, or small children in the group. On average, a person could die c 30 kilometres away from the burial ground, and could be calmly transported and buried in anatomical integrity in the place of choice (table 6.2). This distance could be greater if the transport speed was higher and if death occurred during cooler seasons (fig. 6.8).

The transportation of the body after death to the chosen burial ground is a possibility. This scenario is a costly endeavour, and the confirmation of such practice would emphasize the relevance of these burial grounds for the hunter-gatherer community, as well as the significance of the anatomical integrity of the body in its lifelike appearance. Furthermore, the transportation of the body could be a journey of significant meaning and possibly ritualized. These elements are well known for medieval mortuary practices (Boyer-Gardner and Vivas 2014) but remain speculative for prehistoric periods. These are, however, relevant scenarios with a significant impact that should be considered.

Table 6.2. Estimated walking speed for a small group carrying a human corpse (based on normal human walking speed of 5km/h).

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>3km/h</td>
<td>4 km/h</td>
<td>3km/h</td>
</tr>
<tr>
<td>4 km/h</td>
<td>5h/day</td>
<td>30 km</td>
</tr>
<tr>
<td>5h/day</td>
<td>15 km</td>
<td>40 km</td>
</tr>
<tr>
<td>6h/day</td>
<td>20 km</td>
<td>45 km</td>
</tr>
<tr>
<td>18 km</td>
<td></td>
<td>54 km</td>
</tr>
<tr>
<td>24 km</td>
<td></td>
<td>72 km</td>
</tr>
<tr>
<td>30 km</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 6.8. 60 and 30 km radii from a central point in the regions of the Tagus and Sado shell middens.
Topographical relationships of death

J. Barrett (1996) highlighted how mortuary rituals structure the *topographical relationships of death*. Following Van Gennep’s (1960) threefold division of rites of passage, Barrett identified critical spatial differences in the rites involved in primary burial and secondary mortuary practices. As opposed to primary burial, secondary mortuary practices afford a spatial and temporal separation between the initial rites of liminality and the concluding rites of incorporation (Barrett 1996, 397). Conversely, the mortuary rituals involved in a primary burial will settle both the place and the moment of the transition of death (Barrett 1996, 398) in a permanent place in the landscape. Primary burial and the significance of the body as a whole were central elements in the mortuary practices of the last hunter-gatherers of the Tagus and Sado valleys. Here, the dead were not removed from daily landscapes. They were granted with a formal, permanent, and accessible location in the heart of the social and daily life of these hunter-gatherers.

In this perspective, these sites, as with other early cemeteries, reveal a new conceptual link between the dead and the landscape (Pettitt 2011, 263). Through the development of a place for the dead, the experiences and consciousness of the participants take a material and spatial form with significant implications in the construction of a conceptual landscape. This angle on the perspective is important because in fact, as S. Low and D. Lawrence-Zúñiga (2003) have argued, places are not in the landscape but in people’s minds.

Places of mortuary narratives

Funerary burial practices structured the formation and maintenance of the shell middens at the Tagus and Sado valleys.

Archaeothanatological evidence indicates that the treatment of the dead was governed by common principles, which were familiar to the communities of hunter-gatherers frequenting the Tagus and Sado valleys. In these regions, death rituals engaged in the formation of burial grounds. The well defined chronological and spatial boundaries of this mortuary practice suggest that this relationship with death was particular to these communities. The beginning of the phenomenon coincides with the reconfiguration of the settlement pattern, as well as with other cultural changes in the region, which define the Late Mesolithic in the southwestern Iberian Peninsula. From c 6350 cal BCE, small and highly mobile groups converged on the large estuaries of the Tagus and Sado valleys. The mechanisms of interactions between these groups are still poorly understood. However, multiple lines of evidence suggest that the burial grounds were used distinctively by different groups. Inter-group differences are discreet in the archaeological record but it is possible that diversity was greater in terms of languages, physical appearance, and so forth. The overall homogeneity of the mortuary practices suggests
that these communities shared a common world view, despite their group particularities, thus allowing the harmonious coexistence in a shared landscape.

The topographical placement of the dead within the landscape of the living was a central aspect in the social dynamics of the last hunter-gatherers of the Tagus and Sado valleys. The dead were granted a permanent location through the formation and maintenance of cemeteries, and were afforded a concrete place of memory. This relationship between people and place had an impact on two directions. First, the continued mortuary depositional events reproduced over a more or less long period of time reveal a commitment of the living to the dead, and to these places. Second, the places for the dead functioned as a structural medium for the harmonious coexistence of these communities. The burial of the dead was performed within the community’s world view. Mortuary depositional narratives were carried out according to a social structure and within an historical context. Death rituals had (and have) a valuable integrating effect. The reproduction of mortuary narratives gave significance to the living, in terms of understanding their place in the world they knew and acted, and in terms of coping with their grief and own death-awareness. Simultaneously, mortuary depositional narratives charged these places as meaningful social environments.

Archaeological evidence shows that the formation of the sites at the Tagus and Sado valleys was closely related to the creation and maintenance of burial grounds. The re-enactment of mortuary depositional narratives was materialized by the disposal of the cadaver in a familiar way, and in familiar ground. Social memory and cosmology were created and renewed in these places, in every burial event, through mortuary ritual practices. Death rituals are powerful social practices and acts of cultural production. Mortuary ritual practices allow the living to handle the crisis of death in its biological, emotional, and metaphysical dimensions. Because ritual practices are a formalized, sequential, and repetitive performative language they imply continuity with the past (Connerton 1989). In this sense, performative rituals, such as mortuary burial practices, had an effective impact in the production and transmission of social memory in these communities of hunter-gatherers.

Changing attitudes towards death are consistent with changes of world view of a given society, and are specific to social dynamics (Davies 2005). At the Tagus and Sado valleys, the new way of engaging with death was inscribed in a new cosmology, emergent in the postglacial communities of hunter-gatherers in these regions. As discussed, mortuary burial practices at the Tagus and Sado valleys contrasted with previous and contemporary funerary practices in the Iberian Peninsula. The convergence of people to the confined and ecologically rich new estuarine environments of the Atlantic triggered several of the cultural attributes that define the Late Mesolithic in these regions (Araújo 2015). Various studies have shown that cultural diversity among hunter-gatherers is a consequence of interaction and not of isolation (Sassaman 2011). While mortuary data indicate that the people frequenting the Tagus and Sado valleys shared a common world view, their encounters and interaction possibly motivated a new way of dealing with the dead which was better fit for the new sociality.
People frequenting these sites did not just adapt to a new environment. They structured their communities through specific social and historical practices. These included the formation and maintenance of burial grounds affording the dead with a formal and permanent place in a daily landscape. History was recorded in these sites through mortuary depositional narratives in a historically situated world view. These non-literary acts of history making were defined within a cosmology in the way people saw the world and expressed their emotions and materiality. Death rituals in general and burial practices in particular were structural aspects in the life of these hunter-gatherers, and in developing a sense of community within the landscape as well as maintaining the social ties in both life and death. The sites at the Tagus and Sado valleys were places of shared narratives, where people buried their dead according to a shared world view in a shared landscape.

Conclusion: on the history of death and the last hunter-gatherers of the south-western Iberian Peninsula

The history of death parallels the history of human relationships. (Davies 2005, 28)

The history of death of the last hunter-gatherers in the south-western Iberian Peninsula offers a reading of the history of relations between individuals and between groups.

Death and bereavement were recorded in the shell middens of the Tagus and Sado valleys as mortuary depositional narratives of a shared cosmology. The treatment of the dead was based upon a common set of principles that emphasized the familiar appearance of the deceased. The dead were staged reposing in a lifelike position and were granted with a permanent location. This particular engagement with death, with the development of cemeteries in open air sites, reveals a new relation of death to a daily landscape. This history of death starts with a paradigm shift contrasting with previous and contemporaneous responses to death in the region. This change in death’s paradigm reveals significant changes in world view, and it emerged in the context of settlement reorganization and cultural transformations that define the Late Mesolithic in the region, after c 6350 cal BCE.

Burial grounds were used by different groups frequenting the valleys. Despite the geodemographic segmentation of these groups, the main principles governing mortuary practices were structured under a common understanding of death. This shared world view allowed the harmonious coexistence in a shared landscape. The history of relations between the last hunter-gatherers of the Tagus and Sado valleys was structured by a common cosmology. Mortuary ritual practices expressed common social values reproduced in every burial and in every burial ground.

Mechanisms of change that led to the disruption of these paradigms are poorly understood. The interactions that triggered the new relationship with death were
disrupted by a new world order introduced by the onset of the Neolithic. Further research on the history of relationships between the last hunter-gatherers and the first Neolithic communities will benefit from an approach based on the history of death as multilayered processes. The shell middens at the Tagus and Sado valleys provide the data for understanding these relationships, and detailed analyses with a broad scale approach will offer compelling readings of the deep-time history of the last hunter-gatherers of south-western Europe.

Human-place relationships mediated by the placement of the dead in common burial grounds were an emergent phenomenon in postglacial societies. Understanding these large scale historical patterns requires further examination of historical processes operating in early postglacial communities. Comprehensive research on the history of human relationships in early postglacial societies is the cornerstone for an archaeologically informed reading of the deep history of death, if we are to understand what constitutes the roots of the basic design that shaped our modern concepts of death.
Appendix to this dissertation consists of online-only material and can be found at: http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-271551.

Tables in the appendix are distinguished from those in the body of text by the use of the letter A followed by a sequential number (e.g., Table A1).
References


References


References


Gutiérrez-Zugasti, I. 2009. La explotación de moluscos y otros recursos litorales en la región Cantábrica durante el Pleistoceno Final e el Holoceno Inicial. Santander: Universidad de Cantabria.


References


References


Occasional Papers in Archaeology


R. Meurman. Silverberg i Järnbärarland: bergshanteringens begynnelse i ljuset av Schmidt Testhammar-datering (Silver mountains in iron ore country: the beginning of mining as reflected in Schmidt’s Test-hammer datings. Uppsala 2000. 184 pp., 74 figs.


