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ABSTRACT

THERE AND BACK AGAIN - MOBILITY AND BURIAL RITES IN EARLY MEDIEVAL ENGLAND C. AD 300-1000: AN ANALYSIS OF STRONTIUM ISOTOPES IN CREMATED HUMAN REMAINS

Observable changes in funerary rites in early medieval Britain culminate in the re-appearance of cremation in the 5th and 6th centuries, and again briefly in the 9th century. These changes are traditionally linked to questions of mobility and encompass many thousands of individuals. Analyses making use of isotopic systems have been immensely successful in the exploration of inhumed, unburnt remains in the last few decades - touching on the diet, mobility, and the lifecycle of individuals, and recent work on cremated remains has shown that some of these isotope analyses are also reliable when conducted on calcined bone. Following on from this work, this thesis aims to test whether strontium isotope analysis on cremated remains can be used to extract new information from early medieval cemeteries to investigate such aspects as mobility, animal-human relationships, and social practice of the cremating communities. The project uses multi-skeletal sampling to explore the mobility history of cremated individuals buried at the 5th to 7th century mixed-rite cemeteries at Ingleby Barwick, Stockton-on-Tees, and Cleatham, North Lincolnshire, as well as at the 9th century Scandinavian barrow cemetery at Heath Wood, Ingleby, Derbyshire. Plants within 25km catchments around the sites were sampled to establish the variation of bioavailable $^{87}Sr/^{86}Sr$, ameliorating the sample density and therefore precision of existing Sr isoscapes.

The application of strontium isotope analysis uncovered what appears to be regional mobility amongst the cremating communities at Cleatham and Ingleby Barwick, and long-distance mobility from Scandinavia at Heath Wood. At Cleatham, the larger sample of individuals (54 humans and 4 animals) also allowed us to observe that women, born outside the 25km catchment, moved more frequently into the area than men. This was noted to pertain especially to the early phase of use of the cemetery and highlights that trends in mobility may change across time. Animal-human relationships were explored with reference to the strontium isotope results and agency/personhood theory at all three case-study sites. This work is the first of its kind with a focus on the early medieval period in Britain and its results show that the method has enormous potential to unlock aspects of mobility, animal-human relationships, and social practice of the cremating communities.

There And Back Again - Mobility And Burial Rites in Early Medieval England c. AD 300-1000: An Analysis of Strontium Isotopes in Cremated Human Remains

Tessi Loeffelmann

Submitted for the Qualification of PhD in Archaeology

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FÜR CLARA, ROMY, UND ALVA

1 INTRODUCTION

1.1 OVERVIEW

The early part (from c. AD 410 to 750) of the early medieval period (from c. AD 300-1000) in Britain was one of a significant number of periods in the past where a large percentage of the population practised cremation as a funerary rite. In antiquarian research and until fairly recently, this was explained as a consequence of the movement of people to Britain from continental Europe. Therefore, this particular early phase has also been called the 'migration period', or 'Völkerwanderungszeit'. Slightly later, in the 9th century, a small number of cremation burials occur in the context of the Scandinavian presence in the British Isles, and these are also tied to the mobility of individuals. Unfortunately, because cremation burials have often been treated dismissively due to their tendency to exclude numerous and/or intact accessories or grave goods when compared to inhumation burials of the same period, and because they only feature cremated remains, this has meant that we know very little about the level of mobility of these individuals. In the last few decades, whenever research tried to do justice to cremation burials, the focus for questions and the interpretation remained on the context of the burials – such as the shape, material, and decoration of the urn, associated grave goods, and in some cases osteoarchaeological analysis (i.e. Hills 1977; Gallagher 1987; Sherlock & Welch 1992; Timby *et al.* 1993; McKinley 1994; Hills 2003; Leahy 2007; Squires 2011; Squires 2012, 2013; Hills 2015). While these studies are incredibly valuable, and usually succeed in their attempt to bestow the burials with the detail of attention that they deserve, recent developments of isotopic analyses allow us to go further in tackling the issue of individual mobility.

Strontium isotopes, in combination with oxygen isotopes, have become one of the most successful and frequently used scientific tracers of mobility for archaeological human and animal remains. These isotopes are determined by the bio/geo/hydrosphere and remain

unchanged in specific tissues where they can be measured according to well-established methods, after which they may be related back to the physical environment. In this context it serves to note that while isotope research on unburnt human and animal remains has come a long way since the 1960s and now provides an excellent tool to investigate mobility, the same development has been somewhat delayed in the field of cremation burials. Since 2015, with the publication of a study by Snoeck *et al.* which showed that 'cremated bone provides a reliable substrate for strontium isotope analysis', it is now possible to not simply rely on demographic, palaeopathological, and contextual data, but to combine this with a host of other methods from archaeological science. This is where this project aims to pave a way forward: Using strontium isotope analysis to explore the level of mobility apparent in burnt human and animal remains from three early medieval sites in Britain, this study seeks to investigate the potential of these recently developed methods.

To make the most of the new isotopic data, this project will operate with an interdisciplinary approach including archaeological theory. Here, the focus lies on aspects of agency theory with the incorporation of personhood theory and the exploration of relationships. The aim of this was to confront assumptions about life experiences in the past, and our ideas about past ontologies and worldviews.

1.2 AIMS AND OBJECTIVES

Aim/Aims

This project aims to test whether strontium isotope analysis on cremated remains can be used to draw out new information from early medieval cemeteries to investigate:

i. Mobility

ii. Animal-human relationships

iii. Social context of cremating communities and their rites

The project seeks to expand and deepen the insight into the level and the nature of mobility during the early medieval period in individuals who practised the cremation rite. To accomplish this, the focus of this study will lie on those individuals who were cremated in the period from c. AD 300-1000 - because it is this group of people that it was not possible until very recently to investigate isotopically (until Snoeck *et al.* 2015). By extension, this study seeks to show that cremation burials are useful for isotopic research and mobility studies.

Objectives

- I will examine some of the theoretical underpinnings of archaeological research into mobility and migration. This is a necessary step to provide a better theoretical framework for this kind of research. I will critically evaluate existing ideas and concepts borrowed from related disciplines such as sociology, economy, and human geography in terms of their usefulness.
- I will contribute a substantial amount of isotope data by strategically sampling osteoarchaeologically analysed human and animal remains from a selection of sites. This work will make it possible to evaluate the potential of isotope analysis of cremation burials from different types of sites.
- I will establish in detail the bioavailable strontium range for several sites (those under investigation for this project). This will help other researchers working in these localities to define local strontium isotope baselines more clearly and will contribute to a higher quantity of samples for strontium biosphere determination in Britain.
- I will place the isotope results into context by drawing on archaeological information on the site, the region, the period, and the individual. This will make it possible to assess each burial in terms of obvious agency on an individual level, as well as a

site-level – and to bring the discussion back to identity and agency during the early medieval period in Britain more generally.

1.3 RESEARCH QUESTIONS

The following questions relate to different aspects (dimensions) of the archaeology that this thesis is concerned with. Given that all sites are inherently unique, not all questions will be treated with equal focus in each case.

Spatial dimension (questions concerning differences observed across the site):

- What evidence is there for heterogeneity in the levels of mobility amongst the cremated individuals?
- How is this reflected in the burial context?

Temporal dimension (questions related to changes observed in the archaeology across time):

- Is there evidence for the retention of cremation customs in local populations, or does the evidence suggest that there was a gradual influx of people who were cremated?
- How do these findings alter our understanding of the nature and extent of the movement of people from the continent and other areas of Britain in the post-Roman and later centuries?

Theoretical dimension (questions related to the theoretical framework):

- What does the detected level of mobility mean in the broader context of the sites and early medieval mobility, and what can it tell us about the sense of identity, the

individual agency of people and social memory in early medieval England and in the region that for a time was termed the Danelaw?

- Do the concepts used in archaeological research of mobility and migration provide a sound theoretical framework for this type of study?

Practical dimension (questions related to method-testing):

- What are observable pitfalls/limitations of the methods applied, and how can these be avoided?
- Is it possible to systematically sample cremated bone from individuals in order to create a life-mobility-history approach, with several phases of an individual's life covered?

In the case of Ingleby Barwick Low Lane, one of the 5th to 6th century cremation cemeteries chosen for this thesis, a further objective is to conduct a detailed osteoarchaeological analysis on the excavated cremated remains. The following research questions applied specifically to this site:

- What is the demographic profile of the cremated individuals?
- Is it possible to observe indications for pathology at the site?
- Does this differ from other early medieval populations in the region?

1.4 Outline of thesis

This thesis will engage intensively with the research questions outlined above. Chapter 2, the background chapter, follows a tripartite structure covering theoretical approaches first, archaeological information second, and the use of isotopic studies in archaeology third. It is hoped that this will give the reader an insight into the thought processes which were involved in selecting the spectrum of the work and is highly interdisciplinary. At the end of

the background chapter, the reader should leave with a solid understanding of why it matters to choose a holistic approach when asking questions related to mobility in archaeology, and why theory and specific practice are not simply related but interlinked. They will have a clearer idea of how strontium isotopes work in the biogeosphere and how we can use this information to extrapolate mobility, why plant sampling is necessary, which variables need considering during the sampling and during the interpretation, and the variation of bioavailable strontium around the case-study cemeteries. Chapter 3 outlines the material and methods used for this project in some detail in order to document the approach and facilitate reproducibility. This includes the plant-sampling and the establishment of the strontium biosphere in a 25km catchment for each site in a sub-section. Chapters 4 and 5 concern the two c. AD 410-750 sites – Ingleby Barwick Low Lane, Stockton-on-Tees, and Cleatham, Lincolnshire. The results and the interpretation include a consideration of the osteological and palaeopathological information which was re-assessed for this study. Chapter 6 deals with the 9th century Scandinavian site, Heath Wood, Derbyshire, in detail. In all three site-specific chapters (4, 5, and 6), relevant background information is provided on previous archaeological investigations, followed by the presentation of the strontium isotope results and their discussion in the context of the archaeology. Here, I will also draw on Scandinavian literature/ primary sources to explore aspects of cremation rite and the relationships at play between animals, people, and objects. It is hoped that the theoretical discourse in the background chapter has prepared the reader to smoothly connect theory with archaeology and scientific data interpretation. Following the treatment of all three sites, the last chapter (Chapter 7) in the first instance aims to provide a consideration of the newly gleamed information for each site, and a synthesis of the new isotopic data with comparisons to other contemporaneous sites in Britain and across the Channel. This is followed by a review of the general approach of the study, its limitations, and a final conclusion. The Appendix includes forms used for the recording of plant sample locations and cremated remains, osteoarchaeological catalogues

for Ingleby Barwick Low Lane and Cleatham, and photographs of the bone fragments sampled.

2 BACKGROUND

This chapter aims to provide in-depth background information on three major interdisciplinary strands converging in the following chapters. The first section is concerned with the theoretical underpinnings of the archaeology of mobility, the second section focusses on the archaeological and historical background of the three case-study sites, and the final section outlines the use of isotopic analysis in archaeology with a focus on strontium (Sr) isotopes in cremated remains.

2.1 THEORETICAL CONSIDERATIONS

The following section will tackle several interlinked and relevant theoretical processes which will be taken up at various points during this thesis. The aim is to introduce a basic theoretical framework based on existent literature in which to interpret and situate the isotopic data and archaeological information.

2.1.1 MIGRATION THEORY, MOVEMENT, AND MOBILITY

The purpose of this thesis is to assess - through the application of isotope analysis - the level of mobility of early medieval communities who practised cremation. In order to do this in a structured and coherent manner, it is important to explore in advance the thought-processes which will inevitably be involved in approaching this topic, especially the fundamental conceptions and pre-conceptions which are connected to such words as ‘mobility’ and ‘migration’. This will be discussed in more detail in the following section, which will explore how migration theory has been applied to archaeology, and that new ways of thinking about *mobility* in the past perhaps promise more intimate engagements with the lived experience.

The current main approach to migration theory in archaeological research is based on a small number of papers published in the last 30 years. Perhaps the most influential are David W. Anthony’s 1990 paper ‘Migration in Archaeology: The Baby and the Bathwater’,

as well as Stefan Burmeister's 'Approach to an archaeological proof of migration' (2000). As the title suggests, Anthony (2000: 895) argues that there is no reason for archaeologists to reject the idea of migration as an explanation of (material) culture change, but that a theoretical framework is essential for the study. He also outlines major aspects featured in most recent and contemporary migrations which appear timeless and are inherent to the processes involved whenever people are on the move. Anthony's argument is based primarily on research conducted in the related fields of human geography, economics, and anthropology, although he also touches on linguistics (bringing all these together: Anthony 2010). The five main cogs which are integral to the process of migration are identified by Anthony as

a) Leapfrogging: the way that information is relayed from scouts though mostly kin-groups to other people, building a chain migration – facilitators can be merchants, trappers, mercenaries, craft specialists, etc (2010: 902).
b) Migration stream: migration works as a stream, not as a wave – this is also dependent on information flow. Usually, streams are restricted at their point of origin (due to kin-group focus) (2010: 903).
c) Return migration: every migration stream will develop a counter-stream. The strengths of this are dependent on push and pull factors at origin and destination. Often, this creates an inter-dependence of the locales because of status and/or structure changes at origin or destination. This is also how through time, the nature of the migration and the goals of the migrants can change (2010: 904).
d) Migration frequency: migration begets migration, in the sense that knowledge of feasibility of migration because of personal experience or through the kin-group will make individuals more willing to leave home (2010: 905).
e) Migration demography: Anthony argues that in the early stages of a migration stream, individuals tend to be male and predominantly on the younger age spectrum. However, this changes with time towards gender equilibrium (2010: 905).

While his suggestions were rejected by some processualist thinkers who argued that every movement of people is different and dependent on specific, situational factors (Chapman & Dolukhanov 1992), others emphasised that there was potential in the idea of identifying a general *modus operandum* which directs mobility. Burmeister belonged to the latter group and developed the argument made by Anthony further. He combined Anthony's ideas with Pierre Bourdieu's sociological concept of *habitus* which describes the interconnectedness and reciprocal relationship of individuals with the structures that they live in.

> 'The conditionings associated with a particular class of conditions of existence produce the habitus, systems of durable, transposable dispositions, structured structures predisposed to function as structuring structures, that is, as principles which generate and organise practices and representation.' (Bourdieu 1990: 53)

In brief, the concept of *habitus* entails that people as individuals behave in a way that is informed by their environment, and that they do this partially subconsciously. In that way, they are re-enforcing what is acceptable in their environment and are 'structuring structures' (Bourdieu 1990: 53). As interesting as this theory appears for archaeologists, Bourdieu's *habitus* is fraught with problems relating to objectivism: Arguments have been put forward which emphasise the reductive quality of the concept which seems to leave no room for societal change through reflexion, creativity, subjectivity or flexibility (King 2000). This is especially problematic in environments and situations where different groups of people - or individuals - meet and are required to engage with each other – such as in the process of migration. Burmeister argues, however, that for archaeology of migration, *habitus* becomes relevant in terms of an 'internal, private sphere' and a 'public sphere' (Burmeister 2000: 542). Depending on the circumstances and the physical environment of the new location, migrating people 'dominate' these spheres more or less strongly with features of their home-culture. Archaeologically, these spheres should leave material clues

and provide a *proof* of migration, and Burmeister asserts that this is most likely to happen in the internal sphere, because it is this area which allows for traditional practices and material culture (Burmeister 2000: 542). While it may be true that material features which are visible to other people are more likely to change due to a desire to adapt – in *habitus* this desire would have to be inbuilt into the structure of the society.

Mobility relates to physical and/or mental processes, although the former have so far been more thoroughly interrogated and isolated in archaeological research. In terms of physical mobility and specifically when speaking about mobility in archaeology, the idea is often re-enforced that people and things moved from location A to location B (=migration). This functionalist view of migration appears specifically in the context of culture-historical studies of the last century and is explained very well by Beaudry and Parno (2013: 2-3). This notion simplifies the complexities inherent in the concept of mobility to an extreme and projects an idea of finality of the process. Recent theoretical discourse has shown, however, that this is not the case. Cresswell (2010:18) has argued that 'mobility exists in the same relation to movement as place does to location', so the two occupy similar conceptual spheres, but are not identical because one has temporal connotations (movement, location), and the other centres on the notion of experience (mobility, place) (2010: 25). He goes on to state that 'at any one time, then, there are pervading *constellations of mobility* -- particular patterns of movement, representations of movement, and ways of practising movement that make sense together' (Fig.1; Cresswell 2010: 18). This strongly suggests that mobility, as such, is contextually specific and historically situated. By extension, Cresswell (ibid: 21) speaks of a 'politics of mobility', which emphasises that mobilities are always also political and underlie social and power relationships. This touches on elements of Bourdieu's *habitus* where structures and structuring actors are intimately connected. One aspect that cannot be ignored in the context of mobility is *immobility*, and this is considered part of the equation (Cresswell 2010: 29; see 'Friction' Fig.1). Indeed, this model is helpful in the way that it requires the

archaeologist or historian to approach the actor and their situational mobility through an understanding of the context of the time. While Anthony's take on how migrations generally work is an excellent way to appreciate the main functional aspects, Cresswell's dissection of mobility into its interrelated components gives the researchers of past mobilities greater flexibility to work bottom-up.

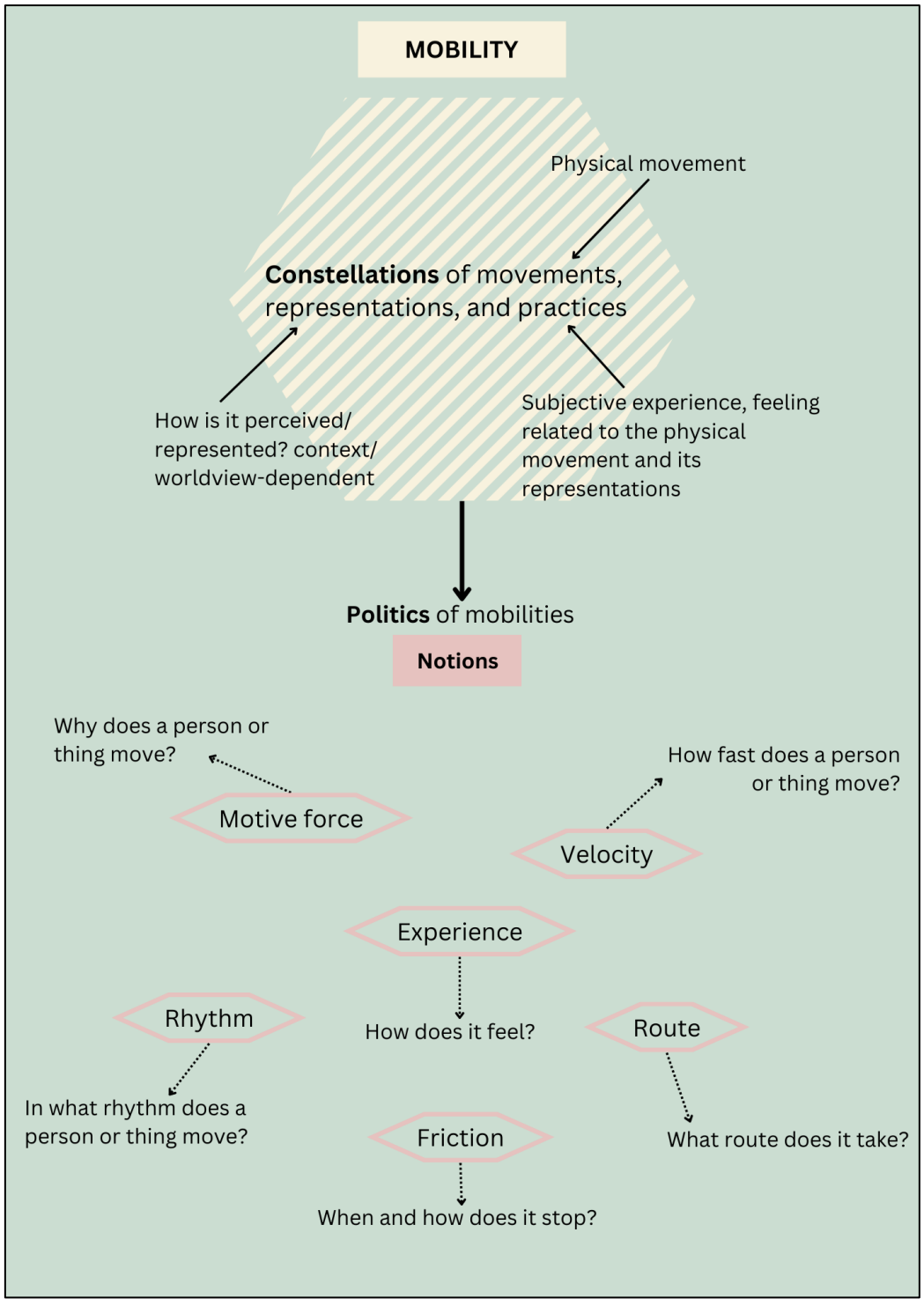

FIGURE 1 - THE CONCEPT OF MOBILITY AFTER CRESSWELL (2010); INCLUDING THE DISSECTION OF THE POLITICS OF MOBILITIES.

Indeed, for a study that is primarily concerned with individuals in the first instance, as is the case in any research project using isotopic analyses, closer consideration must be paid to individual *agency*. A more direct and 'grass-roots' way to look at structure change and

migration is to look at the agents of change themselves, and the relationships between agents and things that work to create structures.

2.1.2 AGENCY THEORY

This section will outline agency theory and give a brief overview of its development and applicability to archaeology. In conjunction, *personhood* theory will be elaborated, because it is intimately linked with agency and shares the culturally-specific way in which both of these are constructed through social practice (Fowler 2004; Williams 2006; Fowler 2016; Harrison-Buck 2018). Personhood and agency inform each other and are subject to the same relational network. An idea of both is needed in order to expand the idea that other-than-humans can be agents. With a grasp on how to understand and examine the theoretical framework, it will be possible to use these concepts when examining archaeological remains – especially those of other-than-humans (i.e. animals, objects).

2.1.3 THINKING ABOUT AGENCY

The concept of agency has been shaped through critique and interdisciplinary discourse in archaeological theory since the 1970s, although terminology has lagged behind and the term has not been used from the start (Dobres & Robb 2000; Fowler 2004; Robb 2010: 496). Because its form and influence has changed since its introduction, and because arguably the discourse is still ongoing, there is some difficulty involved in its dissection. At its core, agency is simple enough to understand, but because of the necessary consideration of the entire spectrum of thought related to it (such as *personhood*), it becomes more difficult to explore. In 2000, Dobres and Robb reviewed the understanding of the concept and presented at least 12 slightly differing definitions by various academics (Dobres & Robb 2000: 9; Table 1.1). More recently, the most basic description of the concept has been 'the capacity for action' (Robb 2010: 493), and this does sum up the essential prerequisite. Problems arise when the capacity for action is conflated with action itself (Dobres & Robb 2000: 8).

The modern mind educated in the west will agree that most people have agency, and perhaps some non-humans, too. However, most action will be influenced by structures which are external to the individual, learned, and internalised (to some degree reflexive). This type of action is engrained in agents through the system that they inhabit, and they in turn reinforce through their actions – in social anthropology, this idea is called *habitus* (see previous section) (Bourdieu, 1977: 72). Similarly, the sociologist Anthony Giddens (1979, 1993) studied how structures influence individuals – agents or actors – and how agents shape these in return through their actions . His agents were far more reflexive of the structures that surrounded and influenced them, allowing for creative change (Giddens 1993: 6; Dornan 2002: 307). Material culture, as the result of action in the past, is used to explore these agent-structure relationships. The main critique of this way of interrogating the archaeology proposed that Bourdieu's *habitus* (and *doxa*) minimalised the ability of the individual to choose, be creative, or self-reflective (Dornan 2002: 306), while Giddens' structuration theory voided the agents of intention and motivation (ibid: 308). In fact, Bourdieu's 'practical theory', which addresses small-scale and subjective engagement, has been argued to be contradictory and incompatible with his *habitus* for the same reason (King 2000: 422). Thus, transformation of overarching structures is difficult to explain – cultural change over time does not get traced back to individuals. Although the theory of *habitus* is still used by archaeologists, the focus of questioning in agency debates has somewhat moved away from structures. In 2000, Hodder argued 'that there is a need to shift from agency and the construction of social beings to individual narratives of lived lives and events' (Hodder 2000: 20). Archaeological theory now allows us to blur ontological boundaries in the discussion of agency by broadening the definition of what constitutes an agent and focussing on *relationships*, rather than the nodes of action and entanglement themselves (Pauketat & Alt 2018: 72). Principally, this means that there are not just social agents, but also 'asocial entities' and 'non-persons' who can be agents – although they

lack ‘the ability to engage in social relationships with mutual respect’, or *reciprocity* (Harrison-Buck 2018: 264).

Haraway has produced some of the most intriguing work in this respect (see also Harris & Cipolla 2017: 156), arguing that humans are just one of a ‘myriad of coshaping species of the earth’ (Haraway 2008: 5). To her, it is ‘the relating’ that is at the core of the matter, and species do not exist in isolation – ‘There cannot be just one companion species; there have to be at least two to make one’ (Haraway 2003: 12). With Haraway, the emphasis lies on the *relationships* between things. This is fundamentally a post-humanist way of theorising the world, with the removal of old-school dualisms, and blurring of ontological borders and lines (Haraway 2003: 15). It contains the recognition that we are shaping the world alongside other species, and crucially, in respect of each other and every individual’s agency. Agency, then, is marbled with notions of personhood. In order to understand the relationality of agency, we must look closer at what this means.

2.1.4 Enter personhood

Personhood theory features strongly in the discourse on agency, a side effect of looking at capability for action and relationships between things. *The Archaeology of Personhood* (Fowler 2004) convincingly lays out how exactly social relationships work to contribute to what a person is. Fowler presents an alternative way of thinking about the world by drawing from anthropological studies of Melanesian and Indian populations (i.e. Strathern 1988). Non-western ways of seeing the world and oneself are an excellent way to reflect on one’s own assumptions and to question and dissect them. Only then is it possible to reject the impulse to project modern western thought-patterns onto past peoples, whose history has led them to develop their own interpretation of social relationships. The pivotal point is that the ideas that we have about personhood are culturally determined and therefore specific to any particular environment in time and space (Robb 2010: 502; Harris & Cipolla 2017: 63, 66). For archaeological theory, this means that agency in the past was also culturally specific, negotiated through social interaction and practices, transforming continually (ibid).

Particularly pertinent for this study is the idea of the 'dividual' (Fig. 2), which is a feature of Melanesian and Indian personhood. The concept suggests that a person is not bounded and 'apart' from the social group (kin/clan) as they are in the western capitalist world (*individual*) (Strathern 1988; Fowler 2004). Instead, a dividual person is a product of this group - made up by all the relationships in the group; essentially, they are *of* the group. Therefore, they are multiply-authored by all their relationships, and they are potentially *partible* (Fowler 2004, 2016). Persons, in all their relationships, can be divisible and partible – much like the idea of *horcruxes* in Harry Potter (Laneri 2021: 107; Note 20; Rowling 2014). By extension, things can become part of a person, or even become persons in their own right, as they are made up of the same relationships. In a similar way, an animal which was raised by the efforts of a community and which is given by a person of that community to someone from a different community, is a part of the community in which it was raised and then equally, becomes part of its new community. The person who gave the animal away is owed something from the other community, and at the same time owes the rest of their own community. A relationship has been established through the handover of the animal, with the expectation that there will be future exchanges (Robb 2010: 504). This exchange describes not only partibility and relationality, but also a particular field of action in which an actor asserts their own and communal agency (ibid). Alternatively, or additionally, dividual persons can be *permeable* – that is, the person 'can be permeated by qualities that influence the internal composition of the person' (Fowler 2004). This is also mediated through relationships. In Indian contexts, certain *source-codes* given from one person to another can alter their internal structure. These source-codes are things (substances, food, liquids, objects) which are associated with male (cold) and female (hot) identity and can imbue the person in this respect. In any one relationship, this can shift based on the context of the situation and the persons present (ibid).

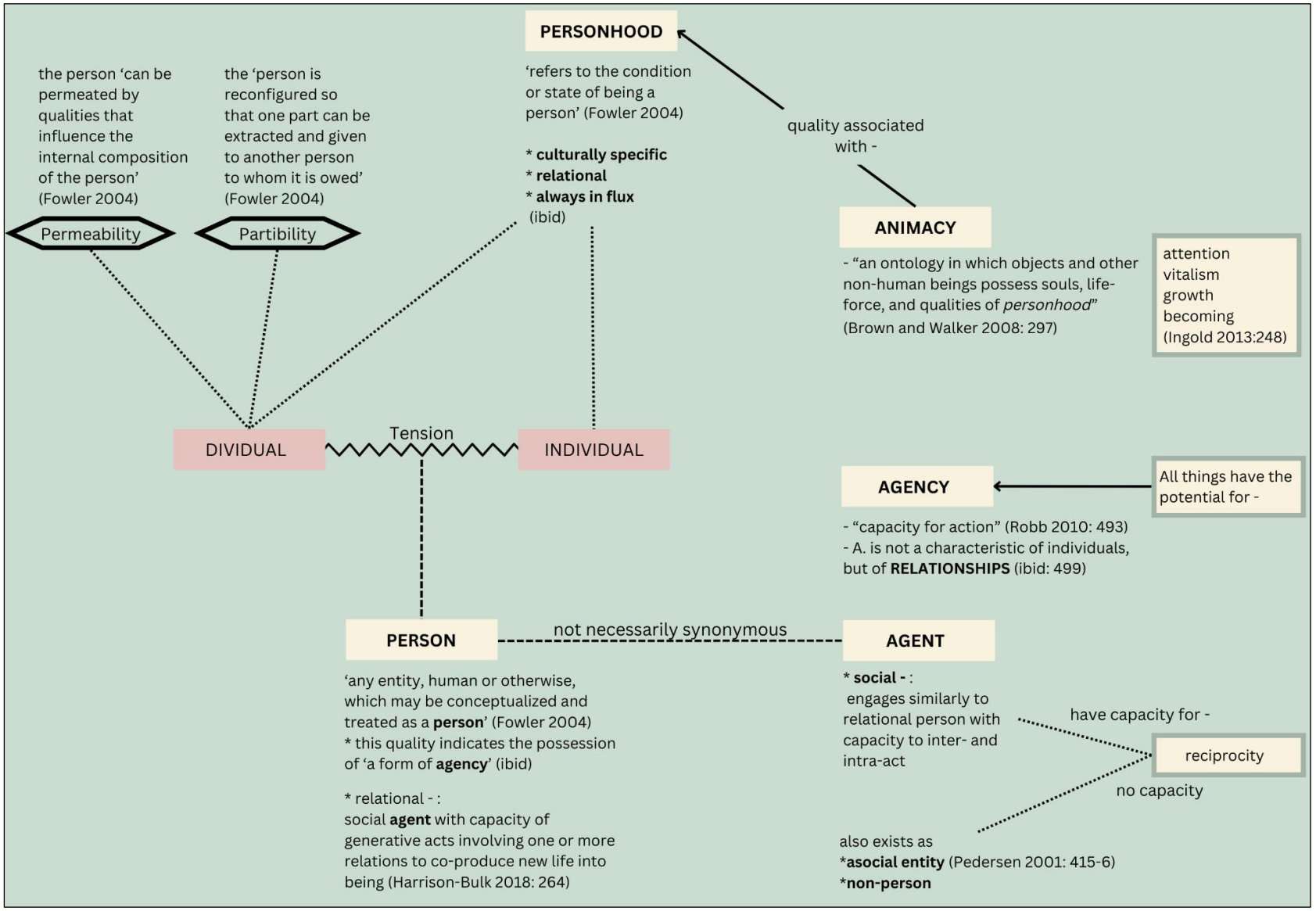

FIGURE 2 – DISSECTION OF THE CONCEPT OF AGENCY IN RELATION TO PERSONHOOD. DASHED LINES INDICATE RELATIONSHIPS OF TERMS WITHIN THE WIDER CONCEPT. MAIN TERMINOLOGY USED IN SQUARE, BEIGE BRACKETS. ADJECTIVES DEFINING MAIN TERMS IN MORE DETAIL IN DIAMOND FRAMES. RED BOXES USED TO BREAK DOWN MAIN TERMS. REFERENCES CONTAINED IN TEXT.

2.1.5 Animal-human relationships

One strand of investigation, which was not included as a primary research objective and nevertheless has turned out to become one of the most intriguing aspects of this study, pertains to animal-human relationships. This kind of relationship can best be explored by intentionally blurring some of the ontological borders which the modern mind insists to place on the world, and personhood theory and ethnographic studies can make this easier. For archaeology, the projection of ubiquitous anthropomorphism is not the answer (although it may occur), as Russell rightfully argues, but the consideration that 'personhood applies to some but not all animals and not all the time; it is often accorded on an individual rather than a species basis' (Russell 2011: 4) is the key here. Currently, we are still ultimately concerned with the meaning of a zooarchaeological assemblage in the context of the human presence on site – it all comes back to the people (ibid: 5). Cross rightly asks 'who is buried with whom?' (2011) – and this question is especially pertinent in prehistoric societies of whose worldviews we have no or little understanding. Isotopic studies can help with such questions, as isotopes display Haraway's 'relating' well (Haraway 2008: 62). Sykes has also correctly recognised the crucial information that can be gathered on an individual level from isotope analysis (Sykes 2015: 141). If a human is interred alongside an animal, there exists already a relationship. Isotopes can then help to establish what this relationship looked like in life.

2.1.6 Return to mobility

Why have we taken the above discourse from mobility and migration theory, through habitus, structure and material culture change, to agency and personhood? The review of theory outlined above shows how these concepts are all strongly interlinked, and essentially connected. If every person has agency, agency is context-specific and relational, structures are shaped through agency, tensions between agencies can change structures, and mobility – including migration – requires agency, then the study of mobility requires at least an engagement with agency theory. Especially since the aim of this body of work is to

reach beyond the material clues and understand as well how these express something of the agency, structures or structural change pertaining and relating to society.

2.2 THE SITES UNDER INVESTIGATION

This section provides a short overview of the sites (Fig. 3) to be investigated in this thesis. More detailed information will be provided in Chapters four, five, and six.

FIGURE 3 – MAP OF BRITAIN WITH SITE LOCATIONS.

2.2.1 5TH - TO 7TH-CENTURY SITES: CLEATHAM AND INGLEBY BARWICK

In 1991, Campbell (21) wrote that 'the early Anglo-Saxon archaeologist must be a Resurrection [Person]: the grave [their] haunt'. He spoke about the ubiquity of funerary sites

of that period, as opposed to other types of sites and this obviously also applies to this study with its focus on cremation burials. Two of the three sites examined in this study date to the 5th to 7th centuries. Both are cemeteries, and both contain cremation burials as well as inhumation burials. The smaller of the two is located in Ingleby Barwick, near Stockton on Tees, in the northeast of England. It is a mixed-rite burial site and contains 15 cremation and 17 inhumation burials. The second case study site is the large cremation cemetery at Cleatham in Lincolnshire. It contains 1009 cremation and 62 inhumation burials. Foremost in the selection process of the sites was the exploration of the potential of isotope analysis for early medieval cremation cemeteries with different scales; while Ingleby Berwick provides a small-scale sample in which each identifiable cremation burial is analysed, Cleatham requires a pre-determined selection process. Sampling bias is therefore limited at the former but needs to be addressed in more detail for the latter. A second consideration was the location of the sites in the northeast. As this is an area with a relatively small number of known cremation cemeteries dating to this period of British history, the idea was to intensify the amount of information that could be extracted from the sites. In fact, Ingleby Barwick is one of the northernmost cremation cemeteries of the 5th to 7th centuries in Britain. Cleatham is the largest known northerly cremation cemetery of the period.

Final considerations were access to material and cost. The remains from Ingleby Barwick are located in the archives of Archaeological Services Durham University, who were encouraging further work on the remains. Cleatham is a well-researched site in terms of contextual information, osteoarchaeology, and material analysis. It is this information which was used to select samples and create a temporal sampling focus, with samples selected from a number of chronological phases of use.

2.2.2 9TH CENTURY SITE: HEATH WOOD

The cremation cemetery at Heath Wood is unique as the only known Scandinavian barrow cemetery of its kind in the British Isles. Its cremation burials take the form of token burials

or *in situ* pyres. In both instances, there is very little bone present to represent the dead. Burnt and purposefully damaged objects were found intermingled with the cremated animal and human bones, and the deposits were covered with earth to form a mound. The cremated bone has been dated in three instances and has returned dates ranging between the 9th and 10th centuries (Richards *et al.* 2004). In total, 59 mounds have been recorded here, but only about 20 have been excavated. Only the remains recovered from two mounds in the most recent excavation are still available. The site is situated on a small hill inside a wooded area, and today the mounds are covered in thick fern, although trees have been cleared from the area to preserve the remains. The cemetery can only be understood and should be seen in the context of the landscape that it is part of. The most important contemporary sites in the vicinity are the town of Repton, which used to be an important royal centre of Mercia at the time, and Foremark, which has recently been identified as most likely site for the winter camp of the Viking Great Army of AD 872-3 (Jarman *et al.* 2019; 2021). In a broader context, although individual Scandinavian-style burial mounds containing cremated deposits are known from the early medieval settlement areas in Scotland and the Isle of Man, no other cemeteries like Heath Wood are known in the British Isles. Close parallels can be found in Sweden and Norway (Nicolaysen 1901; cited in Gustavsen *et al.* 2020: 45). Due to the unique character of the site, and the limited remains still available, all identifiable individuals were sampled.

2.2.3 Archaeological background

The following section provides the archaeological context for the periods and the sites chosen for this study. This is necessary in order to interpret and contextualise the isotope analysis within a regional and temporal framework.

2.2.3.1 Early (early) medieval Britain (c. AD 410 – 700)

Traditionally, the early medieval period in Britain is considered to have begun around AD 410. This approximate date marks the withdrawal of imperial Roman influence from the country in the context of the slow but definite disintegration of the Empire (Williams 2006:

2). While the 'early middle ages' last until the Norman Conquest in the 11th century, this section will focus on the early phase, spanning from AD 410 to c. AD 700, as this is the period to which the cemeteries at Ingleby-Barwick and Cleatham both date. During this period, the top-down, surplus-oriented economic structure in Britain changed to a less centralised, more pastoral organisation (Yorke 1990: 13). Regional variation in terms of land and resource management appear to have become the norm in the 5th to 7th centuries, and political units formed which are termed kingdoms (Yorke 1990: 9, 157; Scull 1993, 1999; Hamerow 2002; Hills 2003; Hamerow 2005). This development is considered, to some extent, to be rooted in already existing regional affiliations from the preceding period (Collins & Gerrard 2004; Collins 2012). Roman influence in Britain had by no means eradicated or replaced local and communal senses of identity, and least of all individual ones (Lucy 2000; Harland 2019).

The following section will explore some of the major developments visible in the archaeology in Britain in the period that has long been termed early 'Anglo-Saxon', with a focus on settlements and buildings, cemeteries and funerary archaeology, as well information on how we understand the economic system, including currency, trade, and land use operated. This will be outlined with reference to social structure and within the context of developments taking place on the continent.

2.2.3.2 A NOTE ON TERMINOLOGY

The term 'Anglo-Saxon' is used sparingly in this work. Recent discourse has noted the usurpation of this term by white supremacist, nationalist thinkers, especially in the United States (i.e. Wilton 2020). While this author agrees with Williams' assertion that 'abandoning the term…would concede intellectual and historical territory to extremists and fringe narratives' (*British Archaeology* 170; see also Sayer 2020: xviii-xix), there is also the following to consider: if 'Anglo-Saxon' describes a cultural phenomenon in a specific historical period, then I would argue that using date range and geographic location is at least equally convenient – especially in respect of the nature of the period; if local and

regional variation was a defining factor across virtually all aspects of life, and if the highly diverse populations we have started to recognise through isotopic and aDNA analyses are any indication, the early medieval period in the British Isles can safely be discussed without overuse of the term, and with reference to time/space. Having said this, I have used the term on occasion, especially in reference to the preceding 'Roman' period.

2.2.3.3 CHANGES IN THE ARCHAEOLOGY

In the academic literature which addresses this particular phase it is often emphasised that the transition from the first four centuries AD to the early medieval period is evident in the archaeology primarily through the disuse of Roman architecture/buildings and the introduction of timber-built structures, as well as the reduced maintenance and occasional abandonment of Roman towns (Higham 2013a: 42). The timber mode of construction is less traceable in the archaeological record and thus it is tempting to imagine the decline of structure in a more general sense and perhaps especially the complex social structure so dominantly reflected in Roman spatial organisation. This is likely to be misleading, however, as Blair (2014) has rightly pointed out that 'lightness and impermanence do not equate with simplicity, let alone crudeness' (12).

Additionally, massive defensive projects like Hadrian's Wall, Antonine wall, and the Gask ridge in Fife were almost never constructed in the early medieval period, apart from a number of possibly defensive dykes. These dykes, in fact, are large-scale construction projects and by extension, this suggest that there were leaders present who could organise the manpower and skill needed for construction (Higham 2013a: 52-54). Dating of the dykes highlights that they were constructed throughout a substantial part of the early medieval era, with Offa's dyke measuring 112km and running along the Welsh-English border (ibid: 53). The scarcity of written primary sources in the 5th to 7th centuries provides a further hurdle in the investigation of this period, which is why it is important to properly assess the information that archaeology provides.

2.2.3.4 SETTLEMENTS

For settlements, the observable trend in the 5th century tends towards rural settlement in smaller groups of households, and although larger communities developed, these were unlike those of the Roman period (Lucy 2000: 2-3; Henig 2011). Many towns of the Roman period were abandoned during the 5th century, such as Canterbury to some degree (Higham 2013a: 46). At the same time, there is evidence for continuity in some places during the 5th and even into the 6th century, although frequently in altered form (Campbell 1991: 20; White & Barker 1998; Henig 2011: 519; although see Lane 2014 on Wroxeter). It is the form of this continuity that changed after the early 5th century, not its existence. Other Roman centres such as Silchester and Wroxeter also show archaeological evidence for continuity (Henig 2011: 517), and Henig makes the case that London, Lincoln, and York were likely amongst them (ibid: 522-525). However, this assessment very much depends on what exactly constitutes a continued existence, as Henig concedes (ibid).

Buildings and observable change

In the archaeology, there are new features which appear in settlement contexts dating to the 5th and 6th centuries. These include *Grubenhäuser*, or sunken-feature-buildings, which are first observed on the continent – especially in the northwest (Hills 2003: 100; Hamerow 2005: 266). From the early medieval period, they are also often observed in settlements in Britain. *Grubenhäuser* were most likely used for storage and were probably connected to activities such as loom weaving, and they are usually found in close proximity to main houses (Hills 2003:100). The main buildings in turn are rectangular in shape and timber-built with openings opposite each other on the long sides. As Hamerow observes (2002: 46), these houses were not exactly the same as the larger longhouses used on the continent as farmsteads. It is unclear why or how this relatively independent style of house developed, but Hamerow sees it as a form of hybrid deriving from the continental-type longhouse (2005: 267). It should be noted that the uniformity of the 5th to 7th century timber house across areas of England is remarkable. Variation is almost absent in the archaeology, apart

from a number of distinguishing features (Addyman 1972: 304; see also Hamerow 2011: 131, 133).

The size of rural settlements in Britain is varied but mirrors that seen in settlements on the continent. It has been argued that one settlement contained approximately 5-20 households (Hamerow 2002: 53). However, it is possible to see a small number of larger settlements which developed in the course of the 6th and 7th centuries in Britain. These are not as large as their Roman predecessors, but they do signify that towards the late 6th century, society was stratified enough in some regions to create settlement foci (Scull & Thomas 2020). These settlements included for example Yeavering in Northumbria, and Cowdery's Down in Hampshire, which Hamerow describes as 'special function' settlements' (2005: 283). They are amongst the first to exhibit evidence for structural repair, rather than the earlier (and predominantly southern/southeastern) *modus operandum* of abandonment (see below; Hamerow 2011: 135, Millett and James 1984: 213, Hope-Taylor 1977).

Shifting vs Investment: the social complexity question

It appears that the mobility of settlements was not so much a curiosity but a characteristic in the 5th to 7th centuries in some parts of Britain. Shifting, or 'wandering' (German: *Wandersiedlung*) in this context means that a house could be rebuild a short distance away from a previous location which resulted in a gradual shift of entire settlements over time (Ulmschneider 2011: 159, Hamerow 2002: 104-106). This was much more prominent in south/southeastern Britain, however. More northerly settlements, for example West Heslerton, do not appear to have shifted (Powlesland 1998). Not much effort is apparent regarding the care and repair of the houses during the early medieval period until the beginning of the 7th century and this has been explained as a symptom of an insecure or unstable society, lacking in a sense of permanence (Hamerow 2011: 135). With the establishment of more hierarchical, or more dominant foci in the course of the late 6th and early 7th centuries, this changed at least in some areas (i.e. Scull *et al.* 2016). As mentioned

above, some of the special-function settlements were the first ones to provide any evidence of repair, suggesting that permanence had become an issue and there was active work to maintain and perpetuate buildings (i.e. dry-stone foundations) (Hamerow 2011:136). This process can be seen as a side effect of the intensification of agriculture, and by extension with developments in the church structure (Ryan 2013: 200). The fact that settlement mobility of various forms can be observed until the 12th century on the continent should highlight, however, that there may have been more practical reasons behind this pattern which necessitated relocation.

2.2.3.5 CURRENCY

It is frequently pointed out in the literature on the topic, that money ceased to be imported into Britain from the mints of the Roman empire in the early 5th century. The year given as an approximate cut-off date is AD 410 (Hills 2003: 85; Blackburn 2005: 673; Campbell 1982a: 19), and AD 400 is one of the last minting dates found on coins in Britain (Higham 2013a: 41) – after this, there is a distinct lack of evidence for the import of money (Campbell 1982a: 19). Britain did not continue minting, nor did they create their own money immediately. However, there is evidence that during the 5th and early 6th centuries, coins were still present in some areas of the country (Campbell 1982b: 62). Many of these were used as grave goods (example often used is Sutton Hoo, 40 gold coins; Backburn 2005: 673; Lebecq 2005:645). Only in the early/mid 7th century did Britain start to mint their own money in the southeast (Blackburn 2005: 673). The earliest finds were re-minted Merovingian coins, in character much like the quasi-private, diverse coins produced by the Franks on the continent. In fact, Lebecq highlights that the creation of the new Anglo-Saxon coins did not happen in isolation, but within the wider network of the North Sea trade which - by the 7th century - involved almost all coastal areas of Britain (2005: 645-6). Frisian areas, with which Britain was in close contact at this point in time also started the production of coins, and the Frankish areas on the continent increased their production (Lebecq 2005: 646). Silver was the material of choice for this coinage (Blackburn 2005: 673), perhaps

attesting to the practicality of the use of silver, or to the impact of the trade networks around the North Sea on the wider region (Lebecq 2005: 653; Loveluck & Tys 2006; Thomas 2019).

2.2.3.6 TRADE

The developments in the area of coinage outlined above somewhat reflect those in the area of trade, which is not surprising as these are interlinked. The sea passages to and from the continent, as well as those between Ireland and Britain, were not secure after (and even before (Lebecq 2005: 641) Roman presence and control diminished. It is unlikely that trade completely seized (see for example Campbell 1996: 94; Campbell 1991: 22) but until at least the 6th century, traffic was likely low (Lebecq 2005: 644). As can be seen by the fact that Roman trade emporia such as London significantly diminished in size but still reveal occasional foreign material culture from the 5th and 6th century contexts, it makes sense to assume that merchants were present in such towns (Henig 2011: 516). It was not until the late 6th century that settlements and society had stabilised enough to single out new trading stations. These have been shown to have developed at Ipswich, London, and Southampton, as well as at York, and held the names *Gippeswic, Lundenwic, Hamwic*, and *Eoforwic* respectively; the *-wic* indicates their Germanic origins in these cases (Pestell 2011: 557). While there are some issues regarding the terminology of these new trading stations due to some of them being outside of the city walls (*Lundewic*), and the possibility of a trading centre doubling as an urban settlement, the chronology is generally consistent. That is to say, trade picked up in the 7th century and tied Britain more significantly into the North Sea network, predominantly with northern France along the Seine, Germany including the Rhine, Belgium, and southern Scandinavia – later including parts of Sweden (Lebecq 2005: 648-65, Sindbaek 2008: 303).

2.2.3.7 MOBILITIES BEYOND MIGRATION

As has been discussed in the previous section on theory, it is highly problematic to equate mobility with migration. It is at least equally problematic to perceive the early medieval

period as ‘static’, which is done easily and frequently in comparison with modern mobility (O'Doherty & Schmieder 2015: x). Archaeological evidence for trade has been discussed in the previous section but shall be returned to briefly to illustrate the mobilities that are implicit through the presence of traded objects. Although there is a caveat in that the movement of objects does not equate the movement of people, there are certainly instances where people are likely to have transported items across larger distances. It is likely that such travel was gendered to a certain extent, but that is not to say that male traders would not have been able to take their families on the road. On the other hand, trade must not always occur long-distance: Given that most 5th to 6th century settlements were rural, trade was likely omnipresent, especially in a non-monetary economy. This would have required short-distance mobility to neighbouring settlements, or indeed to meeting places where exchanges were made. In this context, animal mobility must be expected in the early medieval period. Even without the factor of trade, people from neighbouring settlements would likely have been in touch, exchanging stories and celebrating lifecycle events with each other. This is certainly implied by the presence of such large-scale cremation cemeteries as Cleatham in Lincolnshire, Spong Hill in Norfolk, and others.

It is important at this point to also consider the trade of people, namely in the form of slavery. Fontaine (2017: 467) has argued that this was present across the entire period in the British Isles and Slavic east central Europe and that these regions had ‘small-scale, *ad hoc* trading, as well as long-distance, high-volume networks’ later on, and that ‘the archaeology of early medieval slave-trading should be synonymous with the archaeology of early medieval trade’ (488). In this vein, it can be argued that slavery may have been rarer in the 5th century in Britain, only to pick up in the 6th and 7th centuries. Slave trade and slavery would have affected people of all genders, and it could find expression in regional or longer-distance mobility.

Following on from this, we can discuss the moving of people in the context of marriage. The previous sections on trade and the trade of people illustrate the fact that the British Isles in the early medieval period were not isolated. In the 6th century, long-distance connections are apparent especially in Kent, where Merovingian relationships are consolidated through marriage (AEthelbert of Kent and Bertha of Francia) and later extended to Northumbria and Mercia through the marriages between Edwin and AEthelburh of Kent, and that of Wulfhere and Eormenhild of Kent (Yorke 1990: 18, 28, 36). AEthelbert (of Kent's) sister Ricula married Sledd of Essex, indicating short-distance mobility (Yorke 1990; Harrington 2020: 97). Although these connections are illustrating the 6th century, similar connections will likely have been produced in the 5th century. The crucial aspect here is the scale of movement, or the distances that are covered. For example, more localised mobility whereby a person relocated from one village to another within the same region would not qualify as migration - but this likely occurred in the context of marriage, whereby women or men relocated to the place of the partners' kinship group, thereby extending it, and creating relationships that foster inalienable ties across the landscape. Of course, this type of mobility may have been influenced strongly by such factors as gender or status, especially from the sixth century onwards. Age, however, may not have been as important, as some evidence suggests (see Harrington 2020: 99). It is certainly possible that very young women or girls may have moved around the landscape within the context of marriage.

While the spread of Cristianity is intimately connected with the connections made through the high-status marriages of the 6th century, we should also consider the wider implications: with 7th century Christianity came the visceral cults of saints which prompted pilgrimage locally, regionally, and of course, internationally. While this study is mostly concerned with cremation cemeteries which somewhat pre-date these mobilities, we may keep this in mind as a motivating factor. It is almost certain that the pre-Christian people of Britain had a similarly complex and lived ideology.

Of course, one of the major drivers in the development of the early medieval kingdoms was the ability of rulers to mobilise men for warfare in the dispute for territory. This was certainly an integral part of Frankish kingship and would have been no less important in the British Isles in the 6th century (Blair 1979: 56). Men were unlikely the only people moving around the kingdoms in this scenario, however, because conflict always also affects the people left behind. Refugee groups made up of men, women, and children will likely have had to relocate, or may have been forced to relocate post-conquest. Not all mobility is voluntary or desired, so experiences of moving through the landscape (short or long distance) can also be accompanied by fear and anxiety (see section 2.1.1 and Fig.1 above). This notion must also be considered in the context of slavery, which was an integral part of the early medieval period in many areas of Europe (see above).

Taking all of this into account, we are looking at a period in which community structures developed through different and crucial forms of mobility which operated at several scales. Short-distance movement of people and animals was almost certainly equally as important as long-distance movement, and just as much of a driver for structural change through the tensions created by new relationships. It is crucial to note that migration is not the only form of mobility practiced during this period, and that the two should not be conflated.

2.2.3.8 Subsistence and land use

As outlined above, the 5th and 6th centuries in Britain saw a breakdown of larger towns and the simultaneous establishment of new, small-scale settlements in rural areas (Hills 2003: 86). Hamerow (2005: 268) determines that 'there is little […] sign of socio-economic continuity from the fourth to 6th centuries in lowland Britain'. However, since the 1980s it has also been argued that there is continuity observable in the way that land was used. The intensity of farming clearly lost momentum when compared to the Roman period, although Hamerow (2002: 152; 2012: 145) argues that this does not necessarily mean that there was a 'major discontinuity as such, but essentially a partial reversion to pre-Roman patterns of

land use'. During the Roman period, cattle appear to have been the major livestock, and indications are that they were most often butchered and managed by specialists (Crabtree 2012: 10; O'Connor 2014). With the establishment of small-scale rural settlements in the 5th to 6th centuries came a period of increased use of pasture - especially in East Anglia and Staffordshire (Hamerow 2002: 152; 2012: 145), making animal husbandry an important element of the subsistence economy with an apparent focus on sheep over cattle, albeit with regional variation (Hamerow 2002: 148). It is this variation that leads Hamerow to caution against generalisation (Hamerow 2012: 157). Zooarchaeologists like Hammon (2011), Crabtree (2012), and O'Connor (2014) also emphasise this point in respect of the animal bone assemblages they studied from West Stow, Icklington (late Roman), West Heslerton, Kilham, Spong Hill, Melford Meadows, Quarrington, Wroxeter, Redcastle Fuze, and Gamlingay. Regional variation in animal husbandry appears to some extent to have been informed by the qualities and suitability of the landscape around a settlement (O'Connor 2014: 111).

Very generally, sheep appear to have been often reared for wool production in the early medieval period, and on many sites made up the main portion of livestock (although see Crabtree 2012: 11 on the West Stow assemblage, and Hammon 2011: 285 on Wroxeter). The importance of sheep for wool production can be ascertained not only from the presence of the remains of older individuals in the faunal assemblage, but also by the presence of loom weights in many early medieval contexts. Cattle were not exploited solely for meat – they were likely a fundamental part of agricultural practices which included traction, and perhaps dairying (Hamerow 2012: 156). In this context, it is also their importance in the realm of gift exchange between communities that needs to be emphasised – and this may similarly apply to early medieval horses. Pigs are noted on most early medieval settlements, but often in much smaller numbers than sheep or cattle (O'Connor 2014: 111).

Spelt and emmer wheats, which were dominant in the Roman period, were also grown in the early medieval period, often in originally Roman fields (Oosthuizen 2011: 385; Hamerow 2002: 152; although see Rippon *et al.* 2015: 324). A decline of these two species has been recorded and by the mid early medieval period, bread wheat and barley were more dominant, along with separately grown rye, and legumes, which are argued to have been used for fertilisation of fields (Oosthuizen 2011: 385; Hamerow 2002: 153). Oosthuizen (2011) has also pointed out the more regular layout of fields themselves, which she argues often modified earlier field systems and/or respected topography (389). At the same time, aspects of the landscape such as topography (i.e. slopes) and soil variation are prioritised over earlier field layouts, meaning that just because borders run along similar lines in two different periods, this does not mean that there is essentially continuity (Rippon *et al.* 2015: 321; Williamson 2016).

It is possible to suggest, then, that the use of the landscape changed in such a way from the fourth into the 7th centuries, that it reflects the more general changes taking place in social structuration. While it has become evident that some continual use of the Roman fields/field systems was practised, there was also a shift in the focus of production, with an increase in pastures (Rippon *et al.* 2015: 325). From the 7th century onwards, in the mid early medieval period, further changes and new innovations were introduced which were contemporary with changes in settlement size and organisation, funerary archaeology, and new coinage.

2.2.3.9 BURIAL

The very general trend of burial in this period has to be seen in the context of a non-Christian experience of the world. Variability is a key feature of burial practice in the 5th and 6th centuries. In the east of England, the communities of the period tended to inhume their dead, but also sometimes practised cremation (Williams 2006: 24; see also Fig. 4). In terms of chronological continuation, the latter rite occurred in slight contrast to the predominant inhumation practices of the preceding century (with exceptions, especially towards the end

of the fourth century), and those in other areas of Britain (Lucy 2000: 1-2; Williams 2006: 23-24).

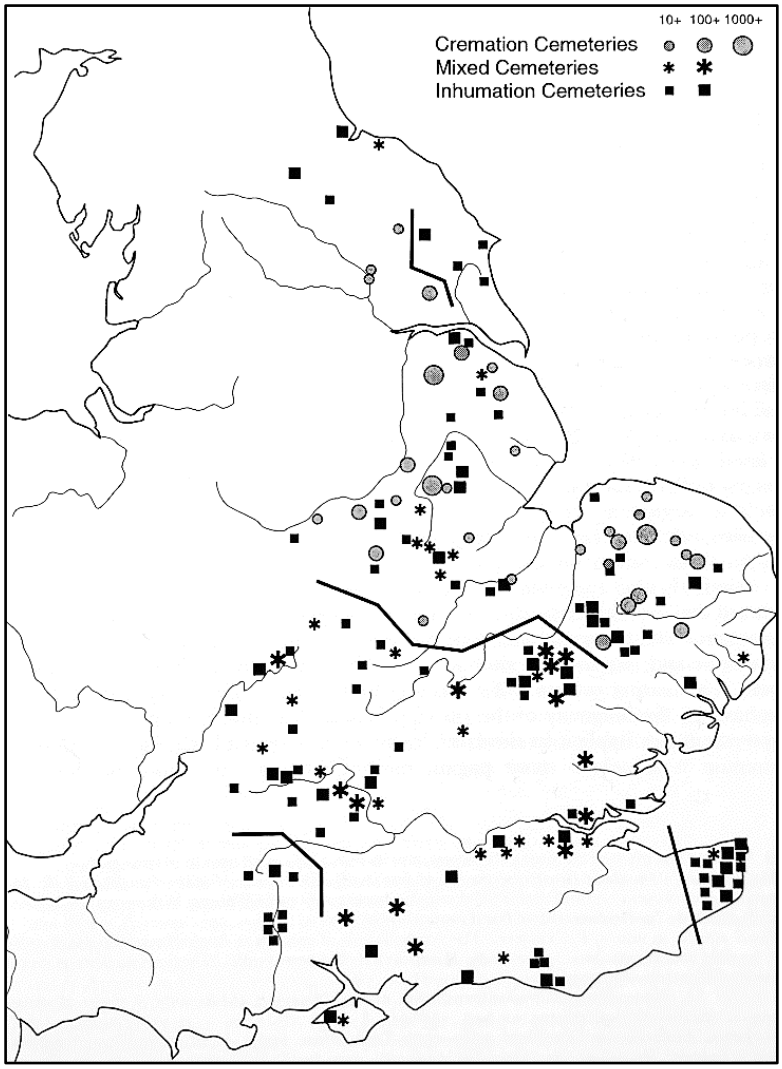

FIGURE 4 – MAP INCLUDING ALL CREMATION, INHUMATION, AND MIXED-RITE CEMETERIES IN 5TH-6TH CENTURY BRITAIN (WILLIAMS 2002: 65; FIG. 6).

Intra-cemetery variability is omnipresent, with many featuring cremation and inhumation practices at the same time (often termed 'mixed-rite'). Archaeological investigations have shown that in eastern England, cremation cemeteries of the 5th to 7th centuries frequently exceeded 1000 burials and could feature up to 2000. Cleatham is a good example of this with its c.1000 cremation burials and 62 inhumations (Leahy 2007; Squires 2012). While the cremation rite spanned the 5th and 6th centuries here, inhumations appear to have been added into the 7th century (ibid). Other areas of Britain such as the southwest, Wales, and

the north, contained an emphasis on other burial rites. For example, square-barrows occupy space in many Scottish cemeteries from this period. Cist-graves – stone-lined graves for inhumations – are also a long-term and persistent feature of the burial in Scotland and to a lesser extent in northern England. These have a long period of use but are an intensive feature in Scotland of 5th-8th century inhumation rites (Maldonado 2013). West-East inhumations were common in the north and west. Another 'key' feature of 5th century burial practice was the provision of grave and pyre goods including weapons, jewellery, toiletries, and accompaniment by animals (Campbell 1991; Williams 2006; Williams 2011). Regional variation was also a factor in this context, and generally the presence of furnished rites diminishes over time, virtually disappearing in the 7th century. Newly established cemeteries dating to the 7th century which are characterised by few or no grave goods are often termed 'final phase' cemeteries, although they are probably simply another expression of the variability seen during the early medieval period (Williams 2006: 25; Williams 2011). Williams has rightly assessed that the regional patterns in mortuary rites is diverse to an almost consistent degree (ibid).

2.2.4 LINCOLNSHIRE – LINDSEY

The Cleatham cremation/mixed-rite cemetery is located in modern Lincolnshire, which, by the 7th century, was termed *Lindissi* (Lindsey). The area was relatively prosperous in the fourth century and densely settled (Green 2012: 32, 46). If the number and distribution of cemeteries is any indication, this state appears to have continued to some degree into the 5th and 6th centuries (ibid: 41). Of note is especially the distribution of cremation cemeteries (Fig. 4). These are all located in proximity to what would later become important centres in their area (Leahy 2007; Green 2012: 62). The fact that there has not been a discovery of a large-scale cemetery associated with Lincoln has led researchers to suggest that in the 5th century, control over this expanse was in the hands of Britons, who did not allow for/use cremation cemeteries in the territory around Lincoln (Leahy 2007; Green 2012: 63). From the 6th century onwards, the number of smaller inhumation cemeteries increased and

marked the decline of the use of the large cremation cemeteries (Leahy 2007: 64; Green 2012). In the late 7th century, Lindsey (then a kingdom) was taken over by Mercia (Yorke 1990: 81; Campbell *et al.* 1991; Scull 1993, 1999). Cleatham is one of the rare, large, and early cremation cemeteries said to have been used by communities across the region – it is therefore of fundamental importance.

2.2.5 DURHAM/TEES VALLEY – DEIRA | BERNICIA

As stated above, Ingleby Barwick is a mixed-rite cemetery dating to the 5th to 7th centuries (ASUD 2005). It is located at the approximate border of the early medieval kingdoms of Bernicia (in the north) and Deira (south) in the Tees Valley, at Stockton-on-Tees. Of course, the development/continuation of post-Roman social structures and make-up are also a matter of complex discussion here. Still, more and more evidence for early medieval life in the area is coming to the forefront with recent development projects requiring archaeological assessments. For example, an extensive early medieval cemetery has recently halted development work at Hart, Durham, located 22km north-northeast from the Ingleby Barwick Low Lane cemetery. The BBC report that archaeologists have recommended the refusal of planning permission based on the expected 'national and international importance' of the site (BBC 16.12.2021). This recommendation was also based on the adjacent development site at Manor Park which, in 2018, revealed the remains of approximately 350 individuals. The report from NEAR Ltd. who excavated the site is unfortunately not available yet.

In between Hart and Ingleby Barwick, north of the River Tees, lies another Anglo-Saxon cemetery – Norton (Sherlock & Welch 1992). Norton is predominantly an inhumation cemetery, but includes three cremation burials (Graves 114, 115, 119; Fig. 5). Here, a total of 120 (117 inhumation) graves have been recorded, which contain ample grave goods and date to between the early 6th and early 7th century (ibid). All in all, evidence for cremation this far north up to the 7th century is sparse. Ingleby Barwick with its 15 cremation burials stands out and thus provides an excellent case study for this area.

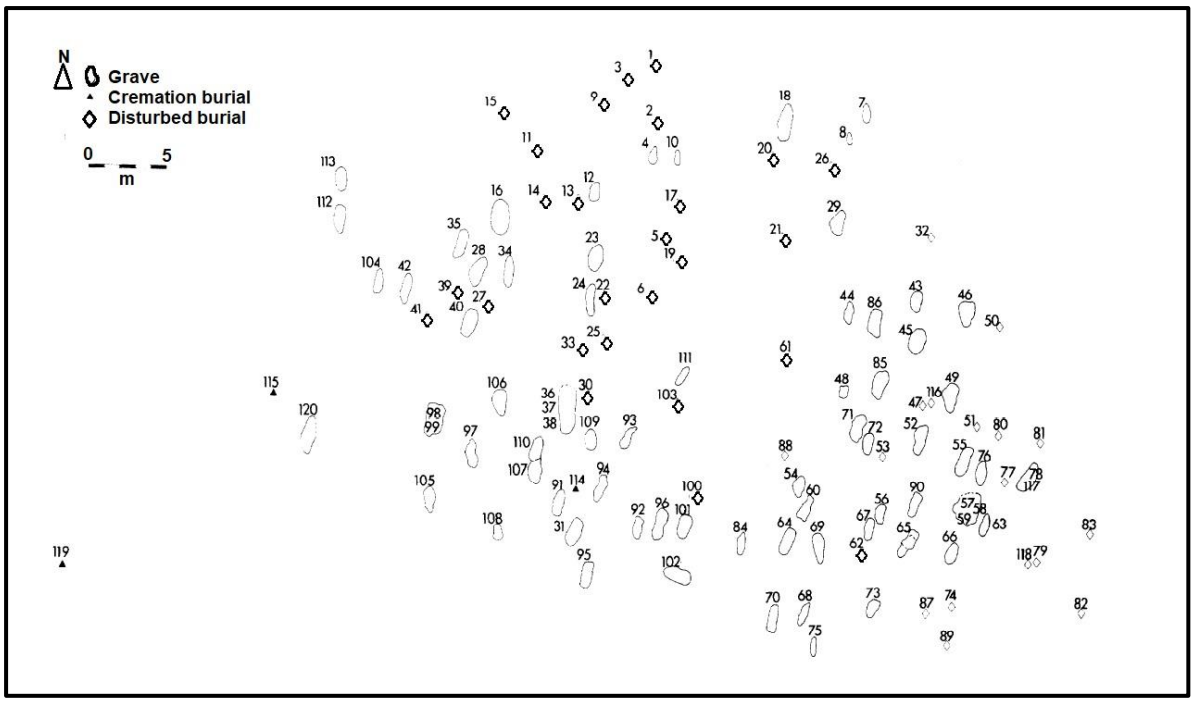

FIGURE 5 - NORTON CEMETERY PLAN AFTER SHERLOCK & WELCH (1992, 93; FIG.22).

Ingleby Barwick Low Lane cemetery is located in a landscape that features some of the northernmost Roman villas. In fact, the most northerly Roman villa known to date, Old Durham, is situated on the south bank of the River Wear north of Durham, and this is located 38.5km north-northwest of Ingleby Barwick (Willis 2013: 166). In close proximity (3km north) to the cemetery under investigation here (Ingleby Barwick Low Lane) is the Roman villa site at Quarry farm, which features probable *Grubenhäuser*, fire pits, and pottery dating to the post-Roman period, the early 5th century (Petts 2013: 198). This suggests that there may have been ongoing activity at the site into the period of interest to us, and it might give us an idea of the immediate context of the cemetery. Unfortunately, the excavation at Quarry farm was not complete, and the soil samples dating to Phase 6 (the Anglo-Saxon horizon) did not allow for solid conclusions to be drawn about the ecology and economy of the environment (ibid). More generally, it is very unusual to find a mixed-rite cemetery with this many cremation burials this far north. Norton is the only other known cemetery of the period containing cremation burials in the vicinity, and there are only three. The unique nature of the site will be explored with this context in mind.

2.2.6 VIKING AGE SCANDINAVIA AND EARLY MEDIEVAL BRITAIN (C. AD 793 – C.900)

By the beginning of the 9th century, Britain was divided into kingdoms (Fig. 6). These kingdoms crystallised during the 7th century (Turner *et al.* 2013: 103), and by the time of the Viking incursions, there appears to have been some struggle for control amongst the rulers of these domains (Nelson 2003: 7). Issues included the lack of land to give to lords, which was a major driving force of early medieval kingship, on the continent as well as in Britain (Wormald 1991: 139-141). The more organised and hierarchical structure of government in the early 9th century was strongly symbiotic with institutional Christianity and saints' cults. The Church was a major owner of land that had been gifted by rulers and lords during the preceding two centuries.

FIGURE 6 – MAP OF EARLY MEDIEVAL KINGDOMS AROUND AD 800. (MAP FROM: HADLEY & RICHARDS 2021: 23).

The change of social structure in the 7th century brought with it changes in the archaeology, and this was expressed by the presence of royal places (Scull 1993; Scull *et al.* 2016; Willis *et al.* 2016; Scull & Thomas 2020). A further change in the archaeology from the 7th century onwards can be found in funerary contexts where there is a shift away from cremation practices, and towards inhumation cemeteries without grave goods. This is a very general observation for England, and it happened at different times in different places (Lucy 2000). Still, by the 9th and 10th centuries, the commemoration of the dead took place primarily in the vicinity of churches (Campbell *et al.* 1991) and was almost exclusively inhumation. New and old saints were attraction points not just in the ecclesiastical landscape but were fully endorsed by rulers intent on creating common ground with other strata of society. Saints' cults, with their visceral appeal, provided a sense of control to worshippers by offering a direct line to the saints who would intercede with God on their behalf. This direct connection existed through tangible, material objects in the form of relics, which were often skeletal remains of humans, animals, or items of clothing or adornment (Nelson 2003).

One such cult can be found in the cemetery at Repton, near Heath Wood, where St. Wystan was commemorated by the Mercian royal line, and where the Viking Great Army overwintered in AD 873-4 (see Figure 6; Wormald 1991; Richards *et al.* 2004; Davies 2019). By the 9th century, coinage started to be widely available again in England, especially that minted in Northumbria (Wormald 1991: 135). There are several written sources which were produced in the 9th century, and which have survived to this day. The Anglo-Saxon Chronicle contains ample information about royal relations and succession, which is in some cases supplemented through information from other annals, charters, and wills (ibid: 138, 140). Most pertinent for this study are the recorded events for Mercia, which included an alliance with the kingdom of Wessex for an attack against the Welsh in AD 853, and succession competition including dynastic tension (ibid: 140). The Viking incursions along the coasts of Britain were a known occurrence by AD 865, when the first heathen army arrived in East Anglia (Fig. 7). However, with this landing, the nature of the contact between

Scandinavians and the early medieval inhabitants of England changed. What followed was a decades long struggle for dominance between the rulers of the kingdoms and the Scandinavian incomers, some of whom were – certainly after AD 865 – planning on staying (Richards 2000/2007: 34; Hadley & Richards 2021).

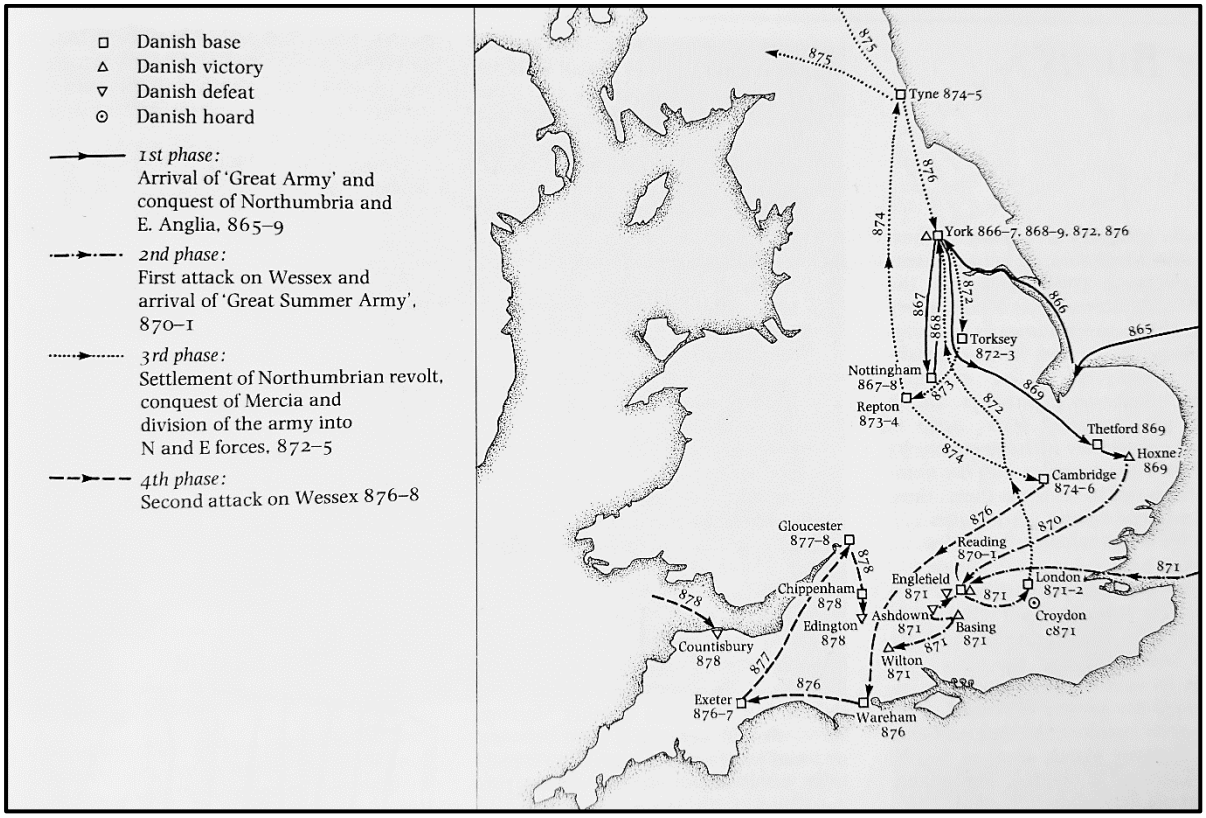

FIGURE 7 – THE MOVEMENTS OF THE FIRST VIKING GREAT ARMY AS RECORDED BY THE ANGLO SAXON CHRONICLE. (WORMALD 1991: 151, FIG. 142).

After repeated clashes with the Great Army, power over the kingdom went to the Scandinavians and Mercia was integrated into the Danelaw. Certainly, the Anglo-Saxon Chronicle reports the 'sharing-out' of eastern Mercian land in AD 877 (Swanton 2000: 74-75; Richards 2000/2007: 35). King Ceolwulf II of Mercia's death in AD 879 likely sealed the fate of the kingdom.

2.3 ISOTOPES IN ARCHAEOLOGY

The last few decades have seen an exponential increase in archaeological research including scientific techniques. This has occurred to the extent that the process has been termed the 'Third Science Revolution' (Kristiansen 2014). Others have taken up the term and broken it down to define the specific directions the discipline is developing in – especially in regard to its essential inter-, multi-, and trans-disciplinarity (Nilsson Stutz 2018). A side-effect of this expanding use of scientific techniques has been an increase in the number of 'debates-via-paper', where interpretations are not accepted, mis-interpreted, or mis-understood by the wider academic community. Prominent examples are the aDNA work on a 'female Viking warrior' in a Birka grave (Hedenstierna-Jonson *et al.* 2017; Price *et al.* 2019), and more recently, the interpretation of multi-isotope data from pig remains from Durrington Walls (Madgwick *et al.* 2019; Barclay & Brophy 2021; Madgwick *et al.* 2021). The latter example is a multi-isotope study which made use of strontium ($^{87}Sr/^{86}Sr$), sulphur ($\delta^{34}S$), oxygen ($\delta^{18}O$), carbon ($\delta^{13}C$), and nitrogen ($\delta^{15}N$) isotopes to show that in the Late Neolithic period, vast networks of mobility existed which facilitated the transport of animals (pigs) from different regions to the Stonehenge area. Unfortunately, because of the depth of required knowledge for understanding various isotopic systems, the end-result (the interpretation of the data) is on occasion lost in translation. In any case, a veritable niche has developed in the last few decades for isotopic studies which employ methods from and knowledge about the biogeosphere from the natural sciences and apply these to archaeology. As this study fits into this niche, a short overview of relevant considerations and methods will be given in the following sections. The aim is to inform and prepare the reader to be able to understand the isotope work handled in Chapters 3, 4, 5, 6, and 7 of this thesis, and to discuss the latest advances in this area of research. For relevance, the focus of this section will lie on Sr isotopes and how they are transferred into the skeletal tissues of mammals, starting with a consideration of the latter.

2.3.1 ISOTOPES

Before it is possible to explore how the isotope system of choice in this thesis (Sr) works, we should outline the basics of the relevant chemistry. Isotopes are atoms of the same element, with the same number of protons (atomic number), but with a different number of neutrons (Faure & Mensing 2005: 5; Fig. 8). This variation does not effect a change in chemical properties, however – all isotopes of an element interact with other elements in the same way (ibid). The only difference between them lies in their masses (ibid).

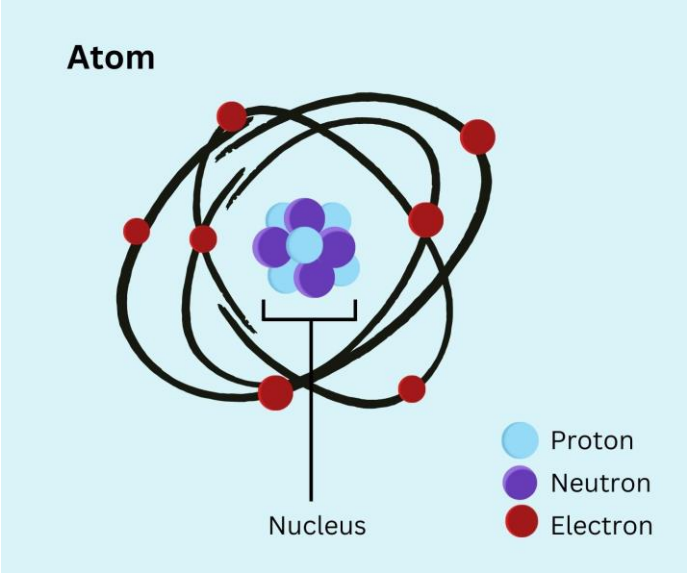

FIGURE 8 – THE SUBATOMIC PARTICLES OF AN ATOM (IMAGE BY AUTHOR).

Isotopes can occur in stable and in unstable form, whereby stable isotopes are generally much rarer in the universe (Faure & Mensing 2005: 8). In fact, all but 26 of the known elements have isotopes which differ in atomic mass because of a difference in the number of sub-atomic particles (neutrons) (Sharp 2017: 2-1). Unstable isotopes are described as 'radioactive' and 'decaying', and the rate of this decay is called a 'half-life' (ibid). If the half-life of an isotope is exceedingly long, the isotope is considered stable (ibid; Walker *et al.* 1989). For example, the decay of ^{87}Rb to ^{87}Sr takes 4.88×10^{10} years (Faure & Mensing 2005: 77). When stable isotopes are measured, they are usually expressed as a delta (δ) value relative to a known standard. This delta value uses the relative abundance of an isotope (ratio = heavier isotope/lighter isotope) (Sharp 2017: 1-9). The elements (their

isotopes) noted in Fig. 9 below are some of those measured in archaeological tissues, but not all are necessarily reliable in all tissues. The cremation process, for example, effects changes which alter not only the material structure itself, but also its isotopic composition. Details of this are considered in the relevant section below (2.3.10).

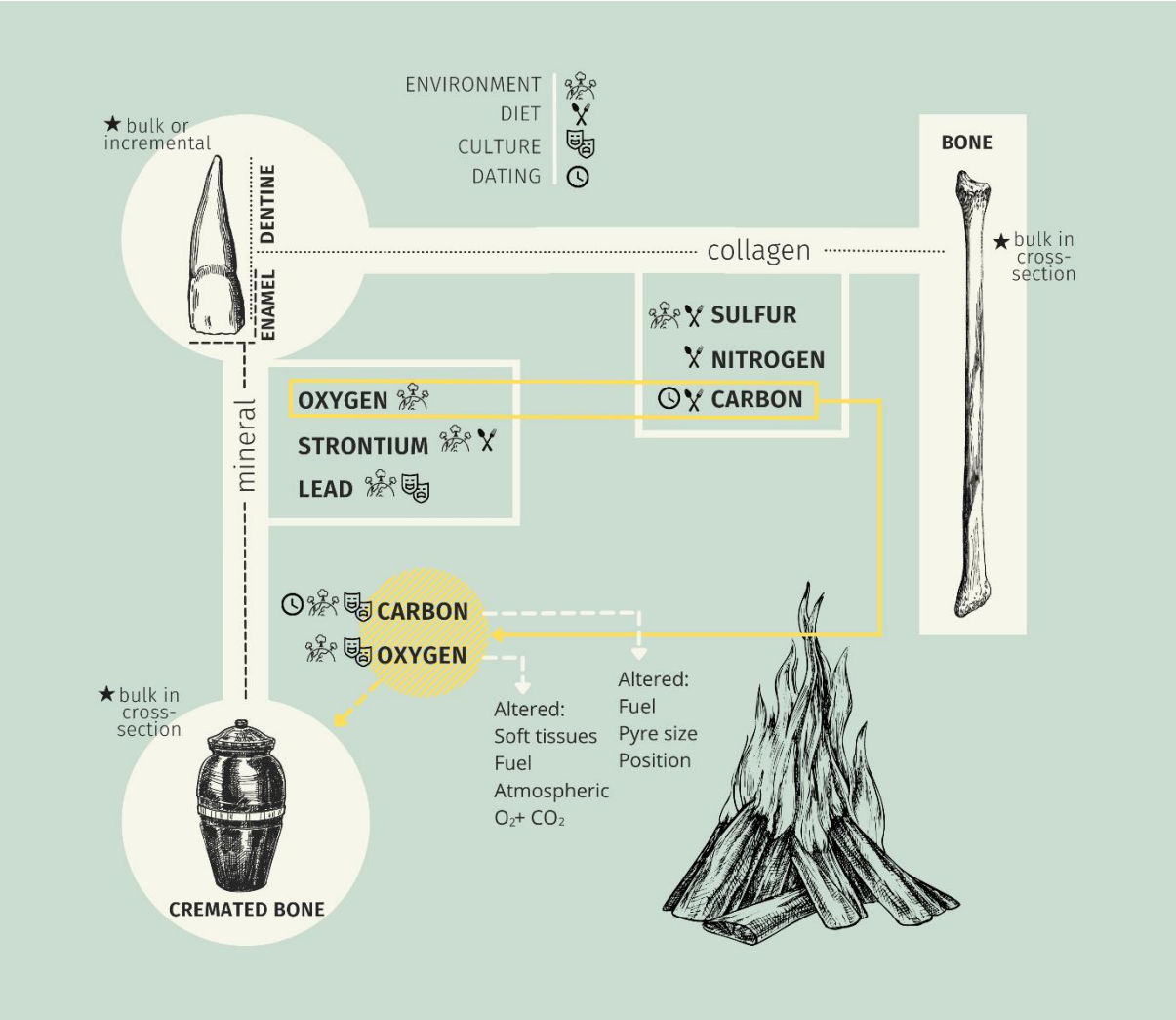

FIGURE 9 – ILLUSTRATION SHOWING WHICH TYPE OF SKELETAL TISSUE IS USED FOR WHICH ANALYSIS, AND WHAT THESE ISOTOPES CAN REVEAL ABOUT AN INDIVIDUAL. STARS INDICATE SAMPLING STRATEGY. LEAD (PB) HAS NOT YET BEEN PROVEN TO REMAIN UNALTERED DURING CREMATION PROCESS/AFTER BURIAL OF CREMATED BONE.

2.3.2 STRONTIUM

Strontium isotopes are found in the earth's crust (0.02-0.03%) and through weathering processes in soils, plants, animals, sea- and freshwater, and indeed across the entire

biogeosphere (Pors Nielsen 2004). This element has an exceptional importance not only for mobility studies in archaeology, but also fronts as one of the most useful elements for geochemistry and geochronometric studies which investigate the age of terrestrial (and extra-terrestrial) rocks and to assess the mechanisms of geological processes in earth formation (Faure & Mensing 2005: 75; White *et al.* 2013: 345). This is the case because one (^{87}Sr) of the four naturally occurring isotopes of Sr (^{84}Sr, ^{86}Sr, ^{87}Sr, and ^{88}Sr) is radiogenic – it is a decay product of rubidium (specifically ^{87}Rb) (Pollard & Heron 2008: 370). This decay facilitates the ageing and the determination of the initial composition (Rb/Sr) of different rocks. ^{88}Sr is the most abundant (83%) of the four, followed by ^{86}Sr (10%), ^{87}Sr (7%), and ^{84}Sr (<1%). The ratio of $^{87}Sr/^{86}Sr$ is used most often when Sr is measured because the two have similar abundances in nature and a small mass difference. Most pertinently, because of the high mass, the fractionation of these two isotopes in particular is negligible on their movement through the biogeosphere (Slovak & Paytan 2011: 743). The main factor contributing to a high $^{87}Sr/^{86}Sr$ is the age of the rock - because of the increasing amount of ^{87}Sr through geological time, but a second variable is the initial composition and amount of Rb (Faure & Mensing 2005: 76-78; Slovak & Paytan 2011). Rocks which have undergone differential metamorphic processes and are composed of varying lithologies will have different $^{87}Sr/^{86}Sr$ ratios. For example, igneous rocks such as granites, and most metamorphic gneisses possess higher $^{87}Sr/^{86}Sr$ than sedimentary lime- or sandstones. It is therefore possible to create Sr isoscapes based on bedrock maps which reflect the variation of $^{87}Sr/^{86}Sr$ in the environment. In the following sections, this will be explored in more detail.

2.3.3 Strontium isotopes in archaeological research

It was Ericson who, in 1985, suggested that geologically specific Sr ratios measured in archaeological human remains could be useful to determine their origins (see also Price *et al.* 1985). Before Ericson presented this idea, Sr isotopes were already used as a tracer, but most often in the context of animal movement and diet (Comar *et al.* 1955; Brown 1974;

Schoeninger 1979; Sillen 1981; an early review of early work Sillen & Kavanagh 1982; Price *et al.* 1985; summarised in Bentley 2006: 135; Pollard *et al.* 2007; Montgomery 2010: 325) and was based on a tidal wave of research conducted on the behaviour of the anthropogenic Sr-90 after the mid-century nuclear bomb tests. Price in 1985 stated that 'the method is still in a developmental stage and should be regarded as developmental' (424) at that point. With hindsight, Pollard *et al.* (2007) have described the early phase of trace element analyses with the following words: 'The willingness to interpret trace element data in bone without considering the possibility of post-mortem alteration has been termed a triumph of hope over reality, and makes for an interesting case study in archaeological chemistry' (21). A further issue encountered early on was non-linearity between diet composition (proportion meat vs plants) and Sr/Ca (Montgomery *et al.* 2007; Montgomery 2010). This was highlighted after some archaeological studies over-simplified this relationship (Burton & Wright 1995; Burton & Price 2002; Burton *et al.* 2003). In 2002, Burton and Price criticised that 'now we have a research method that continues to be applied in a routine, if not appropriate, manner by archaeologists while much of the archaeometric community that created the methodology has abandoned it' (162).

In the years after, the isotope system was used to explore the diet and movement of people and animals at a much larger scale. Crucial analyses by Sealy and colleagues (1989, 1991) and Lee-Thorp and van der Merwe (1991) built on early work by Lambert *et al.* (1982, 1984) and the (elusive) study by Nelson *et al.* (1983), which showed that while the technique promised to be useful to archaeologists to look at mobility, issues with diagenetic changes had to be managed first (see also Sillen 1986; Tuross *et al.* 1989; Sillen 1990). Price *et al.* (1994) continued to build on this work with combined [Sr] and $^{87}Sr/^{86}Sr$ analysis on human remains from Grassopper Pueblo, Arizona (see also Ezzo *et al.* 1997). The samples encompassed tooth enamel and femoral cortical bone, taking advantage of bone turnover to reflect the Sr of childhood and later life. However, even though 5% acetic acid treatment and measurements of Ca/P were used to remove and monitor contamination, it did not

quite manage to tackle the problem of diagenetic Sr in bones. A host of pre-treatments to remove contamination from the bone were developed (for a review of these methods see Wathen *et al.* 2022). One of the first multi-skeletal (and multi-isotope) studies was conducted in 1995 by Sealy *et al.*, the focus of which were two prehistoric and three historic individuals from South Africa. The study also included $^{87}Sr/^{86}Sr$ measurements of tooth enamel and bone (long-bone cortex and rib samples) to explore early childhood Sr as well as later life Sr. Similar publications followed (for example: Grupe *et al.* 1997; Price *et al.* 2004). Ultimately, doubts regarding the reliability of Sr isotopes in bone were shown to be justified by Budd and colleagues (2000) and others (Beard & Johnson 2000; Hoppe *et al.* 2003). From the mid-2000s onwards, most mobility studies using Sr isotope analyses only presented childhood $^{87}Sr/^{86}Sr$ from tooth enamel to mediate the risk of misinterpretation (Wathen *et al.* 2022). This is when some of the first large-scale mobility investigations were undertaken. Especially relevant to this study is, for example, Montgomery *et al.*'s (2005) Pb and Sr analysis of 32 early medieval (alongside 8 Neolithic/EBA and 2 IA) skeletons (details below). The difficulties with interpreting [Sr] as a proxy for diet also meant that many researchers stopped measuring, publishing, or interpreting the Sr concentrations – and many still do not do this.

Recent methodological developments form the basis of this study. In 2014, Harvig and colleagues presented the otic capsule of the petrous part of the temporal bone as substitute for tooth enamel in cremated remains. At this point, the method still included minimal destruction of the petrous part by drilling into the concha from the outside. There are now concerns about contamination of material, and the possibility that the otic capsule is not completely calcined – which is not visually determinable by colour when the capsule is accessed in this way. Before this could be put into practice in archaeology, there was the need to show that a) cremated bone contains *in vivo* Sr values after cremation, and that b) possible contamination can be removed through appropriate pre-treatment before analysis. A) was tackled for [Sr] by Grupe & Hummel (1991), while $^{87}Sr/^{86}Sr$ was shown to remain

stable until fully calcined by Harbeck *et al.* (2011) in the first instance, although the latter study was somewhat limited by the fact that modern bone was used, therefore avoiding potential issues with diagenetic Sr. Given that this is a major concern in archaeological studies, b) was shown to work by Snoeck *et al.* 2015 (as well as a)), and a full pre-treatment method was presented. Since the publication of this, several large-scale projects spanning several periods and geographical areas have included the Sr analysis of cremated remains (i.e. Schulting *et al.* 2016; Grupe *et al.* 2018; Price *et al.* 2018; Sebald *et al.* 2018; Cavazzuti *et al.* 2019; Grupe *et al.* 2020; Cavazzuti *et al.* 2021; Grupe *et al.* 2021; Sabaux *et al.* 2021; Veselka *et al.* 2021; Dalle *et al.* 2022; for a recent review see Snoeck *et al.* 2022). Some of these studies have yielded interesting datasets and will be used for comparison with the data presented in this study. Advances in the sampling and pre-treatment methodology for the calcined petrous part have also recently been made (Veselka *et al.* 2021), although these are still being optimised (Veselka *personal communication*).

2.3.4 Strontium from the Earth into the skeleton

From the bedrock, $^{87}Sr/^{86}Sr$ weathers into the overlying soils and the bioavailable fraction is subsequently taken up by plants. This is not a straightforward process, as the sources of Sr in the environment are varied and the final reflected value in the plants (and by extension mammals) is a composite. At least 22 out of the approximately 45 pages of Bentley's review of Sr isotopes (2006) are concerned primarily with environmental processes and the intricacies related to these, which somewhat illustrates the importance of this discourse. Therefore, a more detailed discussion of the subject matter follows in section 2.3.4, which looks specifically at the problematics associated with bioavailable Sr isotopes in the environment and the necessity for sampling in mobility studies such as this. In the following section, the focus lies on the process of Sr when it reaches human and non-human tissues.

The absorption of Sr from water, food, and aerosols as trace element into mammalian tissues takes place primarily in the gastrointestinal tract (jejunum). During pregnancy, a

foetus absorbs Sr through placental transfer and later through breastmilk (discussed in section 2.3.8, Fig.16 below). This process is founded on the chemical properties of Sr, which are similar to those of Calcium (Ca). Both these elements are alkaline earth metals and are found in the same periodic system; they are bone-seeking elements and easily incorporated into the bioapatite matrix during modelling and remodelling processes (Likins *et al.* 1959; Faure & Mensing 2005: 75; Bentley 2006). Their chemical similarity and comparable ionic 2+ radius facilitate the uptake of Sr in place of Ca in bone bioapatite. More generally, only elements with these 2+ ions can substitute for Ca and are incorporated into the mineral matrix of the bone tissue (Bentley 2006: 137). Because the Sr molecule is larger than that of Ca, they do not exactly work in the same way. Through biopurification, Ca is absorbed preferentially into the tissues compared to Sr, which is why Sr/Ca can be related back to the food chain (Sillen 1986; Burton & Wright 1995; Bentley 2006: 154). Similarly, Sr is excreted more readily than Ca by the body (Pors Nielsen 2004). The Sr/Ca decreases with trophic level (~20%), and herbivores tend to have the highest Sr concentrations, although this is not exactly a linear relationship and needs to be interpreted cautiously (Burton & Wright 1995). Following on from that, it is not possible to determine relative proportions of foods – i.e. how much seafood or fish has been consumed (Burton & Price 1999).

Crucial for the interpretation of $^{87}Sr/^{86}Sr$ in the skeletal material is the fact that the ratio measured represents an average of Sr from ingested and incorporated food and drink sources. This is weighted in favour of the end-member with a higher Sr concentration (Bentley 2006: 143; Montgomery 2010). According to a report for the WHO in 2010, the amount of Sr intake per day is 1.2-2.3 mg from plants, legumes, and from dairy; water contributes 0.7-2 mg per day – which is obviously a wide range; also, not all of this is absorbed into tissues (for slightly different values see Pors Nielsen 2004; Montgomery *et al.* 2006; Watts & Howe 2010). Ultimately, the bulk of Sr will end up in the skeleton as opposed to the soft tissues. In fact, 99% of the incorporated element is deposited in the former

(Odum 1957; also cited in Pate 1994: 166). By extension, the fact that most of the Sr is to be found in mammalian bone also has consequences for what we consider to be the major contributors of Sr to the diet in terms of trophic level. A carnivorous or heavily meat-based diet will not supply large amounts of Sr to the body, while a more omni- or herbivorous diet will (ibid). Most often, animals exhibit higher Sr concentrations than humans in their skeletal tissues, although this is not an absolute. This trend can be observed in the concentrations of Sr measured in the bone and teeth, although with the caveat in mind that geological composition has an impact on Sr concentrations, which may contribute to the inter- and intra- tooth variability seen in some studies (i.e.Viner *et al.* 2010: 2818).

2.3.5 SPATIAL VARIATION OF $^{87}Sr/^{86}Sr$ IN THE ENVIRONMENT

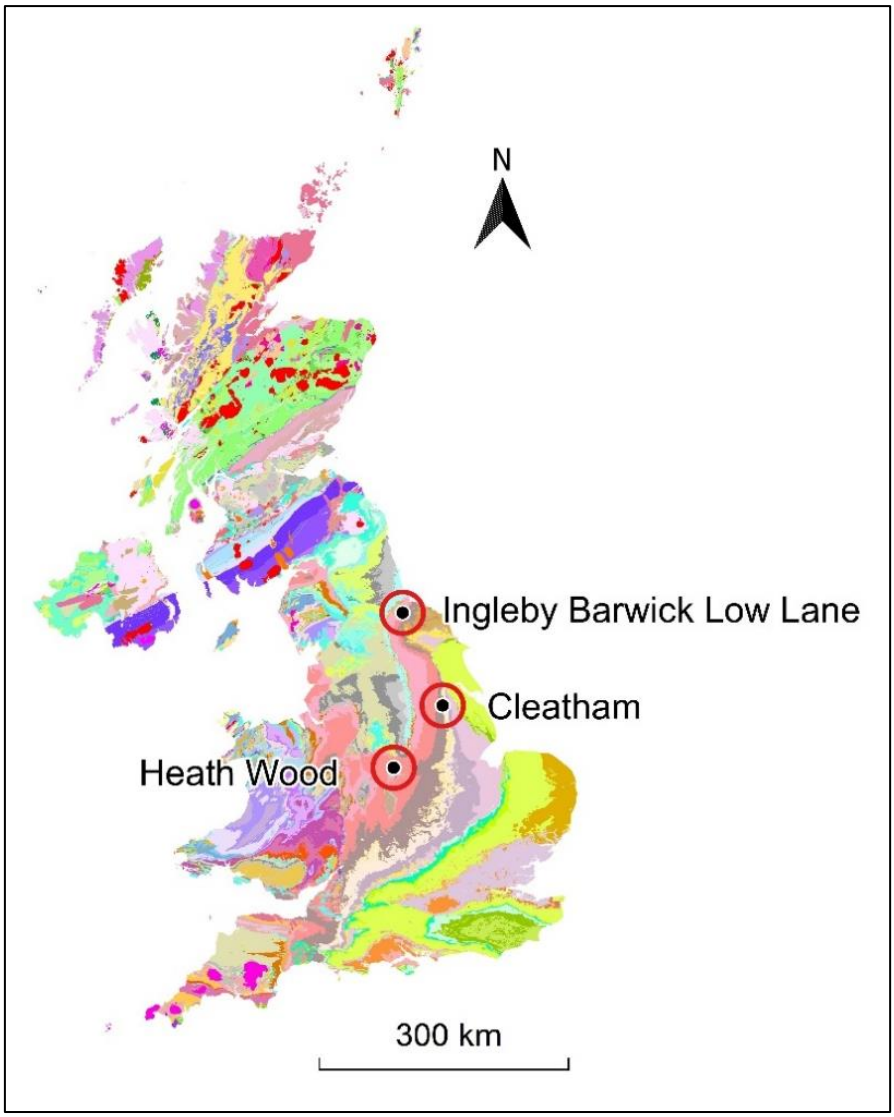

FIGURE 10 – GEOLOGICAL BEDROCK MAP OF BRITAIN WITH THE SITES UNDER INVESTIGATION. RED CIRCLES ARE 25KM CATCHMENTS. BGS 625K BEDROCK MAP FOR GIS USED AS BACKDROP.

Geological maps are often the starting point for archaeological mobility studies. They have reached high resolution and are now readily accessible to archaeologists. For Britain, the British Geological Survey has produced a myriad of datasets, which is also downloadable for ArcGIS and its free equivalent QGIS. The shapefiles used for the maps in this thesis are available via the BGS website (https://www.bgs.ac.uk/datasets/biosphere-isotope-domains-gb/). These datasets form the basis for any exploration of a 'local' Sr biosphere in the British Isles. Evans *et al.* (2010), have released geopackages for GIS which include a relatively high density of $^{87}Sr/^{86}Sr$ samples (from plants, water, and dentine) for the entire country. From

this data, they extrapolated a Sr isoscape, based on the geological formations underlying Britain. This map was updated with new data and a new method for extrapolation in 2018 (Evans *et al.* 2018) and is searchable and downloadable online. The Sr isoscape for the UK does no longer exist in isolation; Further afield, Denmark was recently mapped by Frei & Frei (2011); (also see Frei & Price 2012; Frei *et al.* 2020), and France by Willmes *et al.* (2014). The spatial variation of $^{87}Sr/^{86}Sr$ has been established for Ireland (Ryan *et al.* 2018; Snoeck *et al.* 2020), and the Antilles in the Caribbean (Laffoon *et al.* 2012). Lisette Kootker at Vrije Universiteit Amsterdam (VUA) is currently in the early stages of updating her Sr isosphere map for the Netherlands (Kootker *et al.* 2016). Amanda Sengeløv from Université Libre de Bruxelles (ULB) and Universiteit Gent is working on mapping the $^{87}Sr/^{86}Sr$ variation of Belgium for her PhD, and as part of the CRUMBEL Project at Vrije Universiteit Brussels (VUB). Further ongoing projects include the mapping of Portugal (James *et al.* 2022) and other parts of Europe by Hannah James (*personal communication)* in the course of the LUMIERE project at VUB, and that of Jordan by Lucie Johnson at Durham University (*personal communication).* The mostly ongoing projects listed above provide an idea of the research investment afforded to the task of BASr mapping. Without a basic idea of the spatial variation of $^{87}Sr/^{86}Sr$, it would be impossible to make sense of the $^{87}Sr/^{86}Sr$ measured in humans and animals.

2.3.6 SR ISOTOPES THROUGH THE BIOGEOSPHERE

The pathway of Sr isotopes from the environment into mammalian skeletal tissues has been discussed in some detail above; this section focuses on the way that $^{87}Sr/^{86}Sr$ variation sampling has been conducted in previous studies. The purpose of mobility studies involving Sr isotopes is to determine whether individuals grew up in the place or area where they were buried. As the Sr isotopes are measured on individual tissues, the results need to be related back to the environment. Archaeologists work to establish a region's specific Sr isotopic variation within the biosphere in various ways, ranging from the use of

archaeological fauna (Price *et al.* 2002; Price *et al.* 2014; Kootker *et al.* 2016; Stantis *et al.* 2020), snails (Shishlina *et al.* 2016), dentine of inhumed individuals (Stantis *et al.* 2020), modern vegetation (Bentley 2006), and ground- and surface waters (Frei *et al.* 2020) and soils (Maurer *et al.* 2012; Frei & Frei 2013; Frei *et al.* 2020). On occasion, whole rock samples are used as proxies for $^{87}Sr/^{86}Sr$ (Budd *et al.* 2004). All of these methods have problems, and these can lead to misinterpretations. For example, we must consider that plants take up Sr from the soil that they grow in, and, depending on the plant and location, this means the main source of Sr is the topsoil. Topsoils contain Sr from weathered bedrock, and the weathering process can be differential (Bataille *et al.* 2020: 3). This means that the topsoil can contain more or less radiogenic strontium, depending on the bedrock composition and the weathering rate. Measuring soil or rock samples directly can therefore misrepresent the bioavailable Sr (ibid). Furthermore, topsoil can also incorporate glacial or alluvial surface deposits which originate elsewhere, and which may not correspond to an isoscape based purely on bedrock maps (Börker *et al.* 2018; Bataille *et al.* 2020: 3). A third variable that can cause problems are anthropogenic changes to the landscape. For example, the Netherlands have seen a multitude of structuring and re-structuring measures to win land back from the North Sea, which required massively invasive techniques and shifting of soils. Therefore, there are clear issues related to the straightforward interpretation of measured modern plant samples as bioavailable Sr proxy for archaeological populations without proper consideration of these historical changes to the landscape, hence, in this case, the use of archaeological small rodents is probably the best alternative (Kootker *et al.* 2016). Issues also arise with the use of modern fertilisers which are particularly abundant in arable areas. Although fertilisers do not seem to impact surface waters, they can be retained in the surface of topsoils (Frei *et al.* 2020). Mining, quarrying and other industrial activity also impacts the reflected bioavailable Sr in the landscape (Maurer *et al.* 2012). Surface waters are sometimes used as a proxy for Sr mapping, but - depending on the weathering of the lithologies that the water passes through - the

measured samples can reflect the bedrock from much further upstream (Fig. 11), or the more easily weathered lithologies such as Sr-rich carbonates (Åberg & Wickman 1987; Bataille *et al.* 2020: 3-4). Seasonality becomes an issue when more or less rainfall occurs, or extended dryness impacts on the Sr isotope ratios (Åberg & Wickman 1987: 39). While people and animals in the past might have ingested this water, it does not necessarily reflect underlying geology. Furthermore, in most cases, water contains less strontium than plants (Bentley 2006; Montgomery 2010).

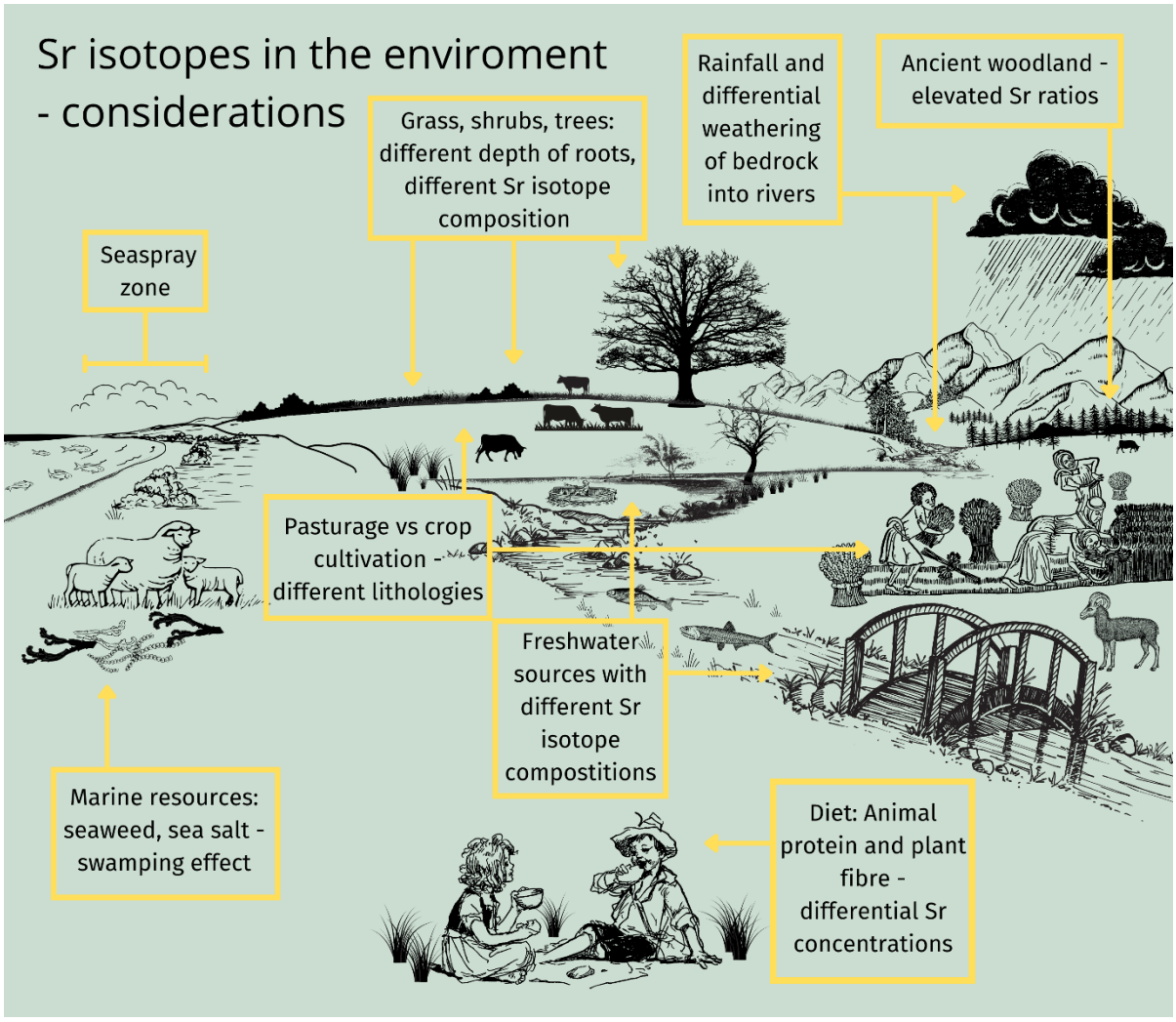

FIGURE 11 – SUMMARY OF ENVIRONMENTAL CONSIDERATIONS THAT CAN HAVE AN AFFECT ON THE SR ISOTOPE COMPOSITIONS AND CONCENTRATIONS MEASURED IN PLANTS, ANIMAL -, AND HUMAN TISSUES.

These and more detailed considerations have recently been critically assessed in a key article by Holt *et al.* (2021). The main points made by the authors was that a) plants are

consistently the most reliable proxy ('archive') for bioavailable Sr where possible, and that b) this should be complemented with other isoscapes where possible (i.e. Oxygen, Sulfur); c) there is a requirement for some consistency in the choice of archive, as well as in the interpretation and modelling of this data for archaeological purposes. They also suggested that d) researchers undertaking their own personal sampling should collect appropriate additional information during sampling and share their results with online databases in order to improve sample-density. Point a) has previously been highlighted (Ryan *et al.* 2018) and is thus considered pertinent in any future investigation of bioavailable Sr. For this thesis, we therefore made use exclusively of vegetation sampling.

Apart from the potential problem sources mentioned above, natural processes in the environment can also confound researchers by causing unexpected $^{87}Sr/^{86}Sr$ results. For example, Johnson looked at factors which may produce high Sr ratios in Britain (2018. Available from: http://etheses.dur.ac.uk/12637/). Her thesis explored anthropogenic changes to the landscape, ecologic processes, and specific geographical areas in Britain. A major takeaway from her work highlights that ancient woodland, due to the process of bioturbation of leaf material including deposits of introduced dust may elevate $^{87}Sr/^{86}Sr$ ratios of the soil. This can then be mirrored in plants which grow in the soil (see Chapter 6 in Johnson 2018 for more detail; Johnson *et al.* 2022). With these caveats in mind, a short discussion follows of what to expect in Britain in terms of Sr bioavailability.

2.3.7 BASR IN BRITAIN — WHAT TO EXPECT?

The underlying lithologies of Britain produce a biosphere $^{87}Sr/^{86}Sr$ range of 0.7070 to 0.7200 (Evans *et al.* 2018), but because of the nature of how resources and people are distributed in the landscape and the types of land available for settlement and agriculture, people do not share this range as the higher values tend to come from upland regions of granites and gneisses. In 2012, Evans *et al.* published a review of $^{87}Sr/^{86}Sr$ results deriving from individuals in Britain. At this point, the highest $^{87}Sr/^{86}Sr$ value from England and Wales was

noted to be 0.7140 (Hereford Cathedral), with values from Scotland sometimes exceeding those of the rest of Britain.

More recent studies have found that $^{87}Sr/^{86}Sr$ ratios exceeding 0.7165 are unlikely for British individuals (Montgomery *et al.* 2019; Johnson *et al.* 2019). Depending on how much they were able to move across distances, and how locally derived their food sources were, it is in theory possible for people living and growing up in England to have a higher $^{87}Sr/^{86}Sr$ ratio than 0.7140 – but this would presuppose that they remained stationary in a small catchment all their lives, for example on the Devonian red sandstones of Herefordshire and Cornwall, in Dartmoor, in southern Wales, or in some of the Scottish Highland regions. Especially pertinent as example is the study by Neil *et al.* (2020: 519) on Early Neolithic individuals from Whitwell, Derbyshire, where five people exhibit $^{87}Sr/^{86}Sr$ values higher than 0.7164, and up to 0.7212. The authors strongly suggest that the individuals migrated to Whitwell from the European continent, although they do acknowledge the bioavailability of these values in plants grown in the spatially restricted areas in Britain mentioned above. A further study by Evans *et al.* on Late Neolithic cattle from Wiltshire, where a small number of animals exhibited $^{87}Sr/^{86}Sr$ values of 0.7140 up to 0.7168 (2019) confirms the occurrence of these high Sr ratios in Britain. Here, $^{87}Sr/^{86}Sr$ values of up to 0.7170 were measured in Neolithic human dental enamel from southern Wales, which suggests – based on the archaeological context – that there may be areas in that vicinity which have not yet been mapped in enough detail (Neil *et al.* 2017: 379, Table 2; Evans *et al.* 2019: 5195). In any case, these ratios are found rarely and, when measured in individuals, are likely to indicate strong spatial restriction to a particular and limited geographic area (see for example Müldner *et al.* 2022).

2.3.8 Material – Skeletal tissues and bone turnover

In order to cover the basic principles of isotope biogeochemistry, this section will look at the essence of any isotopic study in archaeology: skeletal tissues. This forms the material

basis for any isotope measurement and therefore warrants more specific attention. Principally, there are three major tissues in a human or non-human animal body which are used: tooth enamel, dentine, and bone.

Because of its increased crystallinity and much higher proportion of inorganic material compared with the other skeletal tissues (Hillson 2005: 155), tooth enamel is highly resistant to diagenetic changes (Budd *et al.* 2000); these changes can be observed in bone and dentine with the burial environment (Pollard & Heron 2008: 347). While tooth enamel, once mineralised, consists of 99% mineral (by wt.), this is much lower in dentine (about 60% by wt.) (although see: Skinner 2005: 669; Table 30.2; Hillson 2014: 32). Consequently, it is the tissue-of-choice for isotopes which are subject to alterations in the burial environment – this includes Sr and Pb (lead), for example. Pre-treatment to remove potential surface contamination is still necessary and usually consists of surface abrasion with a dental burr and a subsequent acid treatment to destroy diagenetic carbonates (Lee-Thorp & van der Merwe 1991; Montgomery *et al.* 2003; Slovak & Paytan 2011; de Winter *et al.* 2019; Wathen *et al.* 2022). Tooth enamel forms and matures/mineralises (through amelogenesis) at specific and known periods during the childhood of an individual (or *in utero* / infancy, in the case of deciduous dentition and first permanent molar) and therefore provides a 'time capsule' representation of incorporated isotopes (Moorrees *et al.* 1963; Alqahtani *et al.* 2010). Until recently, sampling of tooth enamel has almost exclusively been conducted with a traditional bulk approach, where each tooth provided one averaged sample. This was based on the complexities involved with enamel formation and maturation (Montgomery & Evans 2006: 126-127). Dentine, because of its greater organic component in the form of collagen, is primarily used for C (carbon) and N (nitrogen) isotope analysis. Dentine can be sequentially sampled and analysed for these isotopes and the data then provides high-resolution information on the life of the individual in the period of root formation. Recent advances in the method have improved the resolution through micro-sampling which can increase the number of sequential samples taken (Czermak *et al.* 2020: 780; Cheung *et al.*

2022). A similar method is employed for analyses of C, N, S (sulphur), and rarely O (oxygen) isotopes in the rest of the skeleton.

The third type of tissue used for isotope analyses is bone. Bone has a mineral (inorganic) part (20-25% of bone by weight) which is interwoven with an organic, mostly collagenous (65% of bone by weight), part (White et al. 2013; Martin et al. 2015: 51). Apart from these two, water (10%), non-collagenous proteins (1-2%), and lipids also form a minor portion of the bone material (Martin *et al.* 2015: 52; Kenkre & Bassett 2018: 311; Burr 2019: 5). During the formation of bone, mineral is deposited in-between the collagen fibrils (Burr 2019: 9), and the isotopes that are measured in archaeological remains are contained in both these materials, although which part is used is dependent on which isotopes are investigated.

Macroscopically, bone occurs in two structurally different types: 80% of the skeleton consists of compact (or cortical) and 20% of trabecular (or cancellous) bone (ICRP 1973: 11). Both types can be found in each bone of the skeleton. It is fundamentally the amount of each type that varies by bone: Long-bones of the appendices (peripheral skeleton) are load bearing and need to withstand strain from activity and balancing and therefore consist primarily of the dense cortical bone (Fig. 12 and 13) (Burr 2019: 17); the axial (or central) skeleton on the other hand is functionally different in that it provides support and stabilisation and requires flexibility – therefore it is composed of a higher portion of trabecular bone (ibid). In long bones, trabecular bone is found at the epiphyseal ends, while some of the axial bones (vertebrae and os coxae) consist almost entirely of trabecular bone.

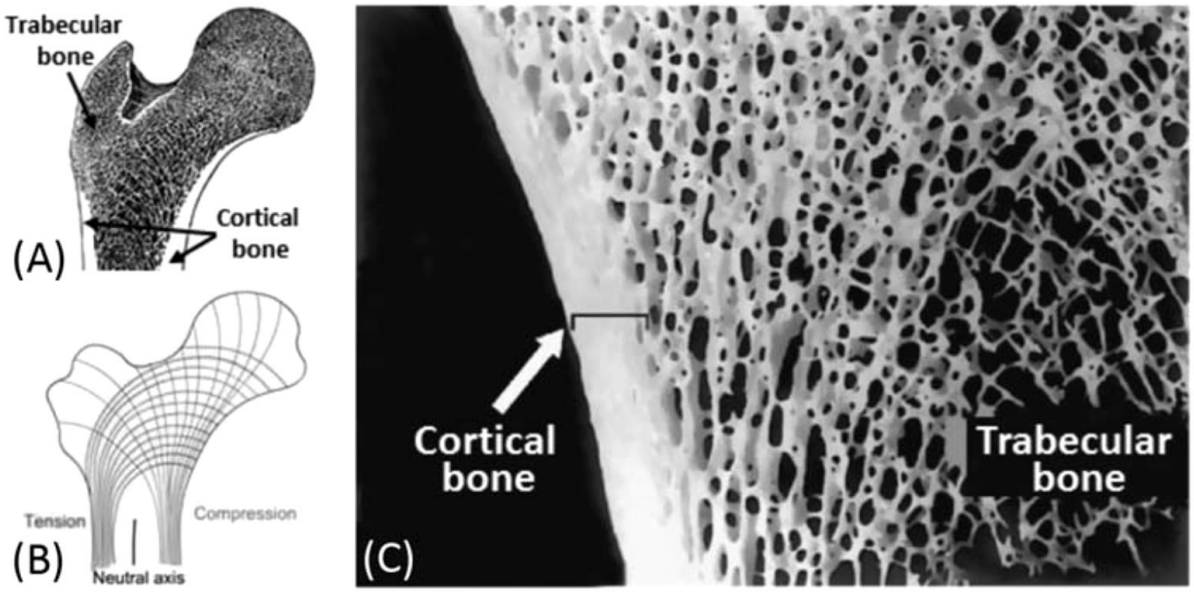

FIGURE 12 IMAGE OF CROSS-SECTION OF PROXIMAL FEMUR SHOWING BOTH TRABECULAR AND CORTICAL BONE TYPES AND THE MECHANICAL PROPERTIES OF THE STRUCTURE. IMAGE FROM KAHLA & BARKAOUI (2021, 16; FIGURE 1.12).

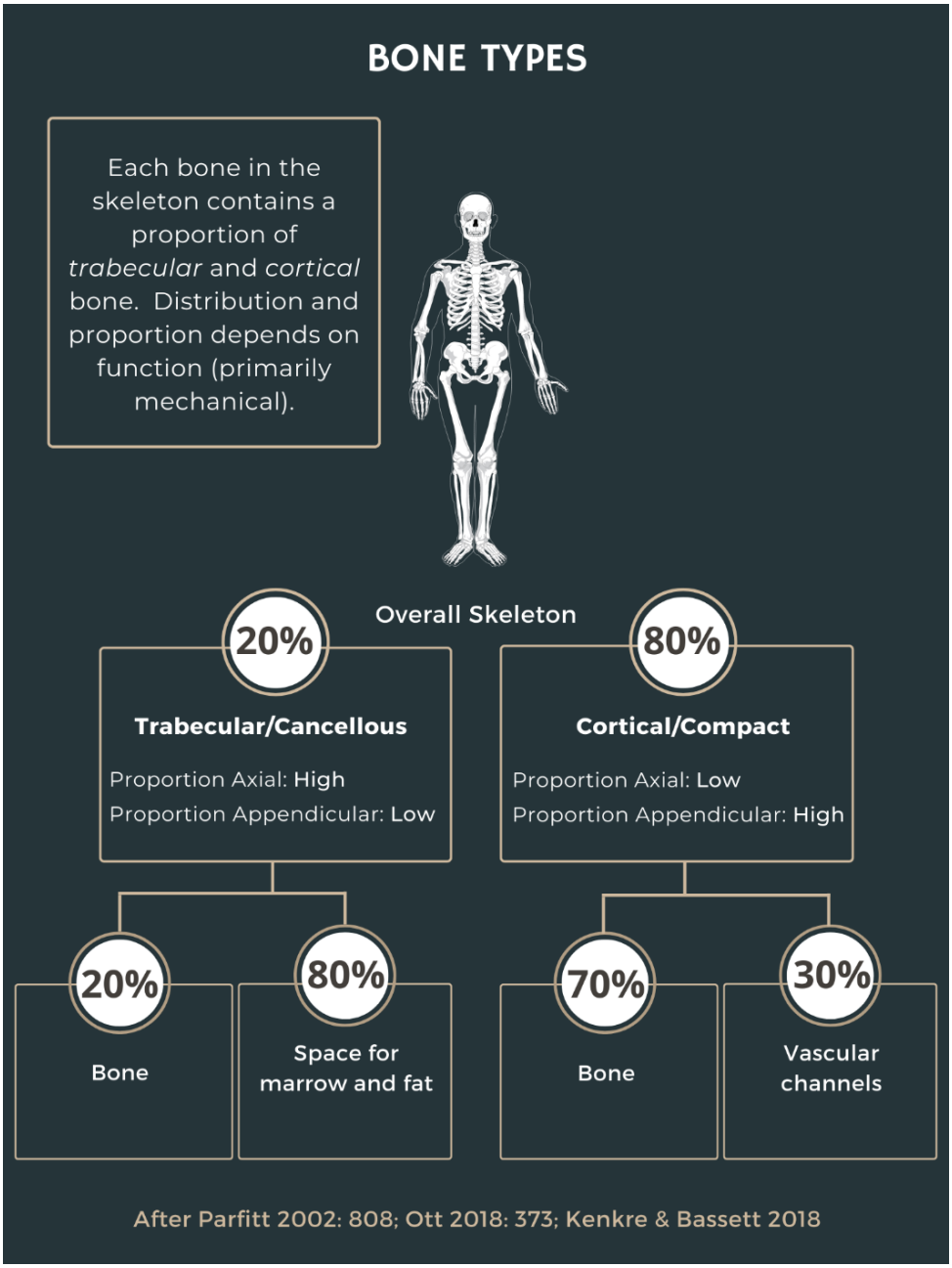

FIGURE 13 APPROXIMATE DIVISION OF THE SKELETON INTO TRABECULAR AND CORTICAL BONE TYPES. DATA FROM OTT 2018: 373; PARFITT 2002: 808; KENKRE AND BASSETT 2018).

2.3.9 BONE TURNOVER

Bone is a living tissue and constantly remodels throughout life. This means that old bone is removed and new bone laid down at subsequent stages in the process (Kenkre & Bassett 2018: 313-314). *Remodelling* is of fundamental importance to the maintenance of bone quality in the adult – old bone is replaced and microfractures are repaired upon osteocyte signalling (see Fig. 14). Bone *modelling* is a slightly differing process essential during the

period of skeletal growth in non-adults until skeletal maturity has been reached. Here, bone formation exceeds resorption to a significant degree to ensure the increase in the size of bone and finally the fusion of ossification centres. Balance is mostly restored once the skeleton has fully fused, provided that there are no underlying pathological conditions. Remodelling appears to slow down significantly in adults over 50, and the equilibrium of resorption-formation is disrupted in favour of bone resorption in post-menopausal women. The major cells involved in the remodelling process are osteocytes, osteoclasts, and osteoblasts. Table 1 below summarises terminology describing specific aspects of bone growth and maintenance.

TABLE 1 – AN EXPLANATION OF TERMS RELATED TO THE BONE TURNOVER PROCESS.

Bone resorption	Process by which osteoclasts remove old bone.
Bone formation	Process by which osteoblasts form new bone.
Modelling	Describes a process by which bone formation exceeds bone resorption, for example during growth in children. Occurs to a lesser degree in adults to adapt to changes in mechanical load/ stress.
Remodelling	Normal process in which old bone is destroyed and new bone is laid down. Occurs mostly on bone surfaces (i.e. periosteal and endosteal) and within the BMU.
Bone turnover	The rate of bone turnover describes the amount of bone remodelled per skeletal element. Usually given as % per annum.
Osteoclast	Bone resorbing cell within the BMU.
Osteoblast	Bone forming cell within the BMU.

Osteocyte	Cell in charge of signalling the need for modelling and remodelling, and the regulation of osteoclast and osteoblast activity within these processes. Role in mineral homeostasis.
BMU	'Basic Multicellular Unit' – consists of osteoclasts, osteoblasts, and blood supply. Regulated by osteocytes and contains all elements necessary for bone remodelling. After Frost (1963).

Remodelling takes place solely on the bone surfaces (Parfitt 2013: 857). In cortical bone, surfaces are reached by osteoclast precursors in the Haversian canals which form the centre of an osteon, and in the lining of the periosteal, and endocortical areas (ICRP 1973: 8; Parfitt 2002: 807-808). In trabecular bone, this process is confined to the exposed surfaces through Howship's lacunae (Kenkre & Bassett 2018: 313). Therefore, trabecular bone may contain some sub-surface bone that does not remodel at all because it is hardly reached by BMU (bone multicellular unit) activity (Parfitt 2002: 809).

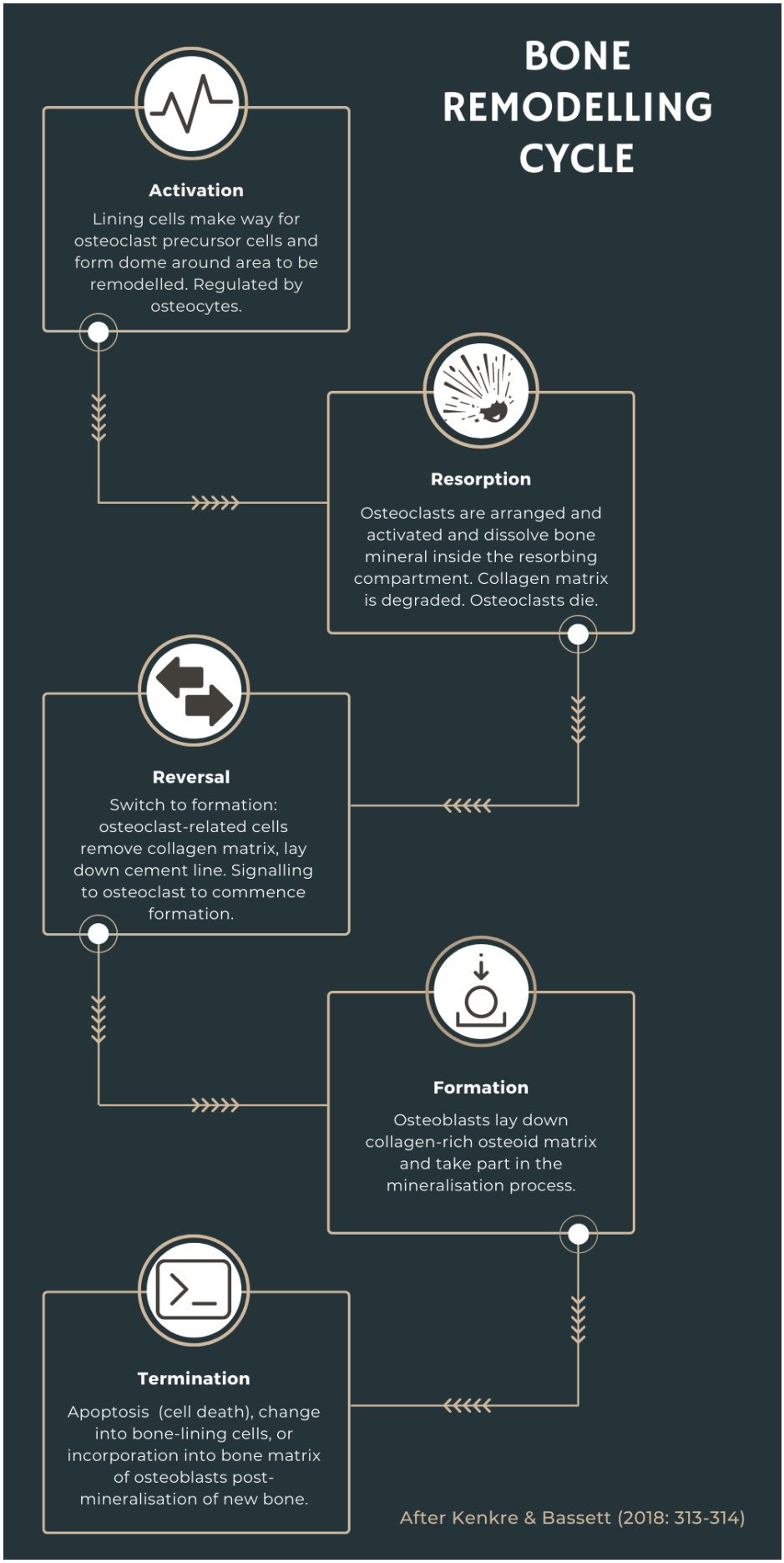

FIGURE 14 – THE FIVE SPECIFIC STAGES OF THE BONE REMODELLING CYCLE OF THE BMU.

Most of our knowledge about bone modelling, remodelling, and turnover rates derives from clinical literature and has been summarised by the International Commission on Radiological Protection. Primarily, a report published in 1973 focussed on turnover rates in adults without pathological conditions. The aim of the report was to determine a basis for future task group recommendations, and to 'provide quantitative information on the distribution of radioactive materials in bone' (ICRP 1973). A subsequent report built up on this in order to update the retention function presented in 1973 (ICRP 1993). In terms of clinical literature which provided the source for these reports, Frost (1960; 1968; 1969, 1990), Jowsey *et al.* (1965), and Kerley were instrumental in defining and measuring resorption, formation, and turnover rates. In the 1960s and 70s, studies often involved tetracycline-labelled biopsies from humans of all ages and were conducted in search of "normal" rates to better define such conditions as osteoporosis which unbalance the delicate equilibrium between osteoclast and osteoblast activity. Apart from this relatively early work, one of the best and more recent sources for bone turnover is Parfitt (2000; 2002, 2003, 2004; 2013) who still draws from the research of the previously mentioned clinicians.

While an argument can be made that "normal" bone turnover is difficult to gauge because it constitutes a process highly dependent on many internal and external variables, a general trend of bone remodelling may be distilled from the information that is available to date. This has the following implications for isotope investigations which focus on the mineral part of the bone: Before skeletal maturity is reached and epiphyses have fused - effectively ending the growth period - most bone contains a significant portion of recent material, because bone formation rates are much higher than resorption rates during this phase (bone modelling) (Kerley 1965; Hill & Orth 1998; Parfitt 2004; Parfitt 2013; Kenkre & Bassett 2018). Once skeletal maturity has been reached, the entire process slows down and, in the absence of pathologies or adverse environmental factors, bone should maintain a relative equilibrium of resorption/formation (remodelling) on the bone surfaces to ensure bone

health (Parfitt 2013). Modelling occurs in adults only when load or mechanics change. There is also a difference between peripheral and central skeleton in terms of cortical and trabecular turnover rates, and bone surfaces adjacent to red marrow appear to remodel faster (Parfitt 2013). According to clinical literature, the cortical bone of the rib turns over 'twice as fast' as that of other cortical bone (ICRP 1973: 35-36), something that has also been articulated by Parfitt (2013) in his observation of the different rate of turnover between central and peripheral skeleton. According to Frost (1969), bone formation (note: not the remodelling or turnover rate) in the cortical bone of the 6th rib of an adult should be around 2-6% per year, but Frost's data excludes activity in the periosteal and endosteal surfaces. It is certain that the overall turnover rate is therefore generally higher than this, because most remodelling occurs on these surfaces (Fig.16) (Parfitt 2013; Moreira & Dempster 2020: 449). Generally, the assumption has been that the diaphyseal cortical bone of long-bones such as femora contain bone from at least the last 15 years of the life of an adult individual and may even contain a significant portion of bone from youth (Mosekilde *et al.* 1995; for collagen turnover see also: Hedges *et al.* 2007; Fahy *et al.* 2017; Kenkre & Bassett 2018). Kerley (1965) have shown that remodelling in the midshaft cortex of the femur, tibia, and fibula of adults occur to a slower degree than that of the rib with rates of 3%, 2.5%, and 4% respectively (ICRP 1973: 34). There are problems with generalising these rates and applying them to all adult individuals, but in the absence of observable pathologies I accept these trends for the interpretation of the data presented in this study. Complications are introduced when genetic, pathological, hormonal, and environmental factors are considered, because these tend to have additional influence on the remodelling of bone (see for example: Luisetto *et al.* 1997; Syed & Khosla 2005; Faje *et al.* 2012; Schlecht *et al.* 2012; Sibonga 2013; Tomita *et al.* 2014). Figs. 15 and 16 below summarises some of the bone turnover and formation rates provided in clinical literature. Clinicians are known to assume approximately equal amounts of formation and resorption in 'normal' bone (i.e.

Frost *et al.* 1960), therefore the formation rate also represents remodelling. The columns have been separated to highlight that there are problems with this assumption.

BONE TURNOVER RATES

Location	BTR	BFR	Ref
Surface bone close to marrow (including endosteal)	Bone mean 0.5 to 4 years old; increases with distance from surface		1
>75µm from bone surface	no surface remodelling		1
Adjacent to red marrow VS adjacent to yellow marrow		15% higher mineral apposition rate; 10-fold higher bone formation (close to red VS yellow)	1
Near (within 1 mm) joint surfaces	high turnover		1; 8
Normal compact bone		2.5% per year	5: p36
Central (cancellous)	15-35% per year		1
Rib cortex (osteoporosis; n=21)		0.09 - 19% per year	3
Normal compact bone (rib)		2.9-4.1% per year	10
Normal compact bone (rib; excl. endo+periosteal activity)		2-6% per year	4
Rib cortex	2% per year		6
Peripheral cortical bone	4% per year		6
Distal radius (cancellous)	2% per year		1

Femur cortex (outer 3rd; n=126)	2.2% per year		9
Tibia cortex (outer 3rd; n=126)	2.0% per year		9
Fibula cortex (outer 3rd; n=126	2.5% per year		9
Femur cortex (n=1; path)		6.57% per year	2
Tibia cortex (n=1; path)		2.12% per year	2
Metatarsal cortex (n=1; path)		4.01% per year	2
Fibula cortex (n=1; path)		6.57% per year	2
Rib cortex VS other cortex	Twice as fast		5:p.35-36
Peripheral VS Central cancellous	Difference larger than in cortical bone (low peripheral - high central)		1

1) Parfitt 2013; 2) Frost, Villanueva and Roth 1960; 3) Villanueva et al. 1966; 4) Frost 1969; 5) ICRP 1973; 6) Parfitt 2002; 7) Parfitt 1983; 8) Parfitt et al 1985 9) Kerley 1965; 10) Pirok et al. 1966 -- Yellow denotes bone of the central skeleton, green highlights that of the peripheral areas. White concerns general observations.

FIGURE 15 – A SELECTION OF BONE TURNOVER RATES AND FORMATION RATES FROM CLINICAL LITERATURE.

PERCENT OF BONE SURFACE IN NORMAL MAN WHICH IS IDENTIFIED MICRORADIOGRAPHICALLY AS BONE FORMATION SURFACE

Age	25	35	45	55	65	75	Mean
Rib (cross-section)	2.6	2.9	1.8	2.3	3.1	2.8	2.6
Iliac crest (anterior)	3.7	4.4	2.0	3.2	3.8	3.4	3.4
Iliac crest (posterior)	1.9	3.0	2.8	2.3	2.9	2.2	2.5
Femur (midshaft)	2.0	2.8	2.0	2.4	2.9	3.3	2.6
Femur (neck)	—	—	—	—	—	—	3.2
Vertebrae	—	—	—	—	—	—	1.9
					Grand mean 2.7 ± 0.5 (S.D.)		

Data on the percentage of bone formation surfaces in different skeletal elements according to Jowsey et al. (1965). Amended and summarized in ICRP (1973: 36; as Table 9).

Age (years)	No. of cases	Bone formation rate %/day	Bone formation rate %/year
0–0.9	16	0.233	85 ± 40*
1–9	43	0.104	38 ± 24
10–19	20	0.058	21 ± 15
20–29	49	0.018	6.7 ± 3.7
30–39	52	0.005	1.8 ± 0.6
40–49	53	0.010	3.7 ± 1.3
50–59	63	0.010	3.6 ± 1.2
60–69	37	0.011	4.0 ± 1.3
70–90	23	0.012	4.4 ± 1.5
		Adult mean	3.5 ± 1.2† %/year (last 5)

* Standard deviation.
† Average standard deviation.

Data on bone formation rates in the cortical bone of the 6th rib midshaft. From Frost (1969). Also cited in ICRP (1973: 35 as Table 8).

FIGURE 16 – BONE SURFACE AREAS AND BONE FORMATION RATES FOR SPECIFIC BONE ELEMENTS.

Apart from dental tissues, only one other skeletal element is known to be almost static; the otic capsule of the petrous portion of the temporal bone (Fig. 17). This encapsulates the inner ear and is not subject to turnover after an individual has reached the age of two years (Sørensen 1994; Sørensen & Bretlau 1997; Harvig *et al.* 2014; Veselka *et al.* 2021).

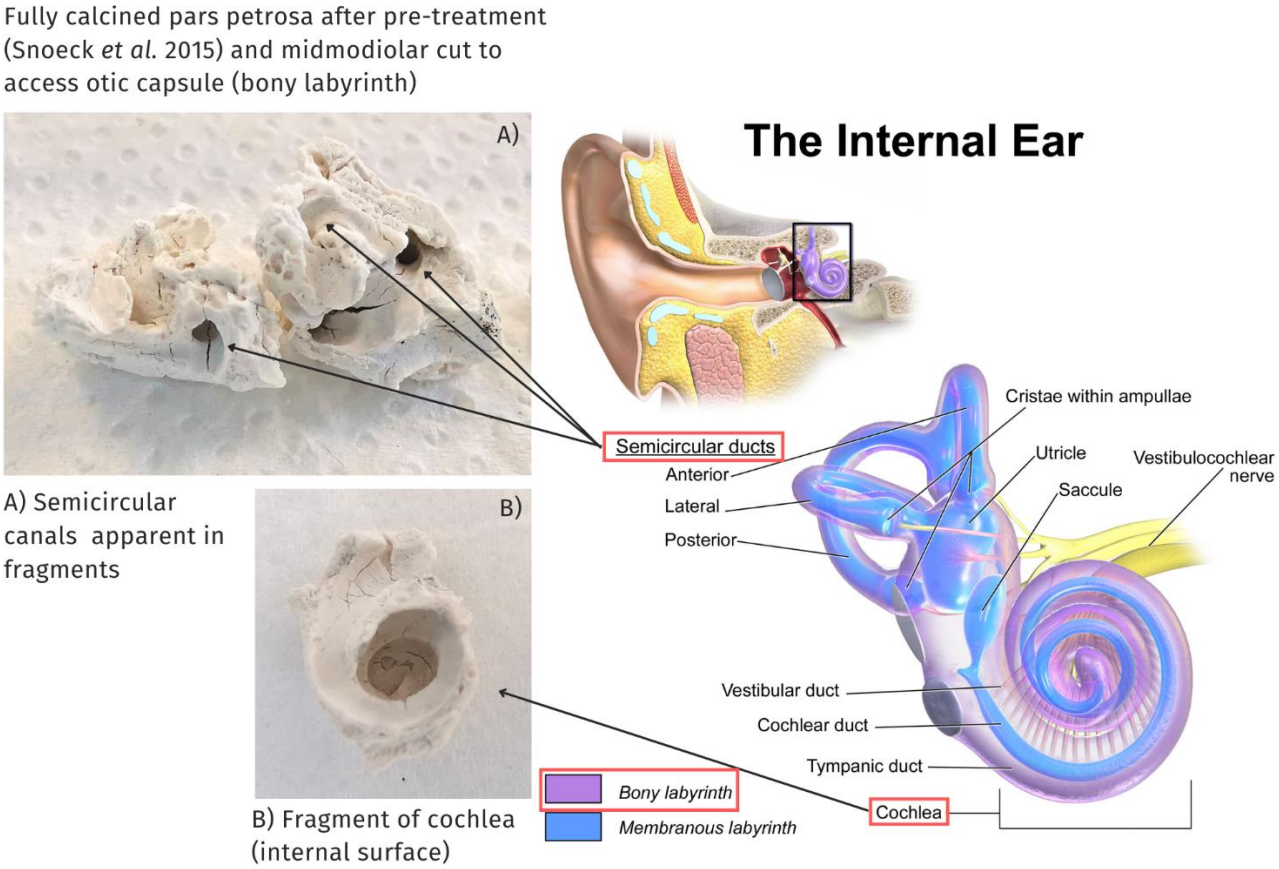

FIGURE 17 – THE OTIC CAPSULE (BONY LABYRINTH) OF THE INNER EAR – ITS POSITION IN THE EAR AND SAMPLING IT. (INTERNAL EAR GRAPHIC FROM WIKIMEDIA COMMONS: BRUCEBLAUS),

It begins to form at 16 to 18 weeks *in utero* (Jeffery & Spoor 2004: 86), which means that this process is interlinked with the calcium metabolism of the mother (DiMeglio & Leonard 2013: 983-4). In the third trimester of pregnancy, a foetus accumulates c. 20-25g of calcium (80% of total calcium accumulation during gestation) (DiMeglio & Leonard 2013: 982) which derives not only from newly ingested calcium of the mother, but also from her skeletal stores. Clinical studies show that during this late period in pregnancy bone resorption increases while formation does not, signifying a net loss of calcium in the maternal skeleton (Black *et al.* 2000; Kovacs 2011). Bone resorption is again increased during lactation to

mobilise calcium into the breastmilk, and this is transferred to the baby (Fig. 18) (Kovacs 2011: 795; Bae & Kratzsch 2018: 41). This increased bone resorption to release calcium in the mother has the side-effect of also releasing strontium. Therefore, although calcium is preferentially taken up into bone tissues compared to strontium, it must be considered that a portion of the strontium isotopes measured in the otic capsule of the baby (and any adult) reflects the strontium released from the maternal skeleton during pregnancy and lactation. The rest of the represented strontium likely comes from ingested 'local' sources which have passed through the maternal organism.

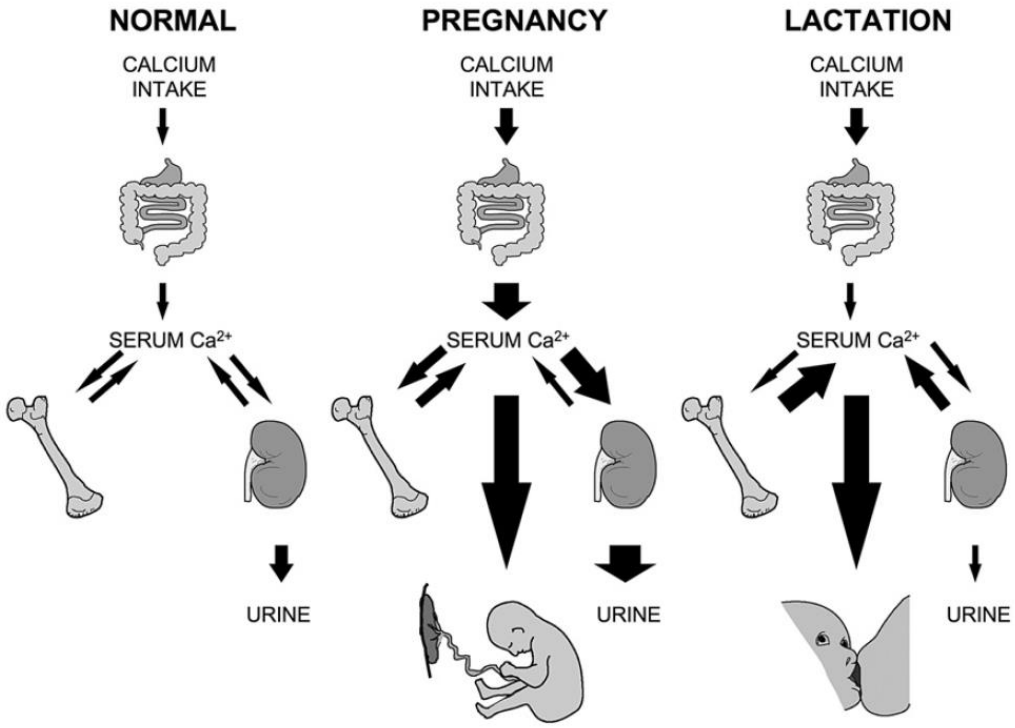

FIGURE 18 – COMPARISON OF CALCIUM HOMEOSTASIS IN THREE DIFFERENT STATES: NON-PREGNANT, DURING PREGNANCY, DURING LACTATION. ARROW THICKNESS SHOWS RELATIVE INCREASE AND DECREASE COMPARED WIT NON-PREGNANT STATE. FROM *KOVACS (2011, 796; FIGURE 1)*.

We can stipulate to the following points when we interpret the isotope data from specific bone samples:

a) Bone turnover is faster in young individuals, slows down in adults, and becomes almost static in the elderly (46+ years). *Bone fragments of young individuals likely reflect the Sr intake from a relatively short time span, especially the thinner cortical*

bone of the ribs. Middle adults (c. 18-40) likely incorporate a large portion of the Sr intake from their growth period, especially in the thick cortex of the femoral shaft. Older adults and mature adults feature a more significant portion of their Sr intake from during their adulthood, although Sr intake from their growth period is still represented.

b) Thin cortical bone turns over faster than thick cortical bone. *Essentially, this happens because turnover takes place predominantly on the endosteal and periosteal surfaces of the bone, and these surfaces are proportionally more extensive in thinner cortical bone.*

c) Older women are prone to osteoporosis which leads to bone resorption exceeding formation. While the quality of the newly deposited bone remains the same, the quantity decreases. *This means that ribs potentially reflect a longer timespan before death when compared to the ribs of men or younger women.*

d) Pregnancy and other stress situations can trigger calcium release from skeletal tissues through increased resorption of bone, which also releases previously incorporated strontium. It is not known to which degree this is re-incorporated into the tissues if it remains in circulation. *It may be that the Sr reflected in the bone tissues of young or middle-aged women has been subject to recent exacerbated exchange.*

e) The otic capsule of the petrous portion of the temporal bone has almost no turnover after the age of two. *Although Ca is preferentially taken up into bone tissues compared to Sr, it must be considered that a portion of the Sr isotopes measured in the otic capsule of the baby (and any adult) reflects the strontium released from the maternal skeleton during pregnancy and lactation. The rest of the represented Sr likely comes from ingested 'local' sources which have passed through the maternal organism.*

2.3.10 Cremated bone

When a body is burnt, several processes take place which alter the chemical structure and composition of the skeletal tissues (Zazzo *et al.* 2009; Snoeck *et al.* 2014; Snoeck *et al.* 2016; Marques *et al.* 2021). Mature dental enamel contains large mineral crystallites which expand under the influence of extreme heat. This causes the crown to shatter, and cremation burials therefore rarely contain any tooth enamel when it is not protected in an unerupted state in the alveolar processes. Dentine and bone contain a more substantial organic portion than enamel (see section 2.3.7 above) which is removed by high temperatures, and these tissues undergo warping, fissuring, and cracking while they turn white in colour (McKinley 2004; McKinley & Smith 2017). Collagen is destroyed, water components are removed, and all that remains is bioapatite (Skinner 2005; Snoeck *et al.* 2014; Stamataki *et al.* 2021: 2). The chemical formula for bioapatite is $[(Ca, Na, [\,])_{10}(PO_4, HPO_4, CO_3)_6(OH, F, Cl, H_2O, CO_3, [\,])_2]$ which is in essence highly substituted carbonated hydroxyapatite $[Ca_5(PO_4)_3(OH)]$ (Skinner 2005: 667). The temperatures that bone mineral is subjected to during cremation leads to a re-crystallisation of the material which can prevent subsequent diagenetic isotope exchanges with the environment (Snoeck *et al.* 2014). Stable carbon and nitrogen isotopes, sulphur isotopes, and sometimes oxygen isotopes are measured on the collagenous portion of the bone, which means that this is no longer possible after cremation has taken place. However, the re-crystallisation of the mineral substrate ensures that after pre-treatment, isotopes such as Sr reliably reflect *in vivo* values (Snoeck *et al.* 2015).

2.4 Life-mobility-History

The points outlined in section 2.3.8 above facilitate the recording of the life-mobility-history potential of different bone sampling strategies. As discussed, different skeletal elements reflect the strontium ingested over different timespans during an individual's life. Sampling can be done in a variation of combinations, and each combination covers a different range, or ranges, of an individual's life. In this way, it is possible to rank combinations and visualise

how much of the life-mobility-history of the individuals can be investigated at any given site. The following life-cover grading system is introduced in this study in order to summarise and visualise the sampling.

Qualification	Samples	Grade
Excellent	>3 (incl otic)	1
Very good	2 (incl otic)	2
Good a	3 (ex otic)	3
Good b	1 (otic)	4
Moderate	2 (ex otic)	5
Poor	1 (ex otic)	6

The grading-system can give an idea of the condition and the potential of an assemblage, even when only a small percentage is sampled. It works similarly to other grading systems used in osteological and palaeopathological studies in that it provides descriptive summary data which is straightforward to understand and access. The grading is based on the sampling of three main elements: a) the otic capsule of the petrous part; b) the rib; c) the femur or other substantial long bone diaphysis (tibia/humerus). As an additional sampling zone the cranium can be targeted, although turnover here is not well understood. Because of the potential of the otic capsule, sampling strategies including this element are higher rated in most cases. For example, sampling femur and rib will give a moderate idea of an individual's mobility history due to the extended averaging of Sr, compared to the sampling of only the otic capsule, which is as useful as enamel bulk sampling (infant Sr intake). The latter is especially valid in consideration of the bioavailable Sr at the burial site. It is not advisable to sample unidentified bone, because the potential of this belonging to an animal is too great in most contexts.

2.5 CONCLUSION

The aim of this chapter was to provide the reader with a review of literature and a solid reservoir of knowledge for the following study. The ground covered included the theoretical foundations of how mobility is understood and applied in the social sciences, especially in

archaeology. Specific emphasis was placed on those aspects, which will become important to the interpretation of the data presented in the following chapters. *Relationships* are considered paramount in matters of agency and personhood, and this will be explored further. Social philosophers such as Bourdieu, Giddens, Haraway, Fowler, Robb, *et cetera* have been drawn upon to reflect on structures, relationships, and to challenge the engrained worldview of the western mind. The archaeological background for the study sites was presented in short, with a focus on the relevant periods and areas, that is 5th to 7th century Lincolnshire and the Tees Valley, as well as 9th century Derbyshire (Mercia). The short introduction to strontium isotopes in the biogeosphere and the subsequent discussion of bone turnover will help the reader to critically assess the interpretations presented in this study from the remains at Cleatham, Ingleby Barwick, and Heath Wood. Finally, the ground covered in this chapter reflects the interdisciplinary nature of this study, but relevance was pursued in each section to prepare the reader.

3 MATERIAL AND METHODS

This Chapter details the methods used for the sample selection, and the processes involved in the subsequent analyses, pre-treatments, and measurements. It is predominantly meant to provide a documentation, and to make this study reproducible.

3.1 PLANT SAMPLING

To establish the variations within the local BASr, plants were collected from several locations within a 25km catchment area around the three burial sites following the procedure described in Snoeck *et al.* (2020). Locations close to arable fields were avoided due to potential issues relating to Sr contamination through fertilisers. The sample sites were pre-selected using Google Earth satellite imagery and BGS 625k Bedrock and Superficial Geology KML layers (Evans et al. 2010) as this pre-sampling step ensures that all the major geological formations within the catchment will be sampled via plants, and that these are at accessible places near roads. Although a lot of care was taken to plan the route and exact sampling places beforehand, satellite imagery was occasionally outdated. In these rare instances, places nearby were scouted. A handheld GPS from Archaeological Services Durham University was used to record the sampling locations as accurately as possible (see Fig. 19).

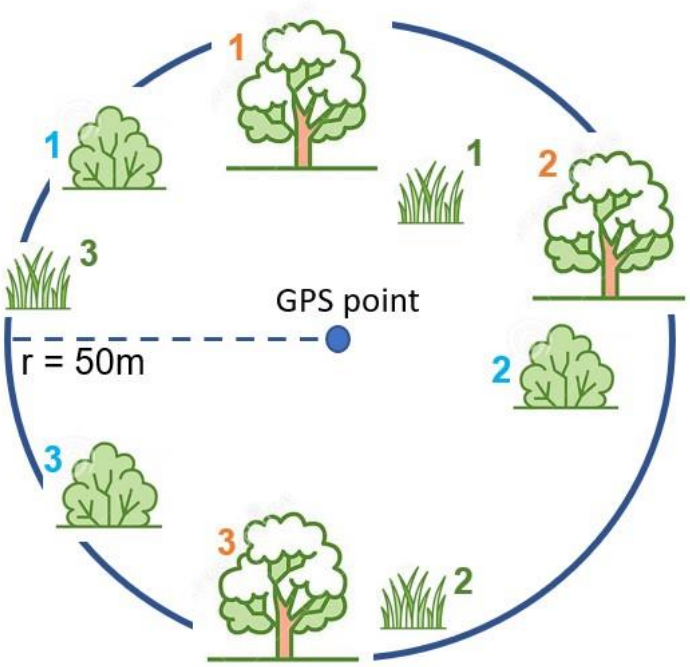

FIGURE 19 – SCHEMATIC DEPICTION OF SAMPLING PROCESS PER SAMPLING LOCATION.

The plant material for sampling consisted of three different types: a) grass, b) shrubs, c) trees. All three types together were sampled within 50m of the recorded GPS point. Leaves and grasses were bagged in paper envelopes to facilitate drying. In the field notes, information was included on Date, Time, Weather, a description of the sampling site with details on possible contamination (i.e. fertilisers), and photos were taken of the plants for future reference. Detailed notes including coordinates can be found in the Appendix (A.2-A.4).

3.1.1 INGLEBY BARWICK LOW LANE

3.1.1.1 CATCHMENT DESCRIPTION AND SAMPLING

The catchment of the cemetery includes the eastern coastline to the North Sea in its northeastern extent. Bands of several geological formations are running approximately northeast to southwest, from Middlesbrough and Hartlepool through the catchment circle and extend beyond it, where they reach all the way south to central and eastern England (Fig. 20). There are six major bands which each measure approximately 4-12km max in width, but the cemetery itself is located on a consistently wide band of undifferentiated

Triassic sandstone. Immediately adjoining the sandstone along its northwestern extent is a thin band of Permian mud-, silt-, and sandstone (also undifferentiated). Parallel to this run the dolomitized limestones of the Zechstein Group, which date to the Permian. East of Ingleby Barwick, there is a further band of Triassic bedrock including mud-, silt-, and sandstone, beyond which lie lime- and sandstones from the Late Triassic – Mid Jurassic Lias and Ravescar Groups. Superficial deposits are limited to Quaternary till, but this extends over most of the catchment area. Along the Tees estuary, there are Quaternary lacustrine deposits including clay. Overall, the most extensive formation in the vicinity are the Triassic limestones, and these also underlie the cemetery itself. Six sample locations were pre-selected inside the catchment for Ingleby Barwick. These cover the major geological formations, and they are complemented by nine plant samples from BGS (Evans et al. 2010; 2018). Sample location 3 is at the cemetery site directly. More detailed notes on the sampling sites can be found in the Appendix (A.2).

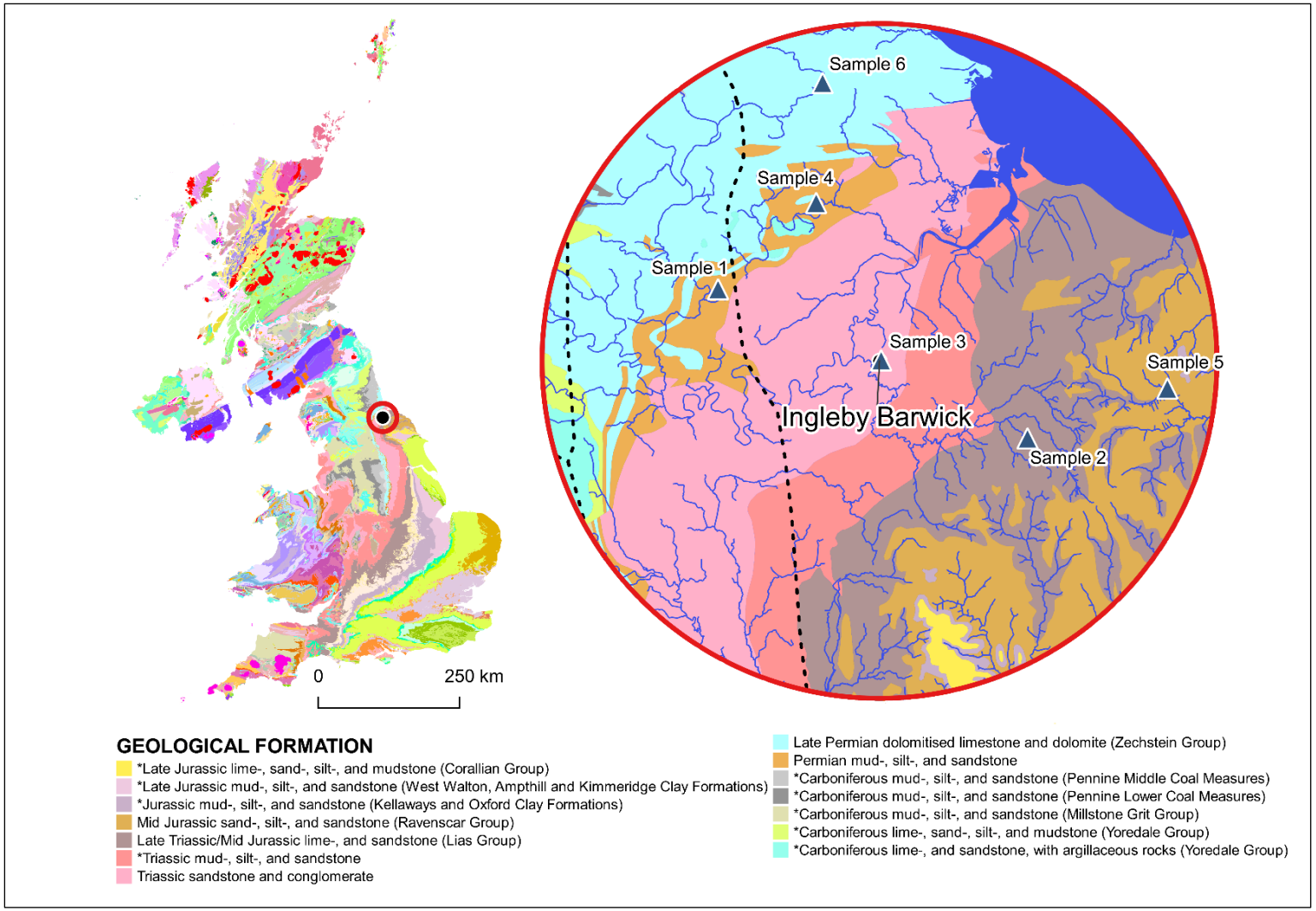

FIGURE 20 - INGLEBY BARWICK LOW LANE CEMETERY LOCATION IN THE UK WITH BGS 625K BEDROCK GEOLOGY BACKGROUND. RED CIRCLE MARKS 25KM RADIUS AROUND SITE. RED CIRCLE MARKS 25KM RADIUS AROUND SITE; DASHED LINE INDICATES ROMAN ROAD; BLUE TRIANGLES INDICATE SAMPLING LOCATIONS. (*) MARKS GEOLOGICAL FORMATIONS NOT SAMPLED FOR THIS STUDY BECAUSE OF THEIR LIMITED EXTENT WITHIN THE CATCHMENT.

3.1.2 CLEATHAM

3.1.2.1 CATCHMENT DESCRIPTION AND SAMPLING

Similarly to Ingleby Barwick, the geological formations underlying the Cleatham catchment are roughly organized in bands. Here, they run latitudinally from north to south from the Humber estuary at the northern extent of the 25km circle (Fig. 21). The same Triassic sand- and mudstones, as well as the Late Triassic rocks of the Lias Group that are found at Ingleby Barwick also run through the western half of the Cleatham catchment. The cemetery is located at the very border between the Lias sandstone and limestones of the Inferior and Greater Oolite Groups. Even further east are more sedimentary rocks from the mid to late Jurassic period (Kellaways Formation and Oxford Clay Formation; West Walton Formation, Ampthill Clay Formation And Kimmeridge Clay Formation). In the very east of the catchment, there is an outcrop of chalk from the White Chalk Group, which runs along the entire eastern coast from Scarborough to Skegness, and also appears in a large extent of eastern and southern England. Seven sample locations were selected for the Cleatham catchment which targeted the major geological formations within the catchment. Sample 1 was located outside the 25 km catchment because the pre-selected site was inaccessible during sample collection. An alternative site was scouted to collect the plants for the Triassic sandstone. Detailed notes including coordinates can be found in the Appendix (A.3).

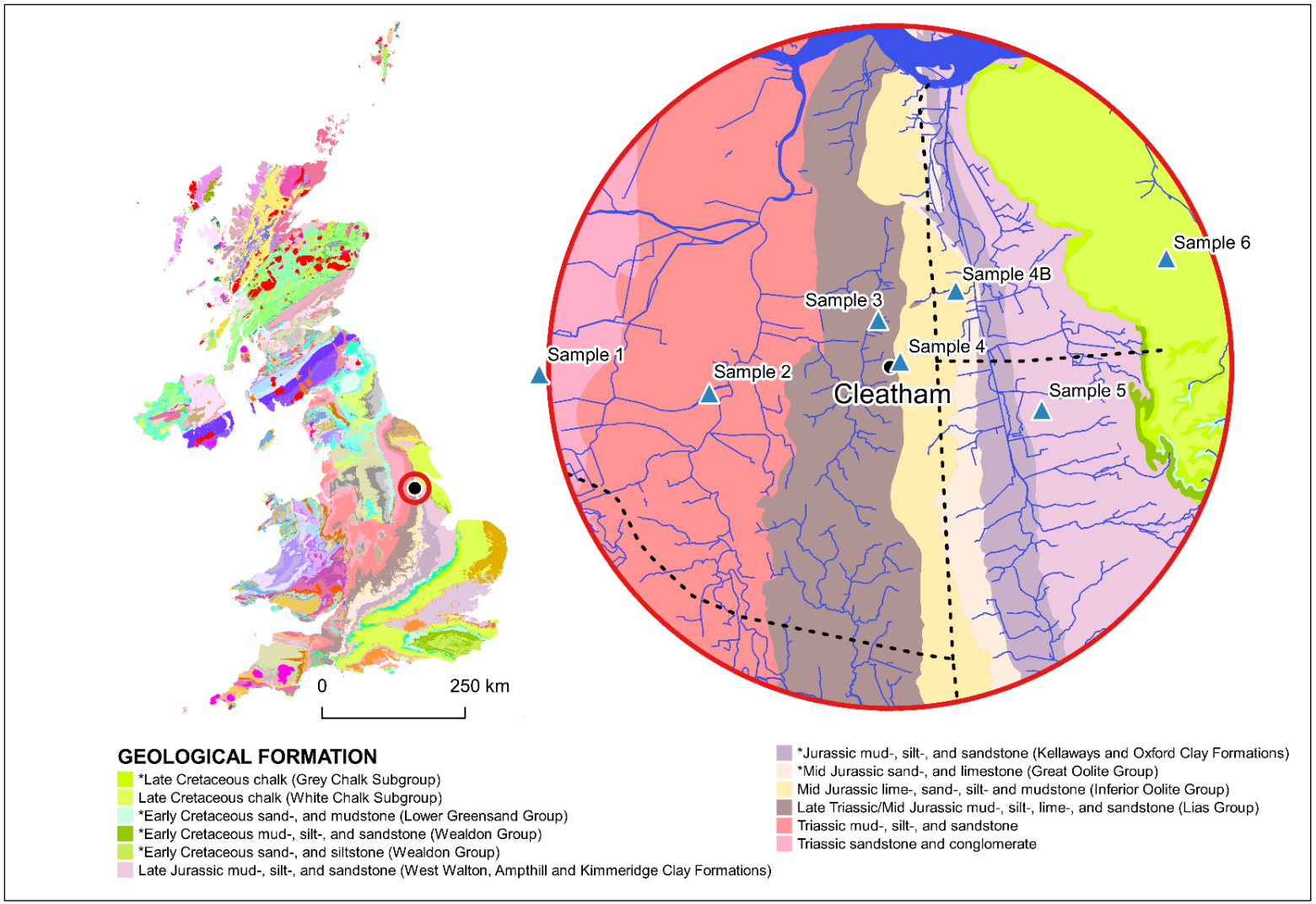

FIGURE 21 - CLEATHAM CEMETERY LOCATION IN THE UK WITH BGS 625K BEDROCK GEOLOGY BACKGROUND. RED CIRCLE MARKS 25KM RADIUS AROUND SITE. RED CIRCLE MARKS 25KM RADIUS AROUND SITE; DASHED LINE INDICATES ROMAN ROAD; BLUE TRIANGLES INDICATE SAMPLING LOCATIONS. (*) MARKS GEOLOGICAL FORMATIONS NOT SAMPLED FOR THIS STUDY BECAUSE OF THEIR LIMITED EXTENT WITHIN THE CATCHMENT.

3.1.3 HEATH WOOD

3.1.3.1 CATCHMENT DESCRIPTION AND SAMPLING

Heath Wood is situated on a slight elevation on Triassic sandstone and conglomerate (Sherwood Sandstone Group). To the east is a small extent of sandstone of the Millstone Grit Group, and this also crops up further north at the edge of the catchment. By far the most extensive formation surrounding the cemetery are the sedimentary Mercia Mudstones, which date to the Triassic epoch and cover almost the entire catchment. Just south of Heath Wood is a small outcrop of Coal Measures, which also appears in the north of the catchment circle. In terms of superficial geology, there are Quaternary alluvium deposits just north of Heath Wood along the run of the river Trent and smaller patches of till scattered across the catchment. Six sampling locations were pre-selected inside the 25 km catchment (Fig. 22) Detailed notes including coordinates can be found in the Appendix (A.4).

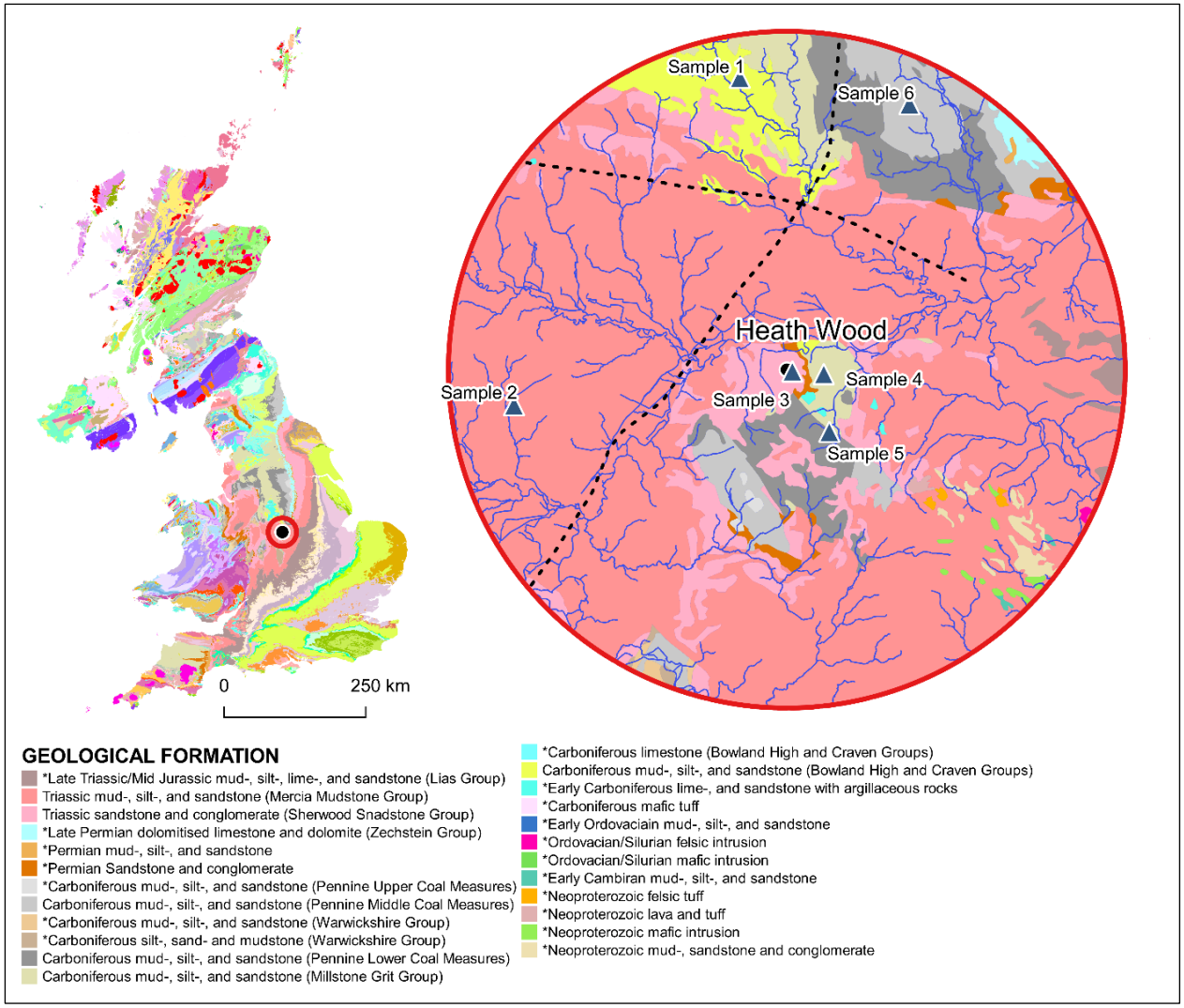

FIGURE 22 - HEATH WOOD CEMETERY LOCATION IN THE UK WITH BGS 625K BEDROCK GEOLOGY BACKGROUND. RED CIRCLE MARKS 25KM RADIUS AROUND SITE; DASHED LINE INDICATES ROMAN ROAD; BLUE TRIANGLES INDICATE SAMPLING LOCATIONS. (*) MARKS GEOLOGICAL FORMATIONS NOT SAMPLED FOR THIS STUDY BECAUSE OF THEIR LIMITED EXTENT WITHIN THE CATCHMENT.

3.2 OSTEOLOGICAL ANALYSIS AND SAMPLE SELECTION

The following section details the osteological analysis of the cremated human and animal remains, and the subsequent sample-selection for each of the three sites.

Ethical considerations

At all times, the human and animal remains were treated and stored according to professional ethical guidelines, including the *Code of Practice* (2019a) and the *Code of Ethics* (2019b) published by the British Association for Biological Anthropology and Osteoarchaeology (BABAO). Originally these date to 2010 but were updated during the course of this PhD in 2019. Further guidelines that were consulted and followed came from *Science and the Dead: A Guideline for the Destructive Sampling of Archaeological Human Remains for Scientific Analysis* from the Advisory Panel on the Archaeology of Burials in England and English Heritage (APABE 2013). For recording of the cremated skeletal remains, the author looked towards the methods described in McKinley (2004), and McKinley and Smith (2017). The remains were treated with the utmost care and respect during collection, transport, storage, and analysis. At all times the work was undertaken to illuminate the life and death of the individuals represented by the remains, which firmly centred as the research focus. By extension, this meant that the handling and destruction of bone for this study was kept to a minimum and conducted in order to tell the stories of these individuals by isotopic and osteoarchaeological means. At no time were they considered a 'material' in the scientific sense of the word, even though the remains are described and photographed in the following section. The placement under the heading of 'Material and Methods' simply follows structural-logical considerations.

3.2.1 OSTEOLOGICAL ANALYSIS

The osteological analysis was conducted for the sites of Ingleby Barwick and Cleatham and involved the assessment and recording of the cremated remains. In this process, the remains were unbagged according to their size category (<2mm, 2-5mm, 5-10mm, >10mm). Wherever possible, the entire cremation burial was analysed at the same time to

check for matching fragments across sizing categories. The bone fragments were then sorted into identification categories: *Cranial, Axial, Upper Limb, Lower Limb, Dentition,* and *Not Identifiable* (Fig.23). Pathologies were recorded in an appropriate section, and contextual information was also noted on every recording sheet where possible.

FIGURE 23 – EXAMPLE OF CREMATED REMAINS LAID OUT FOR OSTEOLOGICAL ANALYSIS.

3.2.2 AGE AND SEX DETERMINATION

Sex estimation was conducted in adults only, as non-adults do not yet exhibit the required skeletal dimorphism. Where possible, the sexually dimorphic traits were assessed using the appropriate reference literature (Cox 2000; Cox & Mays 2000). It was not possible to use bone measurements at the time of analysis as methods of analysis had not yet been published for cremated material (i.e. Cavazzuti et al. 2019; Hlad et al. 2021). In the overall assessment, more weight was given to the evaluation of the pelvic traits, as these tend to be more reliable due to biological function (i.e. childbearing). The categorisation of sex conformed to the much-used certainty scale: male/female (M/F); possible male/female (M?/F?; or M??/F?? for least certainty); indeterminate (Ind; mixed traits); ? (no traits present to assess sex).

Age was estimated using standard osteological methods for unburnt skeletal remains (Buikstra & Ubelaker 1994; Cox 2000; Scheuer & Black 2000a, 2000b) as there are strong indications that some of these are also reliable in cremated bone (i.e. Veselka et al. 2021). The confirmation of these osteoarchaeological methods' applicability to cremated remains is still an ongoing field of research, however, and therefore all sex and age estimations must only be accepted with caution. Most often, age-at-death was based on the degeneration of joint surfaces (Lovejoy et al. 1985 Brooks and Suchey 1990) and dental development where these indicators were available. The age categories used for this study conformed to those frequently used for professional archaeological reporting (Table 2) (i.e. Holst et al. 2019).

TABLE 2 – LIST OF AGE GROUPS, CATEGORIES, AND RANGES USED DURING OSTEOLOGICAL ANALYSIS.

Age Group	Age Category	Age range
NON-ADULT	General Non-Adult Category	<18
INF	Infant	1-12 months
JUV	Juvenile	1-12
AO	Adolescent	13-17
YA	Young Adult	18-25
YMA	Young Middle Adult	26-35
OMA	Old Middle Adult	36-45
MA	Mature Adult	46+
?	Not Identifiable	-
ADULT	General Adult Category	18+

However, they had to allow for certain broadness due to the uncertainty associated with cremation burials and were used in a way that expanded the general categories. For example, in some cases 'YA' was combined with 'YMA': 'YA-YMA'. Uncertainty was indicated by adding a question mark to the category. Where possible, an explanation was

included what exactly this determination was based on to allow the reader to accept/reject the conclusion in the report critically.

3.2.3 PATHOLOGY

During the analysis of the cremated remains, special note was made of pathological changes to the bone that were macroscopically observable. The cremation process causes severe changes to the bone and is highly destructive, leading to the absence of large parts of the dentition. We must therefore acknowledge the bias that is inherent in the pathological analysis of cremated remains. Due to the generally fragmentary nature of the remains, pathologies could only be observed locally, and the true extent was often indeterminate. All bone surfaces were checked for new bone formation indicating acute or healed infection/inflammation as indicated by woven, transitional, or lamellar bone (Buikstra & Ubelaker 1994; Ortner 2008; Buikstra 2019). Childhood stress indicators such as cribra orbitalia (small pin-sized holes in the orbital roofs) usually recorded for archaeological skeletal collections were also noted in detail (Hengen 1971; Buikstra & Ubelaker 1994; Walker *et al.* 2009; Cole & Waldron 2019).

3.3 METHODS – ISOTOPE ANALYSIS

This section provides detail on the methods employed throughout this study. This includes sampling procedures, isotope chemistry, and measurements.

3.3.1 SAMPLING PROCESS

During the osteological analysis the fragments to be sampled were selected and only fully calcined ones (white in colour) were chosen. This is the material of choice for Sr isotope studies of cremated bone because it has been shown to resist diagenetic alteration with Sr from the soil (Snoeck *et al.* 2015). Bone that has not been fully calcined (discoloured grey or black) is not reliable due to the different mineral structure which allows exchanges of Sr with the soil.

Following this, the selected bone samples were pre-cleaned with a Dremel equipped with a diamond dental bur across all surfaces and cut as cross-section with a diamond saw blade (Fig. 24). Afterwards, freshly exposed areas showing soil staining were abraded again with the bur. In-between samples, the drill bits were cleaned submerged in Decon (2%) and placed in the ultrasonic bath for 2 minutes. This was followed by several thorough rinses with milliQ water.

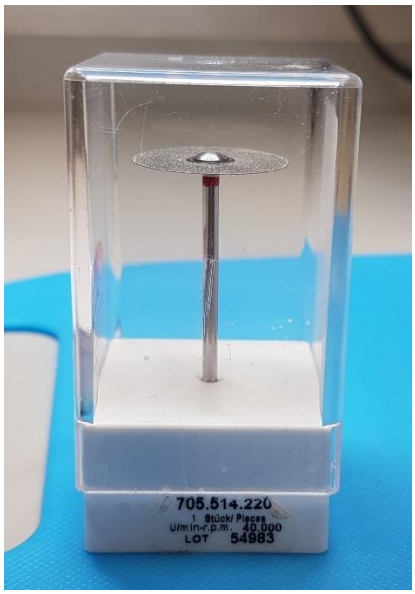

FIGURE 24 – EXAMPLE OF DREMEL SAW BLADE USED FOR DRILL SAMPLING OF CREMATED BONE.

The process for the sampling of petrous portions is currently being refined, but as of the writing of this thesis, the most reliable way to do this is to pre-clean the entire bone in milliQ water in the ultrasonic bath. This should take place even before the petrous part is cut in half for access to the inner ear canals and the concha which contain the otic capsule (Fig. 25). Most of the samples deriving from the petrous part for this study were sampled before any cleaning took place, however. They were sampled according to Veselka et al. (2021) which required the cross-sectioning of the bone through the canals, the cleaning of the surfaces with the dental bur, and the collection of bone powder from drilling.

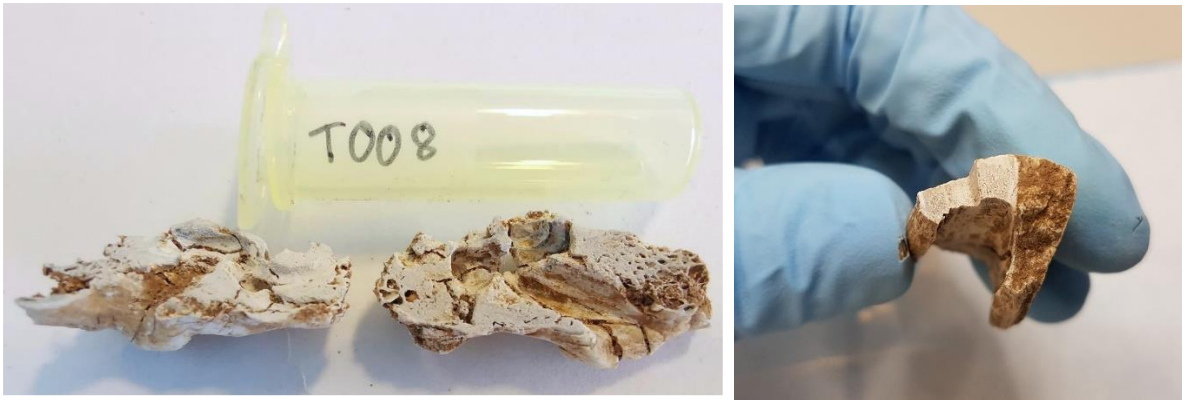

FIGURE 25 – LEFT IMAGE IS AN EXAMPLE OF A CROSS-SECTION OF THE PETROUS PART, EXPOSING THE INNER-EAR CANALS WITH THE OTIC CAPSULE; RIGHT IMAGE IS THE CORTICAL SHAFT FRAGMENT OF THE TIBIA POST-SAMPLING.

3.3.2 SAMPLE PRE-TREATMENT AND PREPARATION FOR COLUMN CHEMISTRY

The calcined bone fragments were cleaned following the pre-treatment laid out in Snoeck et al. (2015) using 1M acetic acid and ultrasound at the Isotope Laboratory at Durham University or the Acid Laboratory at VUB. This was dependent on the duration of the research visits to Brussels. The majority of the Cleatham samples were pre-treated at the newly constructed BB Lab (Brussels Bioarchaeology) at VUB in the last stage of this project. The following steps were taken during the pre-treatment to remove potential contamination from the surfaces of the cremated bone. The protocols differ according to the type of sample: a) bone fragments, or b) bone powder from petrous parts:

Bone fragments:

- The fragments are placed in a clean glass tube which is labelled with the sample number. These are then filled with miliQ (ultrapure) water and placed into a stand inside the basket of the ultrasonic bath (Fig. 26). Subsequently, they are run three times for a duration of 10 minutes each, with three miliQ rinses in-between to remove loose soil.

FIGURE 26 – GLASS TUBES CONTAINING BONE FRAGMENTS DURING THE PRE-TREATMENT PROCESS IN THE ULTRASONIC BATH.

- After the third 10-minute run, the miliQ water is replaced with 1M acetic acid (1mL per 10mg of sample) and ultrasonicated for another 10 minutes, or until the acid remains clear. During this step, it is important to observe the sample carefully, because the acid may cause increased sample loss.

- After three rinses with miliQ water, the three 10-minute runs using only miliQ water are repeated. At this point, the ultrapure water should remain clear when the bone fragment is submerged and ultrasonicated (Fig.27).

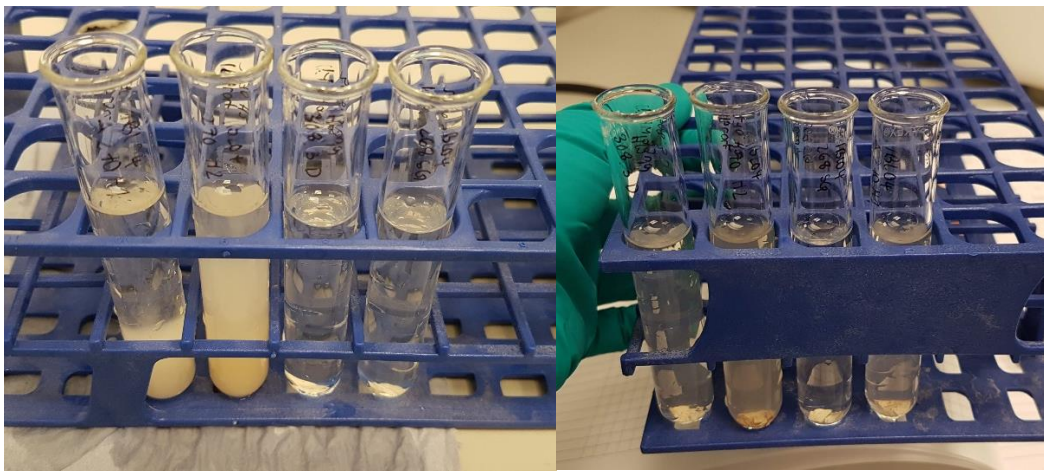

FIGURE 27 – GLASS TUBES WITH BONE SAMPLES AT TWO DIFFERENT STAGES IN THE CLEANING PROCESS.

- The bone fragments are left inside the glass tubes and placed into the oven at 50°C overnight in order to dry out properly.

Bone powder:

The pre-treatment for the sample in powdered form (obtained exclusively from petrous parts) is similar to the one for bone fragments outlined above but has been adapted slightly. As this type of sample derives from the otic capsule and is finite, it is important to minimise the loss of powdered material. The general guidelines followed those published by Veselka *et al.* (2021) with some amendments. These were considered crucial to avoid unnecessary loss of bone powder.

The otic capsule powder inside 2ml treff tubes are submerged in 0.1M acetic acid up to the 2ml line and closed. After a shake to stir up the material, the tubes are allowed to rest for 12 minutes and then transferred to a centrifuge for 10 minutes at 4000 rpm. A pipette is used to remove the acid from the sample tubes; the tubes are then filled with miliQ water, shaken up, and placed into the centrifuge for 3 minutes at 4000 rpm. The miliQ rinse is repeated three times in total, upon which the tubes are opened, lightly covered up (allowing for evaporation of remaining water) and placed into the oven at 50°C overnight.

After all the samples have had time to dry out completely, the bone fragments are powdered down in a cleaned marble mortar (Fig. 28). Once all samples are in powdered form, they are treated the same during the weighing step, where 10-15mg per sample are separated into pre-cleaned and labelled Teflon beakers (Fig. 28).

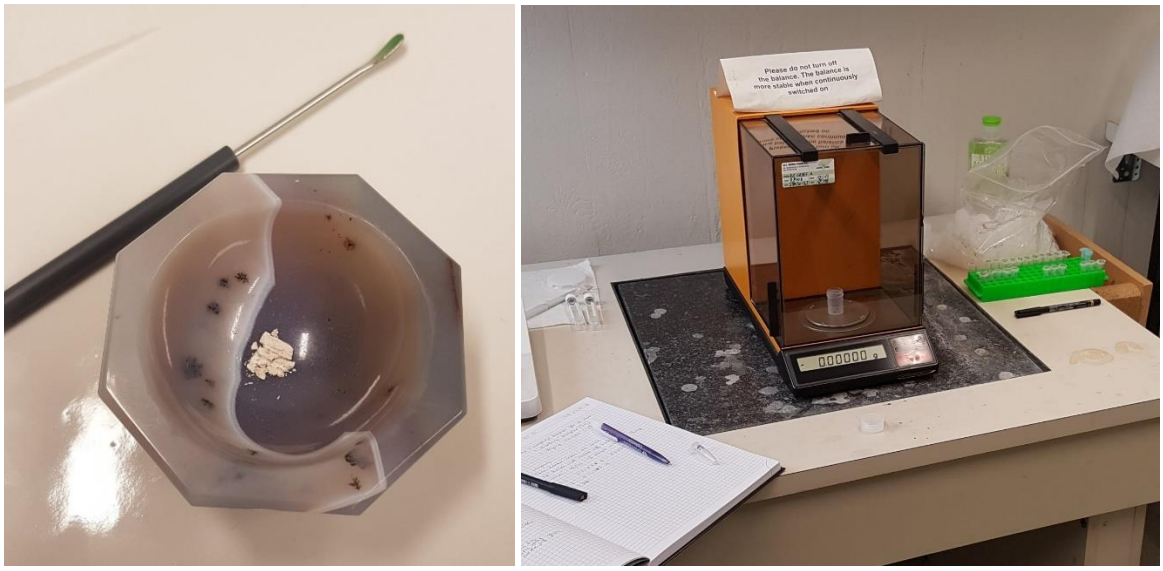

FIGURE 28 – PRE-TREATED BONE FRAGMENT DURING THE POWDERING PROCESS USING A MORTAR AND PESTLE; RIGHT IMAGE SHOWS THE SCALES USED FOR THE MEASURING OF BONE POWDER INTO TEFLON BEAKERS FOR THE SR ISOTOPE COLUMNS.

Notes:

a) The resulting powder should be as finely ground as possible if measurements are taken with the FTIR (at which point the sample has to pass through a 25micron sieve). Note that FTIR results are not included in this thesis and they will be published elsewhere.

b) Caution should be taken during the weighing out of otic capsule material, as these have proven in some measurements to be low in Sr. To be on the safe side, it is advisable to weigh out powder more generously, between 15-20mg.

3.3.3 PLANT SAMPLES

For each case-study site, the plant sub-samples were homogenised by type to a total number of 18 (three per sampling location; six sampling locations per case-study site) in the laboratory facilities at the VUB in Brussels. An amount of 500mg was used for this process. The plant material was then transferred into Microwave cartridges and 4mL of subboiled 14M HNO_3 were added (Fig. 29). The microwave (Milestone UltraWave) was run for 45 minutes after which the cartridges were removed and opened. 1mL subboiled 23M HF was added and placed in the microwave again for 45 minutes to complete the dissolution. The

solution was then transferred back into the Teflon beakers and left to dry on a hotplate at 100°C.

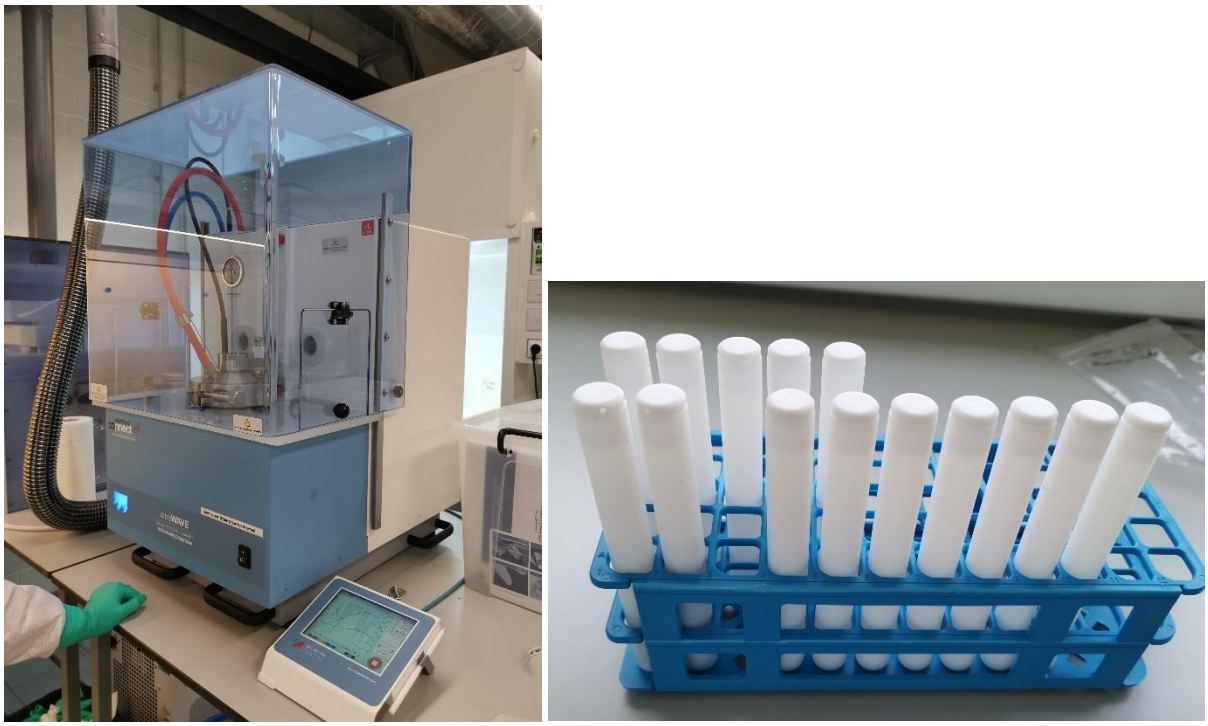

FIGURE 29 – LEFT IMAGE SHOWS THE MICROWAVE USED FOR THE PROCESSING OF PLANT SAMPLES; RIGHT IMAGE FEATURES THE HYDROPHOBIC CARTRIDGES USED FOR THE MICROWAVE.

3.3.4 SR COLUMN CHEMISTRY

The weighed samples were digested in 1mL of subboiled 14M HNO_3 and after dissolution, placed on a hotplate at 100°C until dry. *From this point onwards, plant and bone samples are treated in the same way.* Subsequently, 2.5ml of 7M HNO_3 was added to dissolve the sample. The Teflon beakers were ultrasonicated for 20 minutes, after which 0.5ml of each sample were separated into clean, labelled treff tubes for concentration measurements.

After columns are set up and filled with resin, they are rinsed once with 2M HNO_3, and twice with 1ml of 7M HNO_3. This is followed by sample loading of the columns in 0.5ml increments (Fig. 30). The Teflon beakers are then filled with 1ml of 7M HNO_3, which is also loaded into the columns. This step ensures the complete utilisation of all sample material.

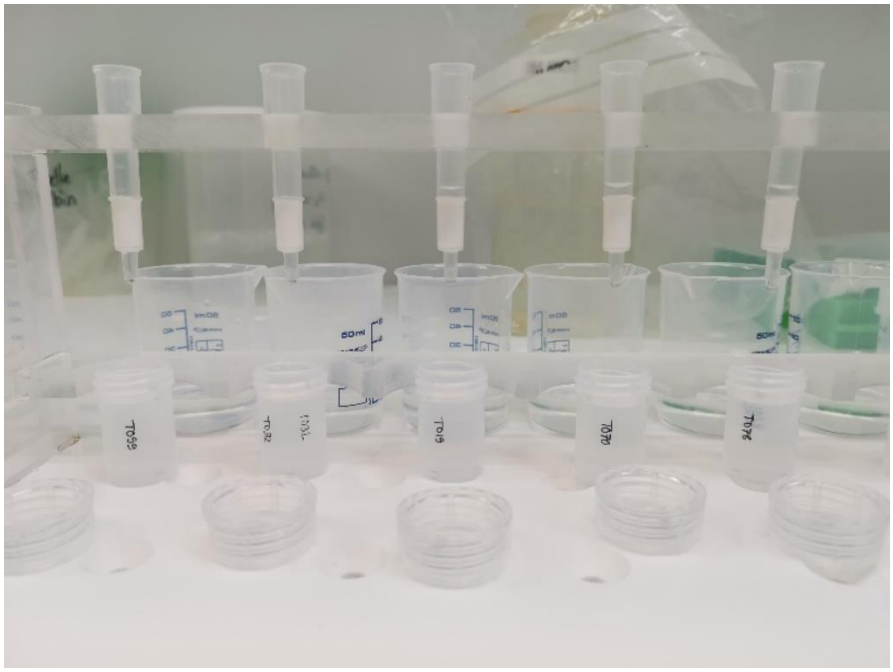

FIGURE 30 – STRONTIUM COLUMNS SET UP DURING CHEMISTRY.

At this point, the Teflon beakers are filled with 0.05mL of 14M HNO_3 and placed on the hotplate at 100°C, closed, in order to undergo cleaning before sample collection. While the beakers are resting on the hotplate, the columns are rinsed 4 times with 1ml of 7M HNO_3. After the third rinse, the beakers on the hotplate are emptied and allowed to dry on the hotplate. Sample elution is accomplished by replacing the waste beakers underneath the columns with the correct Teflon beakers and using 0.05M HNO_3 (6 rounds of 1ml). After this, the Teflon beakers holding the sample elution are placed on the hotplate at 110°C overnight in order to evaporate completely (Fig. 31). Once dry, they can be closed up and are ready for MC-ICP-MS measurements.

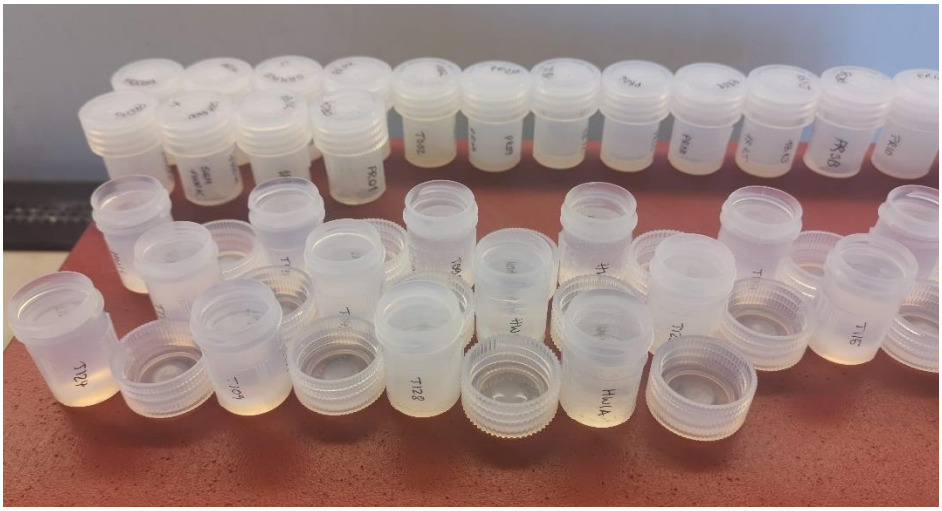

FIGURE 31 – BEAKERS PLACED ON THE HOTPLATE FOR DRYING OF SAMPLES POST-COLUMN CHEMISTRY.

3.3.5 MEASUREMENTS OF THE SAMPLES

Samples were measured on a Nu Plasma MC-ICP Mass Spectrometer (Nu015 from Nu Instruments, Wrexham, UK) at the Université Libre de Bruxelles (ULB).

Repeated measurements of the NBS987 standard were taken in the course of this study and yielded $^{87}Sr/^{86}Sr$ = 0.710246±0.000045 (2SD for >300 analyses). This result is sufficiently consistent with the mean value of 0.710252±0.000013 (2SD for 88 analyses) obtained by TIMS (Thermal Ionization Mass Spectrometry) instrumentation (Weis *et al.* 2006) for the purposes of this study. Each sample measurement was normalised using a standard bracketing method with the recommended value of $^{87}Sr/^{86}Sr$ = 0.710248 (Weis et al. 2006). Procedural blanks were considered negligible (total Sr (V) of max 0.02 versus 7–8V for analyses, i.e. ≈ 0.3%). The $^{87}Sr/^{86}Sr$ value for each sample is reported with a 2σ error (absolute error value of the individual sample analysis – internal error).

Measurements of the Cleatham samples were on the Nu Plasma 3 MC-ICP-MS (BB-Lab, VUB, Fig. 32) following the same protocol.

FIGURE 32 – NU PLASMA 3 MC-ICP MASS SPECTROMETER IN THE BB-LAB AT VUB IN BRUSSELS.

3.3.6 SR CONCENTRATIONS

The Sr concentrations were measured at VUB, and details on the runs are described below.

Fractions of the bone digested samples are used to determine Sr and Ca concentrations in the sample digests with a Thermo Scientific Element 2 sector field ICP mass spectrometer at the Vrije Universiteit Brussel (VUB), Belgium, in low (^{88}Sr) and medium (^{42}Ca) resolution using Indium (In) as an internal standard and external calibration versus various reference materials (SRM1400, CCB01). The strontium concentrations were calculated by normalizing the calcium data to 40%. The analytical precision of the procedure outlined above is estimated through repeated digestion and measurement of two internal bioapatite standards (ENF and CBA) and does not exceed 5% (1SD, n = 33 for CBA and n = 5 for ENF).

4 INGLEBY BARWICK LOW LANE

4.1 CONTEXT

The cemetery at Ingleby Barwick dates to the late 5th to 6th centuries and contains both inhumation and cremation burials. By definition, and in consideration of the frequency of both rites, Ingleby Barwick qualifies as a mixed-rite cemetery. To this date, 15 distinct cremation burials have been unearthed in the form of urns or urn-fragments, alongside 17 inhumation burials. The burials were recovered from two distinct areas, thus suggesting that the burial rites were either chronologically sequential or kept spatially separate at Ingleby Barwick (see Fig. 33). Unfortunately, due to the acidic conditions of the soil, almost no skeletal material survived of the individuals who were inhumed. This destructive process did not extend to grave goods to the same degree, and it was possible to recover a small number of these from six of the grave cuts. The items included jewellery such as brooches, wrist-clasps, fragments of textiles attached to the former, beads (amber and glass), and other metal objects. To date, two phases of archaeological work have taken place at Ingleby Barwick, first in 2003 and then in 2004. An evaluation was undertaken after a planning application had been submitted for the development on site for a school with additional playing field.

Archaeological traces of activity are neither restricted to the field at Low Lane itself, nor the 6th/7th centuries. The presence of a Bronze Age cemetery approximately 250m east of the site at Windmill Fields, Stainton, had been established previously in 1996/1997 (SMR 3536), as well as that of a prehistoric settlement (SMR 4028), and a single cremation burial (SMR 4027) (ASDU 2004; Grahame 2004). An important indicator for the archaeological potential of the area was re-enforced with the discovery of the adjacent prehistoric settlement at Little Maltby Farm in 1998 (ASDU 2004: 17, Appendix 4). More recently, excavations have revealed an extensive Iron Age and Romano-British settlement including a large enclosure ditch and several round-houses to the immediate northwest of Low Lane (ASDU 2019,

2020). Further north, at Quarry Farm, ASDU excavated a Roman villa complex which appears to have been used into the 5th century. Thus, it is clear that the area has been settled and farmed by people for centuries before the existence of the cemetery at Ingleby Barwick. In terms of contemporaneous sites, most records in the HER (Historic Environment Record) are isolated burials such as the one found at High Lane in Maltby (SMR 1376) and Yarm (cremation burial; SMR 491), but also sculpture fragments, isolated finds of jewellery and weapons. These are scattered across the wider area around Teesside, and along the various side-arms of the river, hinting at further burials and settlements. One early medieval settlement has possibly been identified at Kirklevington, approximately 3km south-southwest of Ingleby Barwick (ASDU 2016). Other close settlements and potential settlements are noted at Yarm, Eaglescliffe, and Stainsby Hall.

During the evaluation in December 2003, which saw Archaeological Services Durham University (ASDU) opening seven trenches after consideration of the geophysical (magnetic) survey, a number of features including two cremation burials were excavated (ASDU 2004). One of these cremation burials was recovered from Trench 4 and provisionally given a prehistoric (Bronze Age) date, the other was considered 'Saxon' based on the remains of the urn (Trench 6 – F23). One of the ditches in Trench 5 contained a metal spearhead (no SF number, [55] – fill of ditch F56) which was also dated to the latter period. The presence of prehistoric as well as medieval pottery suggests repeated or continued activity on the site for several periods (ASDU 2005). Most of the cemetery was then uncovered in the open-area excavation ahead of development in 2004. Grey-literature reports of the work undertaken are:

1. Noel (2003) – GeoQuest Geophysical Survey of area proposed for development.

2. ASDU (2004) – Report 1062, report of archaeological evaluation from 2003; contains recommendations for open excavation of area under development (based on GeoQuest results).

3. Grahame (2004) – Tees Archaeology Desk Based Assessment and Evaluation.

4. ASDU (2005) – Report 1200, report of excavation undertaken in 2004, contains recommendation for full analysis of recovered material and human remains.

5. Julie Peacock BSc dissertation 2011 – osteological analysis of the cremations.

Unfortunately, no post-excavation report was ever produced for Ingleby Barwick, although conservation of the small finds and cremation deposits was undertaken by Archaeological Services. The urns were excavated in spits in the environmental laboratory at Durham University by Janet Beveridge, a Field Archaeologist working for ASDU. ASDU also encouraged the osteological analysis of the cremated remains in a BSc dissertation by Julie Peacock in 2011, who completed a summary report on the remains. For this study, the remains were re-examined during the sample selection process. Where information is used from Peacock (2011) it is indicated by reference.

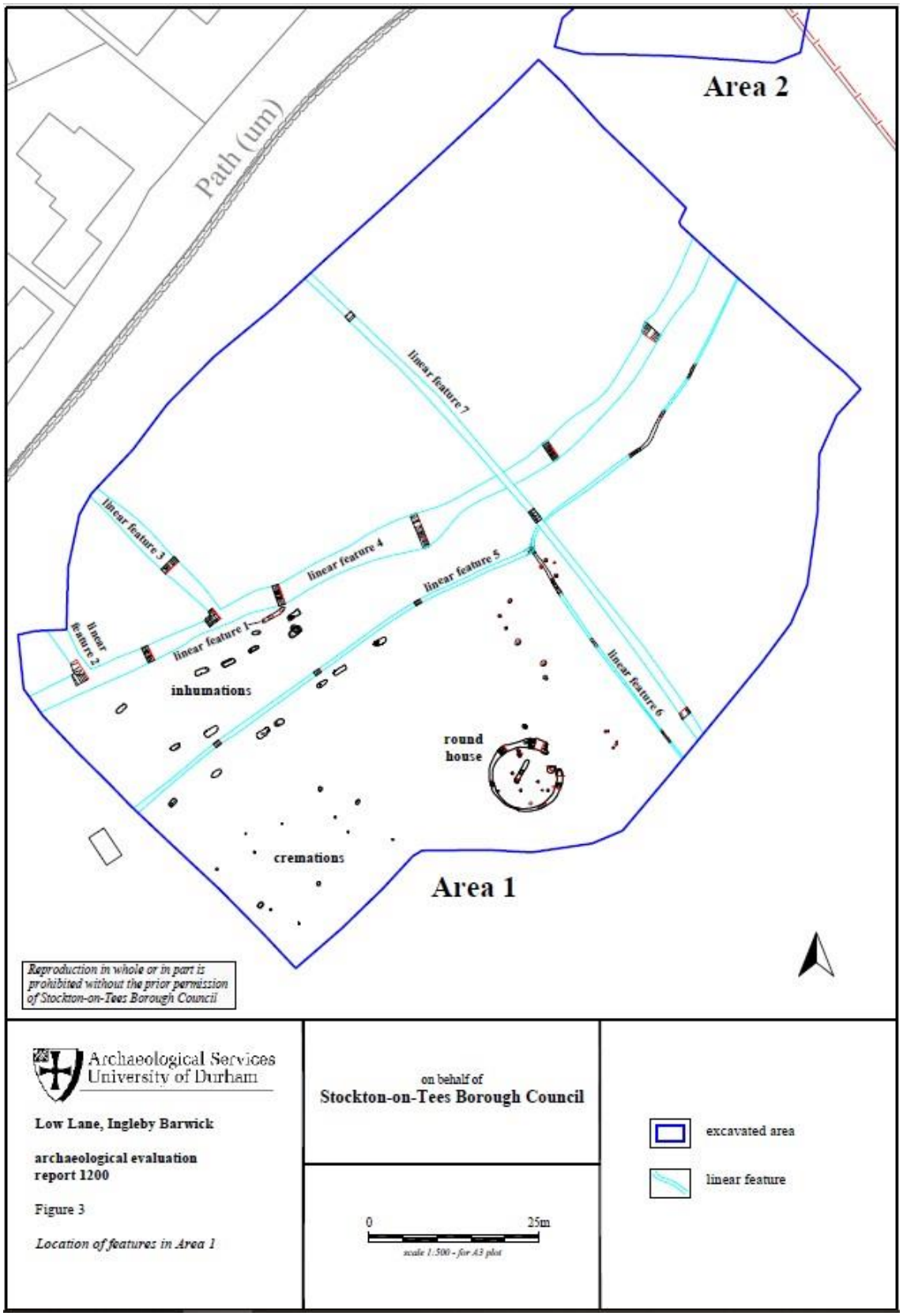

FIGURE 33 – PLAN OF EXCAVATED AREA AT INGLEBY BARWICK. PLAN FROM ASDU 2005, © STOCKTON-ON-TEES BOROUGH COUNCIL.

It is almost certain that the excavation in 2004 did not encompass the full extent of the cemetery based on two observations: a) the fact that the evaluation in 2003 was located slightly outside of the excavated area in 2004 and contained a further cremation, and b) the excavation was ultimately restricted to the area affected by development – ergo, it is more than likely that there are further burials, as well as more evidence for earlier activity at the site. Almost all of the cremation urns were truncated (Fig. 34) and during conservation it was only possible to completely reconstruct one cremation urn (Δ268, Fig. 35).

FIGURE 34 – EXAMPLE OF THE LEVEL OF TRUNCATION AT INGLEBY BARWICK. URN WITH CREMATION DEPOSIT IN SITU. PHOTOGRAPH COURTESY OF ASDU.

The other urns were also cleaned, consolidated, and reconstructed during post-excavation and for most of these vessels it was possible to reassemble at least the base and lower part of the body. However, since a majority of early medieval urns are decorated on the superior part of the body, it was not always possible to determine whether these were

stamped/decorated or not. In total, it was possible to determine that at least three of the urns featured stamp decorations (Δ8, Δ268, Δ274), although this number may originally have been higher. The fact that truncation at the site was substantial likely obscures the true number of stamped vessels.

FIGURE 35 – URN FROM CREMATION BURIAL 268 (F234). © JEFF VEITCH, DURHAM UNIVERSITY.

4.1.1 AIMS OF THIS STUDY

With only a limited number of burials (15 cremation burials and 17 inhumations), it is apparent that the cemetery at Ingleby Barwick is a relatively small site. Fundamentally, its importance stems from its northern location combined with its early date (5th to early 7th centuries). It is fairly unique in this respect and was therefore chosen as a case site for this study. Since no radiocarbon analysis has been done on the cremated remains, it is very

difficult to establish a chronology for the cremation burials. In the first instance, it was considered pertinent to conduct an osteoarchaeological analysis to complement and inform the Sr isotope analysis. Appendix A.6 contains a detailed catalogue of the cremated remains, but some of the results are also discussed in this chapter.

In summary, the aim for this chapter was firstly to establish a clear picture of the burial population at Ingleby Barwick Low Lane, because this has not yet been done. This somewhat differentiates this chapter from chapters 5 and 6 in terms of purpose. Secondly, the aim was to explore, using the isotopic analysis of Sr, whether there are indications for mobility of people or animals to the area from elsewhere. By extension, it was an objective to use this information to extend the discussion of theoretical implications to the phase before death of the individuals, thus making it possible to closer examine individual relationships and the choices made during the funeral and the commemoration process.

4.1.2 Associated finds

The following information was drawn together from partial conservation reports, post-excavation assessments by ASDU, and the excavation report which unfortunately has not been written up into a post-excavation analysis report because of lack of financial provisions. The essential conservation work was undertaken by Vicky Garlick and Jennifer Jones for ASUD, and all the images and radiographs are theirs and ASDU's.

Both the trial trenching and the excavation brought forth a range of artefacts, and these were predominantly related to the inhumation graves (Table 3) – six out of the 17 burials contained *in situ* artefacts, and these have been dated to the late 5th and early 6th centuries (ASDU 2005: 10). A total of 249 beads were recovered alongside 16 fragments of worked bone, and 22 copper alloy (CuA) fragments. The beads were mostly fashioned out of amber and in relatively poor condition upon excavation (n=174). A smaller number of beads was made of glass (gold-in-glass type, n=74) and rock crystal (n=3). Amongst the conserved metal finds were fragments of brooches, buckles, wrist clasps, and knives. Inhumation

graves 5 [F101], 6 [F99], 15 [F97], and 17 [F45] all included extensive grave goods, more so than any other grave.

In contrast with the inhumation burials, grave/pyre goods were only found in two/three cremation burials (3 and 12/13 double burial) out of 15 (Table 4). It is likely that this was in part due to the heavy truncation sustained by most of the urns, which led to loss of remains and possibly also any grave goods deposited in the top third of the vessels. The deposition of artefacts on top of the cremated remains was observed in other early medieval cremation cemeteries – for example at Cleatham.

TABLE 3 - TABLE OF OBJECTS FOUND WITH THE INHUMATION BURIALS AT INGLEBY BARWICK.

GRAVE	BEADS	KNIFE	TWEEZERS	BROOCH	COMB	PIN	WRIST CLASPS	BUCKLE	SHIELD BOSS	CUA OBJ	FE OBJ	RING	TACK	NO FINDS
1										1				
2														1
3														1
4														1
5	16			2		1	1					1		
6	106			2										
7														1
8	1													
9														1
10	1										1			
11														1
12											1			
13				1				1	1		2			
14														1
15	41			3										
16	2	1							1					

17	78							2		7	8		1		
TOTAL	245	1	0	8	0	1	1	3	2	8	12	1	1	7	

TABLE 4 – TABLE OF OBJECTS FOUND WITH THE CREMATION BURIALS AT INGLEBY BARWICK. △ INDICATES SMALLFIND (SF) NUMBERS GIVEN TO THE BURIALS IN THE REPORTS/ASSESSMENTS FROM ASDU.

CREM. BURIAL (ASDU)	SF (ID)	BEADS	KNIFE	TWEEZERS	BROOCH	COMB	PIN	WRIST CLASPS	BUCKLE	SHIELD BOSS	CUA OBJ	FE OBJ	RING	TACK	NO FINDS
1	△296														1
2	△6														1
3	△268			1											
4	△5														1
5	△9														1
6	△270														1
7	△273														1
8	△11														1
9	△8														1
10	△271														1
11	△7														1
12	△274					1									
13	△274	1			1	1									
14	△272														1
15	△10														1
TOTAL		1	0	1	1	2	0	0	0	0	0	0	0	0	12

4.2 RESULTS

To understand the results discussed below, it should be noted that the author used the small find (SF) numbers of the cremation burials as identifiers throughout this study. For their report, ASDU has also given the burials specific burial numbers, which are listed for comparison in Table 5 below.

4.2.1 Condition and Preservation

The preservation of the cremated remains at Ingleby Barwick was poor, as 11 of the urns were severely truncated. This also had a noticeable impact on the presence and weight of bone, as can be seen in Table 5 below (Peacock 2011). The maximum weight was noted for △270 (2189.7g). During the analysis, it was not possible to identify human bone in this deposit with any degree of certainty. However, the presence of a horse was confirmed (Louisa Gidney: *personal communication*) and several smaller mammals were likely present. It was therefore determined that this urn is an accessory vessel to △273, which was the second heaviest deposit and weighed 1537.21g. Cremation burials △5, △6, and △7 could not be sampled because there was not enough bone present to identify whether the remains belonged to a human or animal. This was almost certainly a result of the heavy truncation on site. In order to protect the remains from further breakage, they were not re-sieved or re-weighed for this study. Table 5 below lists the weights recorded for the cremated material by Peacock. Upon excavation of Δ274 it was determined that the burial consisted of two individuals (ASDU burial numbers 12 and 13). According to the excavation report, the urn of burial 12 was found immediately below a deposit containing urn sherds and other molten fragments of pyre goods. This upper deposit is what was described as burial 13. During the analysis, it was noted that the cremated bone from burial 13 was poorly cremated when compared to the remains in burial 12. While this may indicate a separate burial of a second individual, it could also suggest that the vessel sherds and pyre goods stem from the same pyre and were collected separately. One suggestion to support this may be the remains of a bone comb which were found in spits from both burials. As

there are no duplicate parts amongst the remains from both deposits, it was not possible to exclude that Δ274 represents the same individual.

TABLE 5 – WEIGHT OF INDIVIDUAL CREMATION DEPOSITS (JP = PEACOCK 2011) AND NUMBERING SYSTEM USED IN REPORT AND DURING EXCAVATION (ASDU 2005). HIGHLIGHTED DEPOSITS WERE SAMPLED FOR SR ANALYSIS.

ID	ASDU	weight g (JP)
△5	4	0.02
△6	2	3.32
△7	11	0.33
△8	9	707.8
△9	5	244.1
△10	15	189.1
△11	8	661
△268	3	1427.1
△269	1	832
△270	6	2189.7
△271	10	34.2
△272	14	378.93
△273	7	1537.21
△274	12/13	930.26

4.2.2 AGE

Through analysis it was possible to determine that six of the individuals buried in the vessels were adults, and four were non-adults (Fig 36). One of the adults (△272) may have been an adolescent or younger adult based on the presence of a tooth root with a slightly open apex, while most of the remaining bone and the joint appeared to belong to an adult. Duplicate bone elements/landmarks were not identified, and it is therefore considered to reflect an MNI of one. This individual will be treated as adult throughout this report.

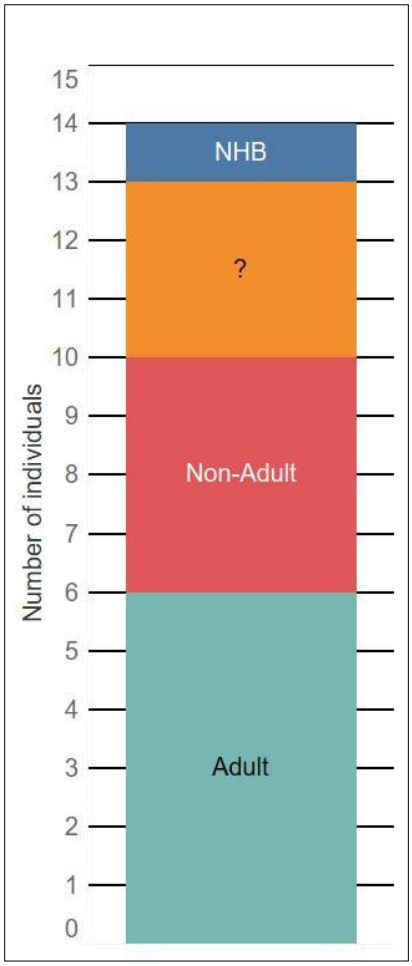

FIGURE 36 – AGE PROFILE OF CREMATED INDIVIDUALS AT INGLEBY BARWICK (EXCLUDING ONE BURIAL FROM THE EVALUATION IN 2003). NHB – NON-HUMAN BONE.

4.2.3 SEX

Two of the cremated adults were assigned a tentative sex (Fig. 37). Based on the 'gracile' appearance of the bone fragments, and the straight slope of the medial aspect of the frontal bone, △11 may be sexed possible female (F?) – although this is a hesitant estimate because of the presence of only one available cranial trait. The other sexed individual was recovered from △268 and, based primarily on the external occipital protuberance, is considered a possible male (M?).

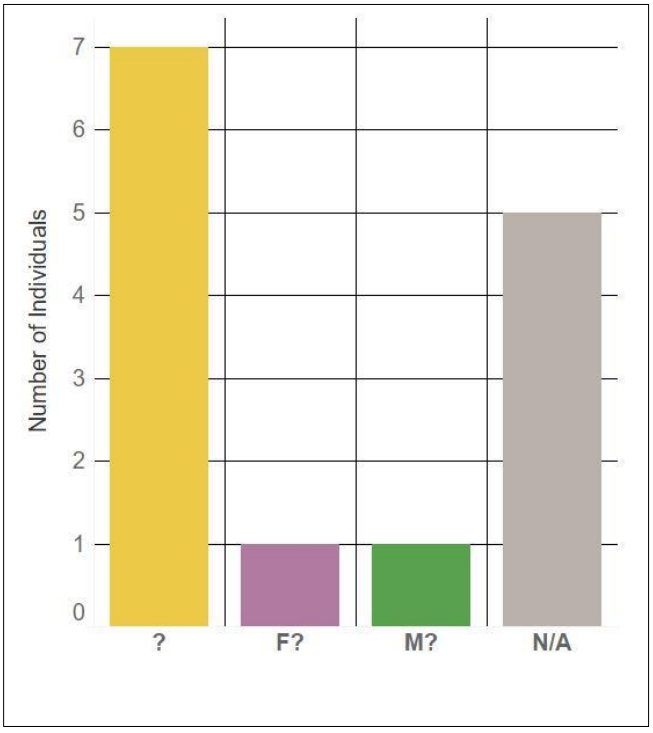

FIGURE 37 - SEX PROFILE OF CREMATED INDIVIDUALS AT INGLEBY BARWICK (EXCLUDING ONE BURIAL FROM THE EVALUATION IN 2003).

4.2.4 NUMBER OF INDIVIDUALS

In terms of cremation burials, 15 discreet urns, or partial urns, were excavated in 2004. One further urn was recovered in the evaluation in 2003. However, due to the limited remains in urns △5, △6, and △7, it was not possible to determine whether they belonged to humans or animals. As discussed above, there are indications that △274 may belong to the same individual, so in terms of numbers of individuals this is counted as one. Usually, a MNI is determined for reports on cemeteries which is based on duplicate skeletal elements which occur most frequently. For cremation burials this is not necessarily sensible. The issue is fundamentally related to logical concerns: If the cremation burial has been truncated in the ground and is therefore incomplete, and the remains are also heavily fragmented, it is highly unlikely that the same skeletal element is represented for each burial. The number would be unrealistically low in most cases and it makes sense, therefore, to establish the MNI per

burial/urn rather than per cemetery (as is common in inhumation cemeteries). At Ingleby Barwick, the number of individuals for the cremation burials is therefore at least 11 in terms of humans (including one adult from the evaluation in 2003), and these have been buried alongside at least 3 animals.

4.2.5 PATHOLOGY

Table 6 below contains the summary information which was gleamed from the osteological analysis. It is important to note the bias created by the cremation process, whereby many pathologies can no longer be observed due to destruction of material (dentition) or are obscured by fragmentation, warping, or other surface change. Pathologies were observed for five of the individuals, and most of these consisted of woven and lamellar new bone formations on external bone surfaces of the long bone diaphyses. This periosteal reaction is non-specific and may be part of a large number of disease processes. Cribra orbitalia (CO) was observed in the orbital roof of one juvenile, △9, although this was slight in expression. One of the adults (△273), had osteoarthritis present in one of their joint surfaces and this was diagnosed through the presence of eburnation.

TABLE 6 – SUMMARY TABLE OF OSTEOLOGICAL ANALYSIS FOR INGLEBY BARWICK.

ID	ASDU	AGE	SEX	SAMPLE	PATHOLOGY
△5	4	*	*	*	*
△6	2	*	*	*	*
△7	11	*	*	*	*
△8	9	Adult	*	Femur (Humerus)	Normal striations on long bone fragments
△9	5	Non-adult/OJ	N/A	Femur/Tib/Humerus	Slight CO in right orbit roof; possible woven bone on external surface of long bone fragment
△10	15	Non-adult/older	N/A	Tibia/Humerus	None observed

△11	8	Adult	F??	Femur; Rib	Normal striation on some long bone fragments; woven bone observed on visceral surface of one central rib; light periosteal reaction on radius/ulna shaft
△268	3	Adult	M??	Femur	sesamoid bone?, DD: osteochondritis dissecans fragment?
△268	3	Sheep/goat	*	Diaphysis	-
△269	1	Non-Adult (<△9, but not much)	N/A	Femur	Normal striation on some long bone fragments; woven and lamellar new bone on at least 15 long bone fragments (periosteal reaction)
△270	6	Horse	*	Sesamoid	None observed
△271	10	Non-Adult/YJ	N/A	-	None observed
△272	14	AO/Adult	*	Tibia/Humerus	Normal lamellar striations on long bone diaphysis fragment
△272	14	Sheep/goat	*	distal tibia shaft	-
△273	7	Adult	*	Tibia/Humerus	Strong lamellar striations on long bone fragment; one joint surface fragment with eburnation – OA
△274	12/13	Adult	*	Femur/Humerus	None observed

It was possible to sample remains from 12 individuals – nine humans and three animals - out of ten of the 14 burials (15 including burial from the evaluation in 2003). The plan below (Fig. 38) shows the location of these with associated burial and SF numbers. Unfortunately, no complete or semi-complete petrous portions were found amongst the remains, which meant that only other skeletal elements could be sampled for analysis. These are listed in Table 6 above.

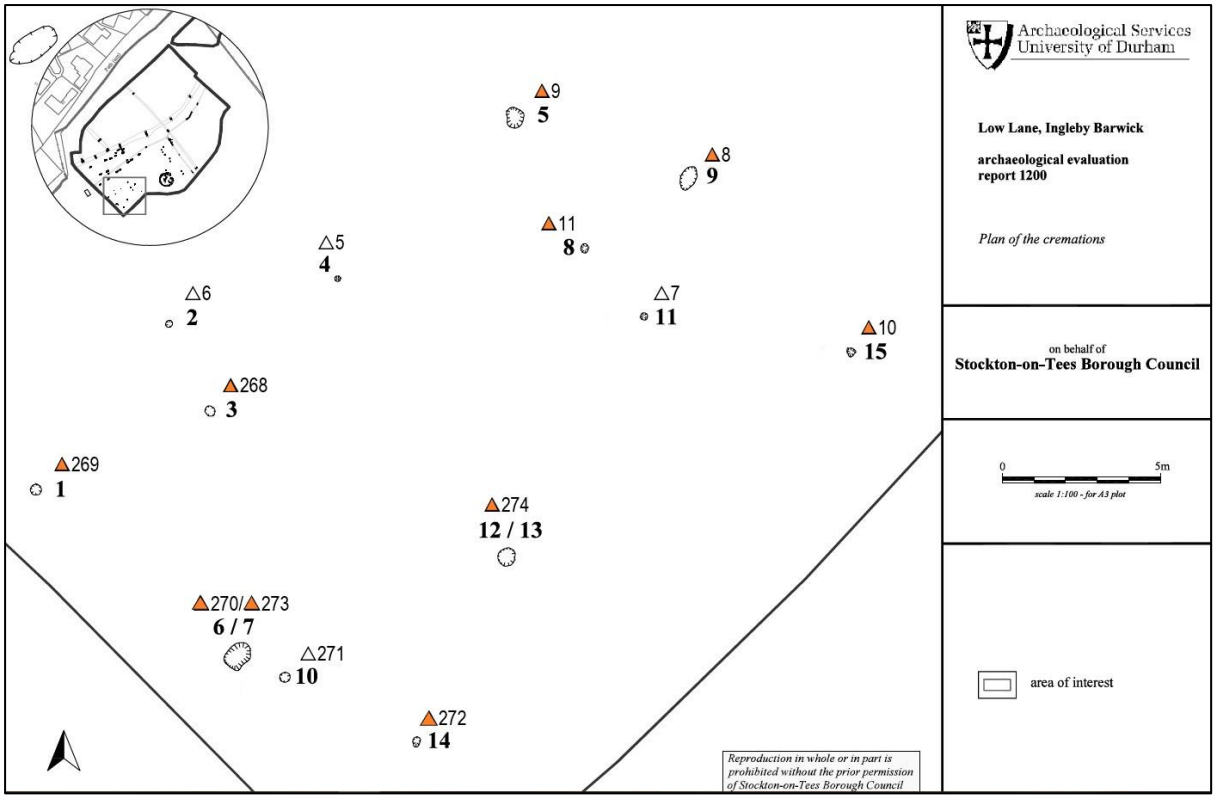

FIGURE 38 – PLAN OF CREMATION BURIALS IN SOUTHWEST AREA OF SITE. ORANGE HIGHLIGHTS INDICATE SAMPLED CREMATION DEPOSITS. REPRODUCED FROM *ASDU (2005; FIGURE 14)* WITH MODIFICATIONS.

4.2.6 SR ISOTOPE ANALYSIS

4.2.6.1 PLANTS

The results for the plant samples from a 25km catchment around Ingleby Barwick are listed in Table 7 below. Included in this table are nine $^{87}Sr/^{86}Sr$ ratios from Evans *et al.* (2010; 2018), which have been used to supplement the new samples from this study. The maximum $^{87}Sr/^{86}Sr$ was measured in the grass sample from sample location 2 (2-a: 0.71834). The minimum $^{87}Sr/^{86}Sr$ derived from the tree at sample location 4 (4-b: 0.71008). The highest variability is caused by the grass samples, two of which are outliers when compared with the associated shrub and tree samples from the same location (2-a and 6-a). When the two outliers are excluded, the highest $^{87}Sr/^{86}Sr$ values measure >0.7130, and come from the Triassic sandstone at Sample location 3. The Sample locations 1 and 4 have been combined in the table as they represent the same geological formation.

TABLE 7 – INGLEBY BARWICK LOW LANE -87SR/86SR RESULTS AND ASSOCIATED 2SE FOR PLANT SAMPLES.

Sample location	Geological Formation	Sample type	Sample ID	$^{87}Sr/^{86}Sr$	2 SE
1+4	Permian mud-, silt-, and sandstone	Grass	1-a	0.711886	0.000008
			4-a	0.711992	0.000008
		Shrub	1-c	0.711573	0.000012
			4-c	0.710339	0.000009
		Tree	1-b	0.711969	0.000010
			4-b	0.710080	0.000010
2	Late Triassic/Mid Jurassic lime-, and sandstone (Lias Group)	Grass	2-a	0.718341	0.000021
		Shrub	2-c	0.710562	0.000010
		Tree	2-b	0.710483	0.000008
		Plant	Catt-V-08	0.709680	not available
3	Triassic sandstone and conglomerate	Grass	3-a	0.713230	0.000009
		Shrub	3-c	0.712999	0.000007
		Tree	3-b	0.712570	0.000018
		Plant	Catt-V-09*	0.712010	not available
			Catt-V-10	0.713830	not available
			Catt-V-11	0.710010	not available
			Catt-V-12	0.709030	not available
			Catt-V-13	0.709470	not available
			Catt-V-14	0.709580	not available
5	Mid Jurassic sand-, silt-, and sandstone (Ravenscar Group)	Grass	5-a	0.710116	0.000010
		Shrub	5-c	0.711500	0.000009
		Tree	5-b	0.710514	0.000008
		Plant	Catt-V-07	0.710160	not available
6	Late Permian dolomitised limestone and dolomite (Zechstein Group)	Grass	6-a	0.715136	0.000011
		Shrub	6-c	0.711467	0.000011
		Tree	6-b	0.711866	0.000010
		Plant	Catt-V-15	0.710650	not available

4.2.6.2 CALCINED HUMAN AND ANIMAL BONE

For Ingleby Barwick, sampling mostly consisted of single-skeletal elements, either long bone diaphyses or rib fragments. Animals were also included in the analysis, but only where parts could be identified without a doubt. Some of the samples were measured for $^{87}Sr/^{86}Sr$ two or three times to look at variation in the same sample, and these are presented

as average $^{87}Sr/^{86}Sr$ in the table below. Where an average was calculated this is indicated by (**) or (***), depending on whether two or three measured ratios were averaged, and the standard deviation is given in the table(Table 8). The same procedure was followed for the Sr concentrations [Sr]. The highest $^{87}Sr/^{86}Sr$ was measured in the tibia shaft fragment of a sheep/goat, which was identified amongst the remains of △272 (0.7130). The lowest $^{87}Sr/^{86}Sr$ derived from one of the adults - △8 (0.7106). Sr concentrations ranged from 62.7ppm in △8 to 319.5ppm in △270, the horse in the accessory vessel.

TABLE 8 - SUMMARY TABLE OF INGLEBY BARWICK HUMAN AND ANIMAL BONE SAMPLES WITH 87SR/86SR RESULTS. (SR PPM RESULTS ARE NORMALIZED TO 40 WT% CA).

Sample ID	Age	Sample type	$^{87}Sr/^{86}Sr$	SD	2SE	Sr ppm
△8 (***)	Adult	Femur (Humerus)	0.710574	0.00009	0.000010	63
△9	Non-adult/OJ	Femur/Tib/Humerus	0.711930	-	0.000008	67
△10	Non-adult/older	Tibia/Humerus	0.711733	-	0.000008	74
△11 (**)	Adult	Femur	0.710567	0.00015	0.000008	77
		Rib	0.712675	0.00001	0.000009	155
△268	Adult	Femur	0.711517	-	0.000008	79
		Rib	0.711764	-	0.000007	77
△268_SG	Unknown	Sheep/goat	0.711508	-	0.000009	300
△269	Non-Adult (<△9, but not much)	Femur	0.711450	-	0.000008	90
		Rib	0.711488	-	0.000009	96
△270 H (**)	Unknown	Horse	0.712514	0.00001	0.000009	320
△272 (**)	AO/Adult	Tibia/Humerus	0.711732	0.00030	0.000011	67
△272_SG	Unknown	Sheep/goat	0.712977	-	0.000010	228
△273	Adult	Tibia/Humerus	0.711536	-	0.000008	77
△274 (**)	Adult	Femur/Humerus	0.711432	0.00004	0.000014	75

4.3 DISCUSSION

4.3.1 PATHOLOGY

Keeping in mind the bias issue with cremated bone whereby some areas of the skeleton are subject to greater destruction than others, by far the most frequently observed pathological condition was the presence of new bone formation on the surfaces of long-bones. In some cases, this was noted to be within the normal range, or potentially well-healed and smoothly incorporated into the cortical bone surface. However, a more acute disease process was evident in four people where woven or transitional new bone was observed. In these cases it is possible to speak of *periostosis* (White & Folkens 2005: 424). Woven bone are deposits of disorganised new bone under the periosteum, the lining which surrounds bone surfaces. In a non-cremated state, the deposits are usually grey in colour and often occur at delimited locations and as small foci with sharp margins but can also extend over larger surfaces. They indicate locations of trauma, tumours or inflammation (systemic or localised) under/at the periosteum and are generally non-specific (Ortner 2008: 196), although observable patterns exist which can be indicative of specific infectious diseases or particular infections such as ulcers and dactylitis (Ortner 2008: 198-199). New bone formation can give an indication of timescales through the appearance of the deposits; as mentioned above, woven bone are markers of an active reaction process at the time of death. In time, new bone can be observed to merge into much more organised structure to eventually become lamellar bone (Brickley & Ives 2008: 23). The presence of the active new bone formation in the case of Ingleby Barwick is an indicator for acute disease. Two of the affected individuals were adults (△11, △273), and two were non-adults (△9, △269). While the expression of the new bone was not extreme or frequent in individuals △9 and △273, it was markedly so in the other two.

FIGURE 39 – LAMELLAR BONE STRIATIONS ON THE TIBIA SHAFT SURFACE OF △11 (POSS. FEMALE ADULT), INDICATED BY RED ARROWS ON EITHER END, EXTENDING OVER AT LEAST THREE FRAGMENTS (C. 8 CM).

FIGURE 40 – IRREGULAR LAMELLAR BONE ON RIB SURFACE OF △11 (POSS. FEMALE ADULT). LOCATION INDICATED BY ARROW.

FIGURE 41 – WOVEN/TRANSITIONAL NEW BONE FORMATION ON ?FEMORAL SURFACE OF △269 (NON-ADULT), APPROXIMATE EXTENT INDICATED BY ARROWS.

FIGURE 42 – FINE NEW BONE FORMATION ON LONG BONE SURFACES OF △269 (NON-ADULT) INDICATING ACTIVE INFLAMMATION.

Cribra orbitalia was observed in slight form in the right orbit of △9, a non-adult (likely older juvenile). It was not possible to note the exact location and extent as the entire orbit was not present. This pathological condition is frequent in archaeological populations, and it is often seen by bioarchaeologists as an indicator for metabolic 'stress'. Previously, the orbital lesions have been associated with iron deficiency anaemia (see Aufderheide & Rodríguez-Martín 1998: 350-351; Roberts & Manchester 2010: 524), but this has been called into question by researchers since (Waldron 2009: 137; Walker *et al.* 2009; White *et al.* 2012: 449-450; Mann & Hunt 2013: 28). Other suggestions include the possibility of causation by haemolytic anaemia (Buckley 2006), which, in turn, has been shown to be associated with malaria (Roberts & Manchester 2010: 554; Gowland & Western 2012; although see Cole & Waldron 2019). Other connections have for example been made with leprosy where chronic eye-infection may cause porotic lesions (or small foramina) in the superior orbit (Ortner 2008: 201-203). Because there is ongoing debate about the cause for and aetiology of cribra orbitalia, it shall suffice here to report on the presence of fine foramina in the superior orbit of one non-adult at Ingleby Barwick. It is possible that this indicates the presence of physical 'stress' in the form of an anaemic response, or as part of another disease process. The cremation burial was found to include a bone fragment with a possible woven bone deposit (see above) which may also indicate or trauma or systemic stress. The possibility of malaria was explored based on reports of outbreaks as mapped by Gowland & Western (2012). In Fig. 45 below, crude prevalence rates of Cribra orbitalia in early medieval inhumation cemeteries (including at Norton) are plotted next to areas which were identified in historical primary sources to have been affected by malaria (grey areas, GIS generated) (Gowland & Western 2012: 308 - as Fig.8). The location of Ingleby Barwick is marked with a red star and clearly does not appear to lie in an area reportedly inhabited by *Anopheles Atroparvus,* or affected by "ague" (see Gowland & Western 2012: 301). Similarly, at the closely located inhumation cemeteries at Norton (Bishopshill School) and Binchester, crude

prevalence rates of cribra orbitalia were 3.5% and 5.5% respectively (ibid: 305 – in Table 1). Therefore, the cribra orbitalia observed in △9 is almost certainly not related to malaria.

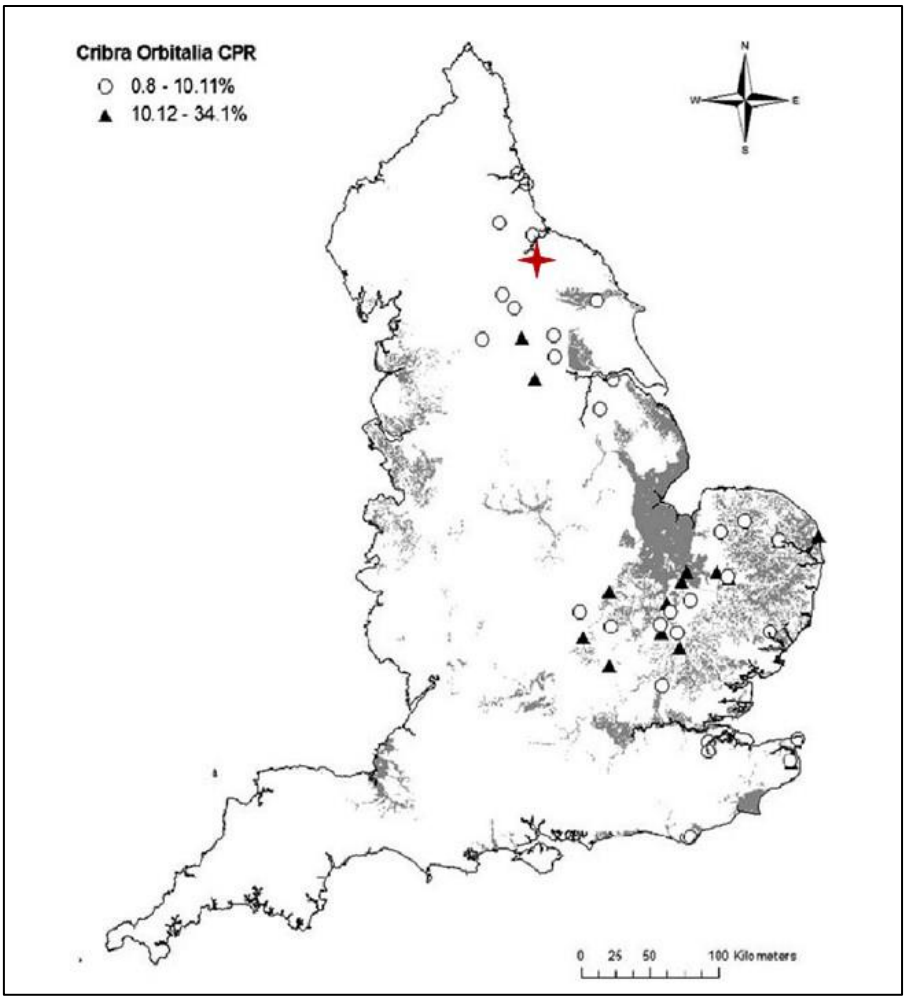

FIGURE 43 – CRUDE PREVALENCE RATES OF CRIBRA ORBITALIA FROM ANGLO-SAXON INHUMATION CEMETERIES NEXT TO AREAS REPORTED AS 'MALARIAL' (GREY) FROM GOWLAND & WESTERN (2012: 308 – AS FIG.8). RED STAR MARKS LOCATION OF INGLEBY BARWICK LOW LANE MIXED-RITE CEMETERY.

One individual (△273) was observed to have suffered from osteoarthritis as evidenced through the presence of eburnation on one of their joint fragments. Eburnation has the appearance of a polished surface in the area of contact on a joint and is the result of the disappearance (through age, trauma, disease, movement, *etc*) of cartilage (Fig. 46) (Waldron 2009: 27-28; White *et al.* 2012: 441). The result of absent cartilage is direct abrasion of bone-on-bone in synovial joints, and this is associated with localised pain and stiffness. Unfortunately, it was not possible to identify which joint was affected because the

fragment was partial, and it is therefore not clear whether this reflects primary or secondary osteoarthritis.

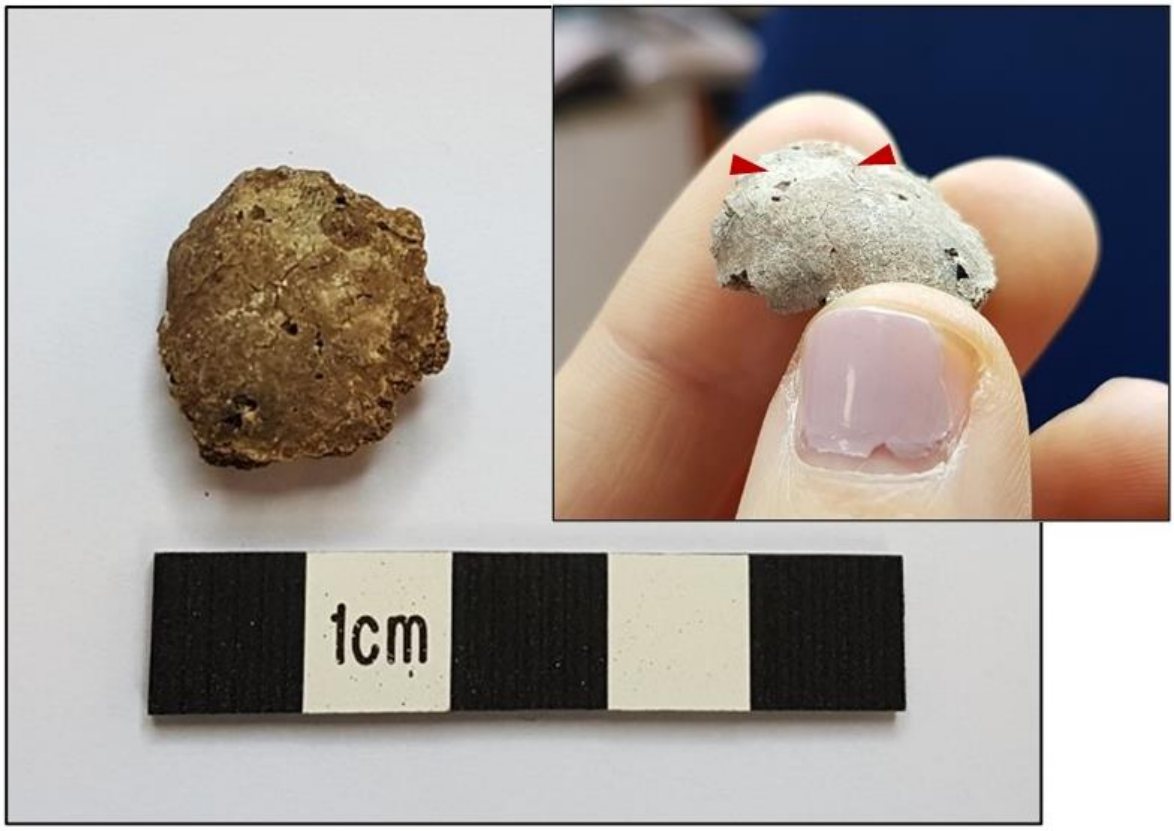

FIGURE 44 – JOINT FRAGMENT OF △273 (ADULT) WITH EBURNATION INDICATING THE PRESENCE OF OSTEOARTHRITIS. AREA OF EBURNATION INDICATED BY ARROWS.

The pathologies observed at Ingleby Barwick are frequently present in archaeological populations. It is apparent that the skeleton of the non-adult, △269, was affected by active or recent new bone formation on some long bones. It is possible that the individual suffered from a systemic disease, because at least 15 fragments were observed to feature new bone. However, due to the issues inherent in dealing with cremation burials, it is not possible to be more specific about this individual. The periosteal new bone on one of the ribs of △11 (possible female adult) may hide a well healed fracture. Alternatively, this reactive bone could be related to an infection of the lung or viscera. Osteoarthritis was observed in the joint of one individual only – the adult △273. The affected area of polishing is small and due to the limited extent of the surface present for observation it was not

possible to exactly identify the element (possibly head of first metatarsal?). The same individual also had lamellar bone extending along the shaft of at least one side of one tibia, which, by itself, is not an uncommon occurrence in archaeological populations. The lamellar bone was striated in wide grooves and appeared solid, which may indicate that the bone was healing at the time of death. The osteoarthritis could indicate that the individual was at the older maturity aspect of the age spectrum, but based on one isolated joint, this would be a careless conclusion to make, as younger individuals can also suffer from it (Waldron 2009: 31).

Overall, the pathologies found at Ingleby Barwick are not exceptional for archaeological populations. At Sancton I, McKinley noted the presence of lesions on the bones of 96 individuals which came to 32.1% of the individuals identified by her (although this number includes different types of lesions, not exclusively periosteal reactions) (Timby *et al.* 1993: 299). At Spong Hill, periosteal reactions were observed in seven individuals (McKinley 1994: 115,117), and osteoarthritis in 16.6% of the adult population (one joint affected), or 3.6% (two or more joints affected) (ibid: 111).

4.3.2 PLANTS

The grass samples from sampling locations 2 and 6 were measured and returned with $^{87}Sr/^{86}Sr$ ratios of 0.7183 and 0.7151 respectively. These ratios stand in contrast to the rest of the samples, as well as those measured for Late Triassic/Mid Jurassic lime-, and sandstone and Late Permian limestone by Evans *et al.* (2010; 2018) in the vicinity of the site. On this basis, it was decided to exclude these two points from the consideration of the catchment BASr. The collected grass samples are stored at VUB and will be re-measured in the near future for a review of this issue.

The box and whisker plot below (Fig. 39) summarises the available data points for plant measurements from Evans *et al.* (2010; 2018) and shows the variation for the various geological formations inside the 25km catchment. As can be seen in the plot, the greatest

variation in measurements exists for the Triassic sandstone. The $^{87}Sr/^{86}Sr$ ranges from 0.70903 (Catt-V-12 from Evans et al. 2018) to 0.71323 (3a – grass sample from this study), which is quite extensive. When the map (Fig. 20) is considered, it appears that there is a pattern in the distribution of the higher and lower measurements on the geological formation. All the higher ratios are found around sampling site 3, which is the cemetery site investigated for this study. Complementing the grass sample are the shrubs (0.71300) and trees (0.71257), as well as two plant samples from Evans *et al.* (2018) – Catt-V-09 with 0.71201 and Catt-V-10 with 0.71383. All the samples which returned the lower values for this geological formation are located much further southwest of sampling location 3. We may therefore consider that there is regional variation present which is not immediately apparent from the bedrock determination. Investigation of the superficial deposits in the area revealed that most of the samples are located on the same glacial till and alluvium cover. Therefore, this does not seem to cause the variation seen in these two areas located approximately 10km apart. For the interpretation of the $^{87}Sr/^{86}Sr$ from the people and animals at Ingleby Barwick, this spatial variation on the Triassic sandstone must be taken into account.

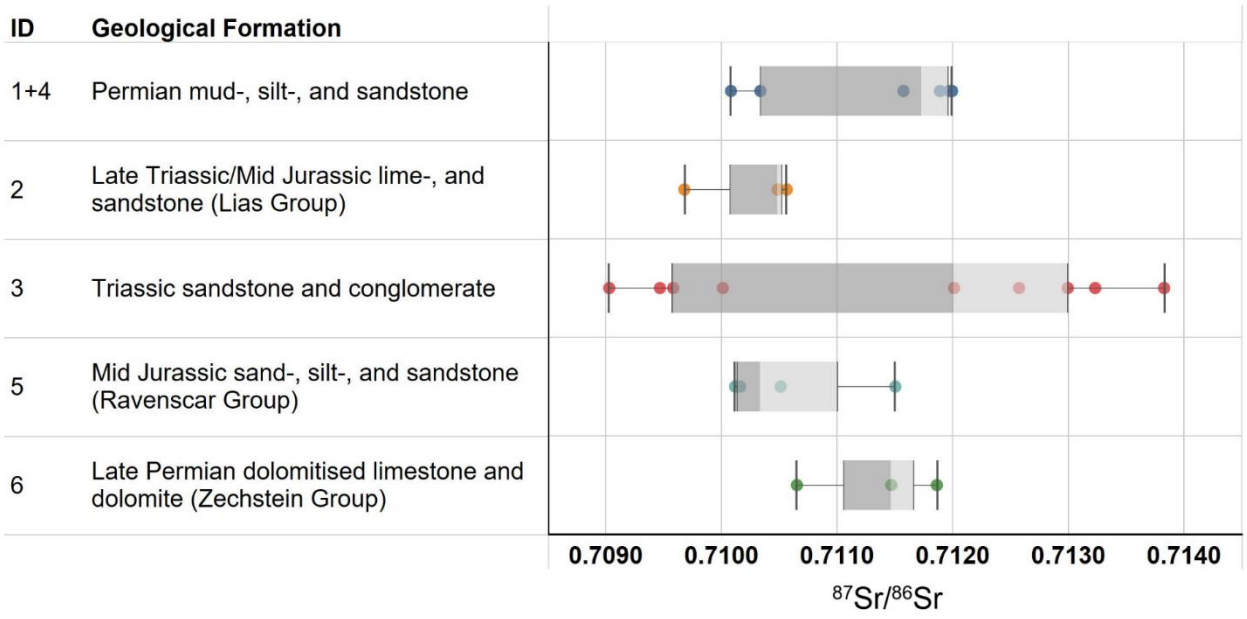

FIGURE 45 – BOX AND WHISKER PLOT OF $^{87}SR/^{86}SR$ VARIATION FROM DIFFERENT GEOLOGICAL FORMATIONS IN 25KM CATCHMENT AREA. PLOT INCLUDES AVAILABLE DATA FROM EVANS ET AL. (2018). BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES.

4.3.2.1 BASR INGLEBY BARWICK

Based on the considerations discussed above, the 'local' Sr biosphere at Ingleby Barwick ranges from 0.7093 to 0.7138, but this range is spatially identifiable; the higher spectrum – that is, those plants measuring around 0.712 and above – appear to be found specifically around the cemetery site itself, with a westerly extension towards the Permian sedimentary lithologies. Any Sr ratios measured below 0.712 and above 0.710 are consistent with most of the catchment and are unlikely to reflect a more precise location.

4.3.3 CALCINED HUMAN AND ANIMAL REMAINS

As can be observed in Figure 40 below in which $^{87}Sr/^{86}Sr$ is plotted against [Sr], the Sr results fall into different groupings. First of all, most of the humans from Ingleby Barwick cluster in the same area of the plot in terms of both $^{87}Sr/^{86}Sr$ and [Sr], and in terms of mobility this appears to indicate that they were local to the area. This is especially notable considering that for most individuals for whom femur and rib samples were measured, these plot exceedingly close together. There is no suggestion of a change in diet or mobility within the last 20 or so years of life. It is unfortunate that otic capsules could not be sampled, because these might be able to reveal mobility during youth of some of the individuals. The non-adults △9, △10, and △269 all plot consistently within the expected local range and are unlikely to have moved from elsewhere. There are intriguing exceptions, however. First of all, although this is not marked, there appears to be a slight difference in $^{87}Sr/^{86}Sr$ ratios from the long bone diaphyses of individuals △8 (adult) and △11 (adult, possible female) compared with the core group of values. These two are very similar to each other, although the $^{87}Sr/^{86}Sr$ for the rib sample from △11 is completely different and plots closer to the horse (△270) and sheep/goat (△272). Interestingly, we know that the individual was affected by some form of inflammation in the respiratory system which caused new bone formation on some of the visceral surfaces of the ribs. It is possible that the strongly diverging value is tied to anomalous bone turnover, or new bone formation.

Second, the horse recovered from the accessory vessel △270 which was found next to △273 (adult), and the sheep/goat △272 found with an adult both have $^{87}Sr/^{86}Sr$ ratios exceeding 0.712. These two individuals, as well as the third animal (sheep/goat △268) also have much higher [Sr] than the human individuals and therefore plot apart. At the same time, the latter falls rather closer to the human individuals in terms of $^{87}Sr/^{86}Sr$. We can therefore identify approximately three distinct plot areas which appear to distinguish the individuals into ‘groups’ and this requires closer examination.

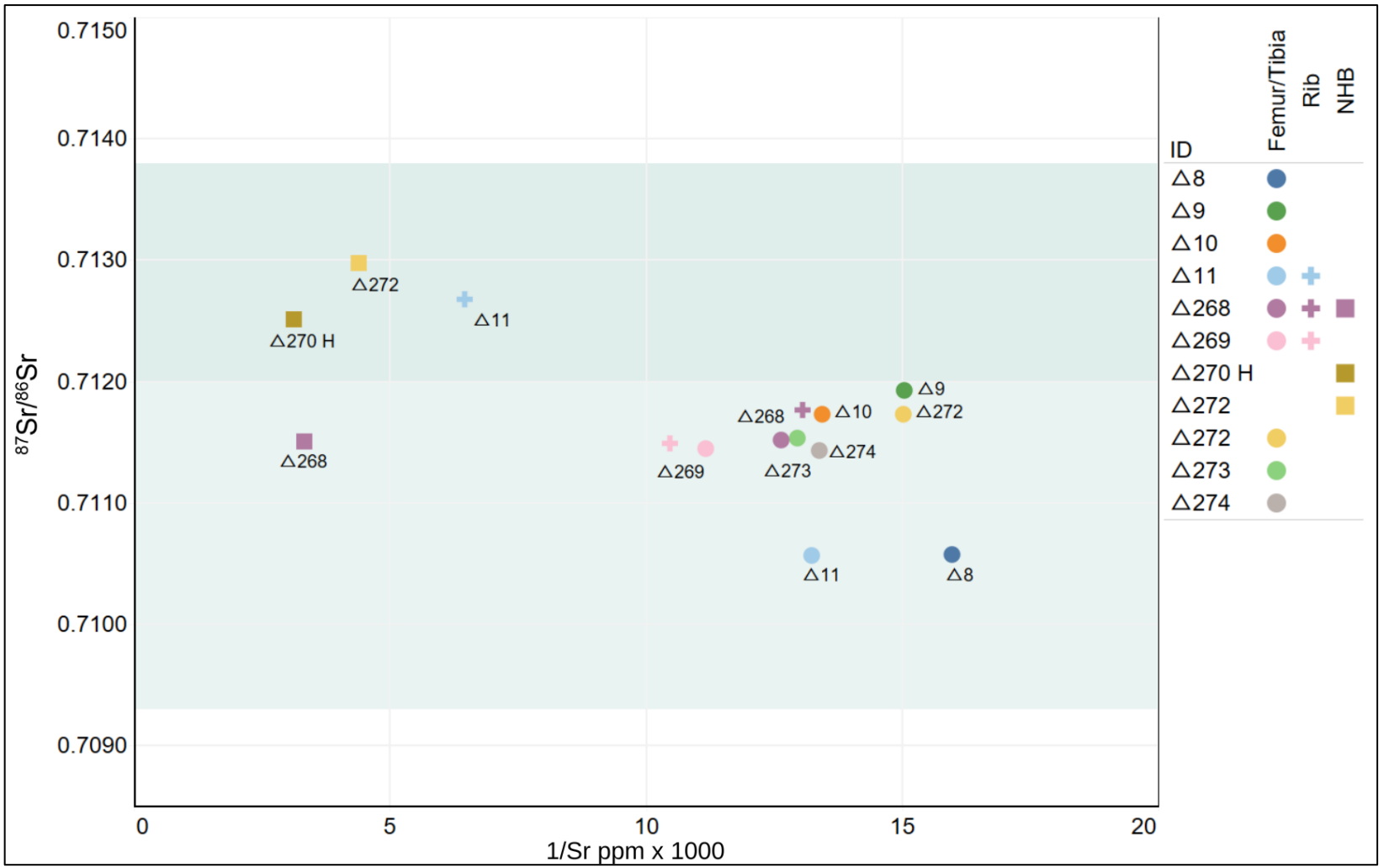

FIGURE 46 – SCATTER PLOT OF $^{87}SR/^{86}SR$ AGAINST [SR] (EXPRESSED AS 1/SR PPM X 1000; NORMALISED TO 40% CA). LIGHT GREEN REFERENCE BAND INDICATES WIDER CATCHMENT, DARKER GREEN BAND INDICATES AREA AROUND INGLEBY BARWICK CEMETERY AND WESTERN AREA OF CATCHMENT MORE SPECIFICALLY.

As discussed in Chapter 2, Sr concentrations can be tied to trophic level, with herbivores often reflecting higher values than omni- or carnivores. Plant fibre contributes the bulk of the Sr content reflected in bone and therefore horses and sheep/goats, who feed by grazing, will have incorporated more Sr into their tissues. This is also dependent on the Ca content of the underlying lithologies, but at Ingleby Barwick it is possible to observe this trend between the animals and the majority of the people. The Sr concentrations of the three animals range between 228 ppm and 320 ppm, with the horse exhibiting the highest value. Interesting is especially the sheep/goat △268, which was cremated and buried with the possible male adult. Although in terms of Sr concentration it fits well with the other animals, it has a relatively lower $^{87}Sr/^{86}Sr$ ratio, and this is much closer associated with the people buried in the cemetery. The implication is that this sheep/goat was eating plants from the same, or a similar area as the people buried at Ingleby Barwick, specifically the individual that it was cremated and buried with (△268; possible male adult).

Clearly, then – the animals buried in the cemetery had a different diet from the people. A second implication of the differing $^{87}Sr/^{86}Sr$ may be a difference in food procurement areas within the catchment. If the people buried at Ingleby Barwick derived their food from close to their settlement, as appears to be the case during the early medieval period in Britain, it is unlikely that this settlement was located in close proximity to the cemetery. Two out of three animals exhibit $^{87}Sr/^{86}Sr$ >0.712 ratios, as opposed to the people (approx. 0.7114-0.712). Therefore, it is possible that the location of the cemetery is in close proximity to pasture areas for the animals, while the settlement of the people (or their agricultural plots) was located further west on the dolomitised limestones (Sample area 6), or on the Permian sandstones to the north (Sample areas 1+4). Noted settlements in these areas are for example Green Bank, Darlington, possibly Newton Bewley, and/or Hart. Further afield to the northwest, there is Ferryhill, Durham. Of course, the two animals (△270 and △272) may have also been acquired by trade from elsewhere – perhaps another settlement within the catchment, or even outside of it. Either way, it is unlikely that the bulk of their diet derived

from the areas south and east of the cemetery as the $^{87}Sr/^{86}Sr$ ratios from the plants in these catchments are consistently too low. By extension, this has interesting implication for the two adults, △11 and △8, whose femoral $^{87}Sr/^{86}Sr$ measures 0.7106 and is therefore exhibiting a variation of at least +/- 0.0008 when compared with the rest of the human burial population. While this is not a profound difference, it may indicate a greater contribution from food sources along the catchment outskirts, away from Ingleby Barwick. Whether they moved to the same settlement as the others during adulthood is not possible to determine. However, the highest Sr concentration in the human individuals was 155 ppm, which was measured in the rib of the possible female adult, △11, who appears to plot with the animals. Her(?) femoral concentration is consistent with that of most of the other humans at 77 ppm, but her(?) rib evidently displays a much higher Sr concentration and isotope ratio. The question whether the rib fragment was mis-identified and belongs to an animal – or indeed another human – who was cremated with △11 is relevant. Especially in cremation burials fragments of ribs from some mammals can look very similar. While this is a possibility, then, another explanation may be that this individual moved during the latter part of her(?) adult life from an area along the western/southern/eastern catchment periphery towards the centre around Ingleby Barwick - for example to Yarm, Eaglescliffe, Stainsby, or Quarry Farm where higher $^{87}Sr/^{86}Sr$ ratios are recorded. The higher concentration can be explained with a shift in diet, perhaps by switching to more plant-based foods during the last five or more years of life. For individual △8, who we do not have a second bone sample for, the following considerations are valid: a) they lived at a different settlement from the rest of the individuals which was located in the catchment periphery or east of the site rather than around the cemetery itself, b) they moved to the same settlement during adulthood and their femoral $^{87}Sr/^{86}Sr$ ratios still reflect a contribution from a different area, although they are approaching the values of the group, or c) they derive from somewhere outside the catchment area, but fall into the ‘strontium of doom’ range which means that they could have grown up in many regions of England and the continent.

It is almost certain that the cemetery has not fully been excavated yet, therefore we are missing a holistic representation of the burial population. This issue is exacerbated by the fact that this is a mixed-rite cemetery, and we are equally lacking isotope data from those individuals who were buried in a different manner (inhumation). Two out of three animals were feeding away from the area where the humans were growing their food, or where they were settled. That this is not a consistent occurrence is evidenced by the presence of △268. This sheep/goat was most likely raised in closer proximity to the people, and not in the same place as the other two animals. In short, the horse and other sheep/goat (△270 and △272) were either managed differently by the same community or acquired from elsewhere. If the rib fragment from △8 does indeed belong to the same individual as the femoral sample, this could highlight mobility in later life of the individual.

4.3.4 Comparative sites

The closest parallels to Ingleby Barwick in terms of cemetery spatial organisation, number of burials, the proportion of inhumation to cremation burials, and the general assemblage appear to exist with Hob Hill, Saltburn. Unfortunately, only one summary report on this site exists which is based on a local farmer's notes and correspondence with antiquarians from c.1909 (Gallagher 1987). It describes the layout of the cemetery which features inhumations and cremation burials in equal numbers – 19 of both types (ibid 11-25). Cremation burials were found predominantly to the south and east of the inhumation burials, which suggests a similar separation of burial areas, although at Ingleby Barwick, there is little evidence for intercutting and this is in contrast with Hob Hill cemetery. In at least four instances, the cremated material was not found within an urn, but instead spread in a layer across the ground (ibid); it may be suggested that these were remains of *in situ* pyres, but this is not possible to determine with any certainty now. At Hob Hill, grave and pyre goods from the cremation burials include amber-, gold-in-glass-, blue-, and crystal beads, and these were most of the time deposited underneath the vessels. A single pair of tweezers was apparently unburnt and placed into one of the urns before it was filled with cremated bone.

Tweezers were found in one urn (△268, possible male adult) at Ingleby Barwick, which mirrors the Hob Hill report. The bead types also mirror those found at Ingleby Barwick, although there they are almost always found with the inhumation burials in the latter case. Hob Hill cemetery has been dated to the early 6th century with a suggested continuation into the latter part of the century based on a cruciform brooch in one of the inhumation burials (ibid: 21), and this means that at least for some time it was in use alongside Ingleby Barwick. The similarities between the sites certainly support this notion. Gallagher suggests at the end of the cemetery summary report that Hob Hill was most likely a commemoration place for not one, but several surrounding settlements (ibid: 21). This assessment is based on the political division of the area in the later part of the early middle ages. For Ingleby Barwick a similar explanation can be proposed where almost all animals are from settlements (or pastures) in the immediate vicinity, while the people are from further afield. At the same time, the difference observed amongst the people does not necessarily suggest that they belong to different settlements, with the exception perhaps of △11 and △8. They may have been separate at one point, but then migrated through marriage, work, opportunity, or otherwise and found themselves with family or kin group at another settlement. The spatial limitation of the excavation must be kept in mind, where certain areas of the cemetery were excavated but others were not. If the cemetery was used by different communities or kinship groups, these may have been spatially separated. This is further complicated by the inhumation burials which may also hide certain regional affiliations.

4.3.5 Belief systems and animal-human relationships at Ingleby Barwick

When compared with the period of the Scandinavian incursions where it is necessary to confront Christian accounts of contact, the recordings for this earlier period are scarce. It is therefore very difficult to attempt to reconstruct contemporary ontology or ideas about the cosmos. On the continent, or rather external to the core areas of the Roman Empire, Germanic areas perpetuated an oral tradition which likely varied across time and space.

Few elements have been documented, but some indications can be found in adversarial primary sources. Indications are that the worldviews that we encounter amongst the communities who cremated their dead alongside animals in the late 5th to 6th centuries may not have been fundamentally different from the Scandinavian ones three centuries later (at the time of arrival of the Viking Great Army in Britain) (Fern 2010: 133).

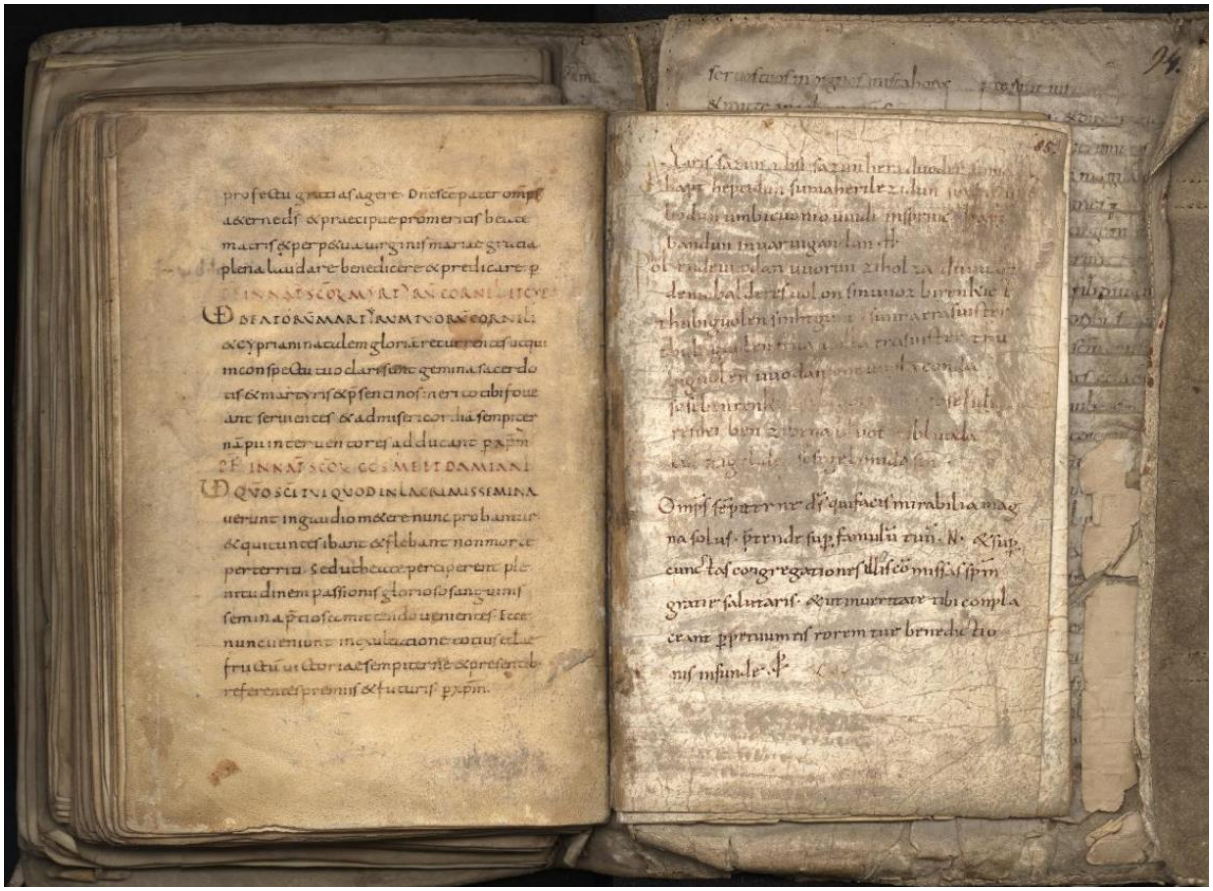

FIGURE 47 – THE MERSEBURG CHARMS (RIGHT PAGE); MERSEBURG DOMSTIFTSBIBLIOTHEK: CODEX 136, FOLIA 85R.

One aspect of early sources should be highlighted here: the importance that appears to have been afforded to horses in the early medieval period. The second *Merseburg Charm* (dating to the 9th century), for example, involves an injured horse (Fig. 47). Three similar instances can be found in other early medieval charms, although they have been altered to feature Jesus Christ rather than Odin as the healer of the animals (Lamberti 2011: 217). Also significant is the origin myth of *Hengist and Horsa* as reported by Bede and recounted in the Anglo-Saxon Chronicle - the Old English names of the brothers clearly reference horses

(Simek 1993: 169-170; Fern 2010: 132). The presence of horses in early medieval cremation and mixed-rite cemeteries is well attested (Fig. 48 and 49). At the large cremation cemeteries of Sancton I and Spong Hill, horses are the most common animal to be found alongside humans (Bond 1996), and make up approximately ten percent of the total number of burials (Fern 2007: 93). In Fig. 48 below, Fern did not include the horse from Ingleby Barwick as this had not been identified yet (ibid). The distribution has now expanded northwards, with the individual from this study presenting as the most northerly horse cremation burial in England. Further afield on the continent, the same can be observed as has been highlighted by Cross (2011, 200; see Fig. 49 below). Variation is a hallmark of these equine burials, although this is clearly limited in cremation cemeteries.

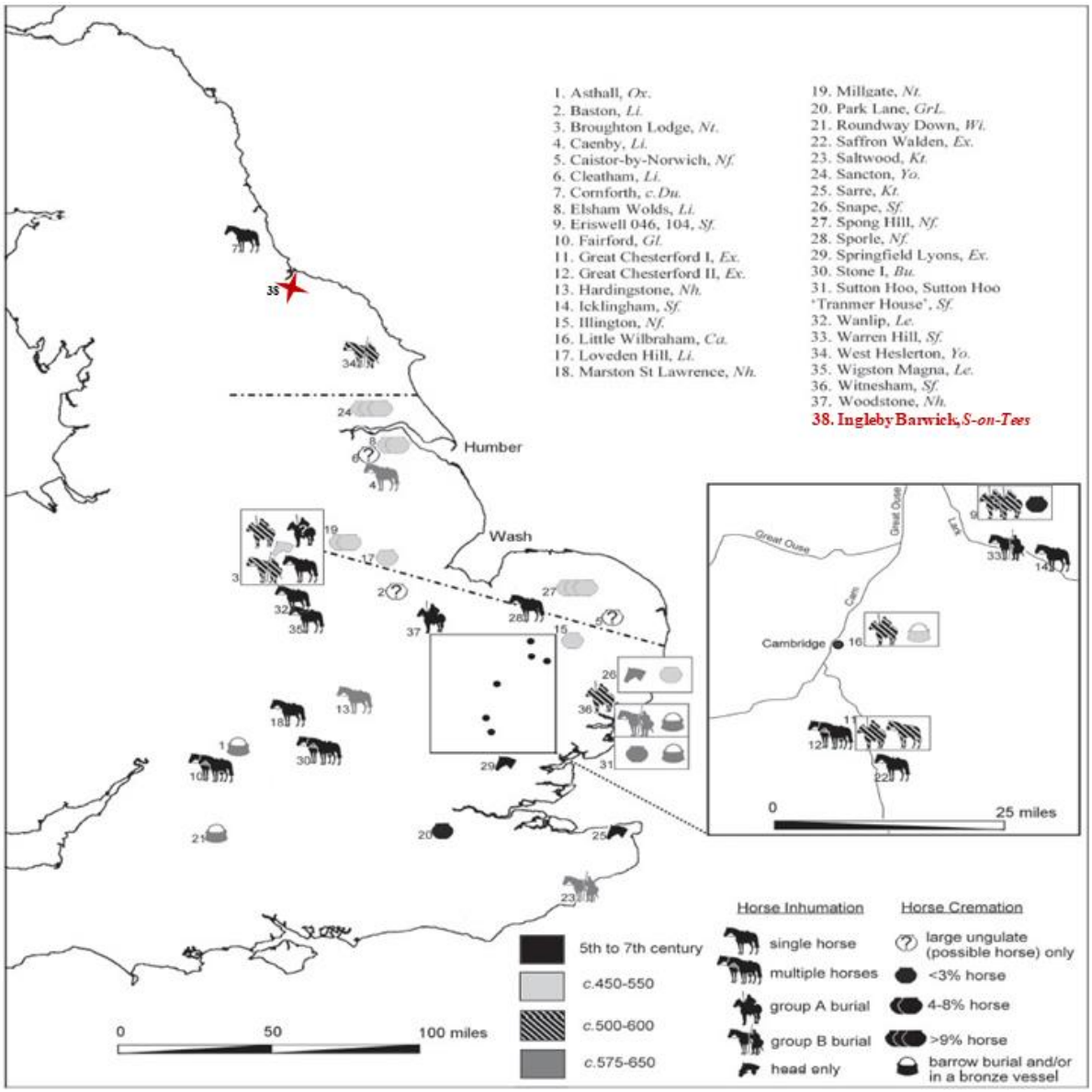

FIGURE 48 – MAP OF BRITAIN SHOWING THE DISTRIBUTION OF HORSE BURIALS IN THE EARLY MEDIEVAL PERIOD. CREATED BY FERN (2007: 93 – FIGURE 1). AMENDED BY THIS AUTHOR TO INCLUDE LOCATION OF INGLEBY BARWICK (IN RED).

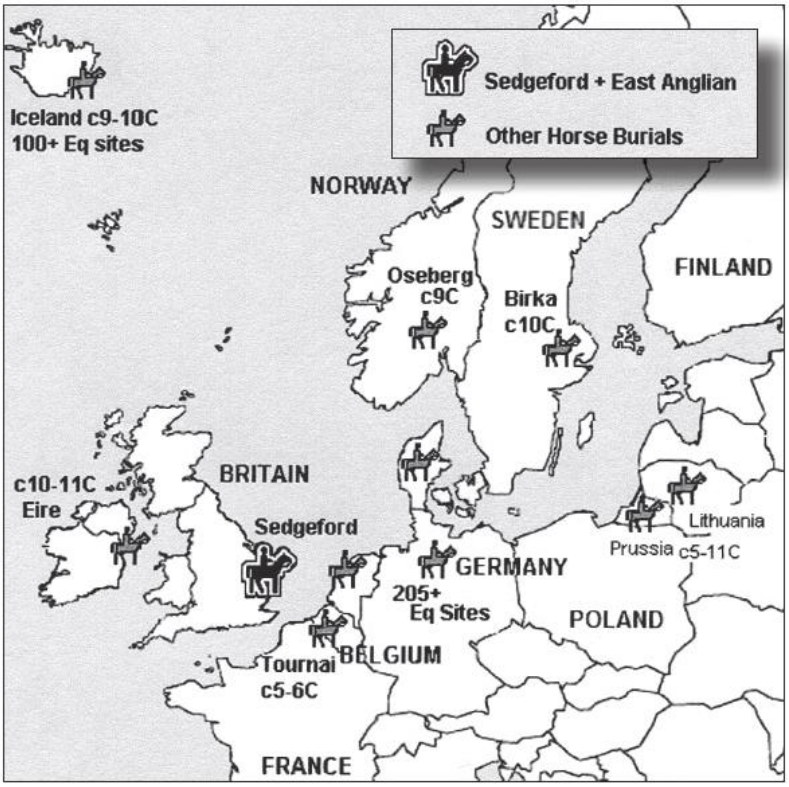

FIGURE 49 – A SELECTION OF HORSE BURIALS DATING TO THE EARLY MEDIEVAL PERIOD (NOT EXHAUSTIVE). FROM CROSS (2011: 200 - FIGURE 2). NOTE THE 205+ EQ SITES IN THE AREA OF GERMANY.

At Ingleby Barwick, the relationships exemplified by the burial of the human adult △273 with that of the horse in △270 shall be explored further in this context. We know that the adult and the horse were buried at the same time, as the excavation report states that 'the urns were positioned in such a way that they were touching, with no fill material between them, indicating that they belong to the same phase of burial' (ASDU 2005: 13). Unfortunately, due to the lack of a detailed animal bone report for Ingleby Barwick to ascertain whether all parts of the horse were present, it is not possible to confirm whether this was the case. Neither of the urns appears to have been decorated (both were truncated), and no artefacts were recovered besides a CuA stud (unburnt) inside △273. In Fig 50, the urns are clearly touching each other. The smaller vessel contained the majority of human remains, while the larger one (△270) held the remains of at least one horse and several smaller animals. There were no identifiable human remains within the latter urn, but

this does not mean that fragments might not have been camouflaged through fragmentation. Still, the indication here is that a conscious decision was made during the funeral event to collect the horse remains in a separate vessel to the human remains. Furthermore, a vessel with a larger volume was used to collect most of the horse bone - presumably, this was due to practical considerations.

FIGURE 50 – DOUBLE URN BURIAL OF △273 AND △270 (LARGER URN ON RIGHT). PHOTOGRAPH COURTESY OF ASDU.

Both the horse and the human in this double burial were analysed for $^{87}Sr/^{86}Sr$ and [Sr], and the result showed that food-procurement was almost certainly spatially separated. By extension, it can be argued that through the collection of the cremated bone into distinct urns, this spatial (perhaps ontological?) separation was maintained to a certain degree. Further away, at Spong Hill, where McKinley noted the presence of 227 horses, these were most often intermingled with the human remains, although some 'accessory vessels' were present (Timby *et al.* 1993: 309; McKinley 1994: 92ff). McKinley makes the point that where separation of remains occurs, this was likely a conscious effort and enforced through keeping the cadavers slightly apart from each other on the pyre (McKinley 1994: 98). At Sancton, few urns containing only (or predominantly) animal bone have been identified, and

only one of these included a horse with any certainty (Timby *et al.* 1993: 310). At Ingleby Barwick, this is where the separation stops, however – both urns were placed side-by-side into the centre of the excavated pit, and they were physically touching. Neither urn seems to have been preferentially treated, decorated to stand out, or given special grave or pyre goods. There is an element of equilibrium observable in the handling of this burial, despite the larger size of urn △270. Of course, this may in part have been caused by truncation where artefacts or decoration could have been removed. If what we observe is real, however, then there are important points to be made about the funerary process. Fig. 51 below illustrates the idea that in the case of the (at least) two individuals in this burial at Ingleby Barwick Low Lane, space is shared at three points of convergence – a) during interaction when they were alive, b) during the cremation on the pyre, and c) in the burial environment where they are commemorated. To this, we can add the association of the individuals with each other in the memory of the mourners who attend the high-energy funeral. In this case it is of little import whether the horse and the human were indeed affiliated or had an emotional attachment during life. Williams has aptly shown how the cadaver and the mortuary process in the early medieval period were mnemonic forces in the commemoration of the deceased (Williams 2006). This is clearly observable at Ingleby Barwick, and it is here that the Sr isotopes help us to gauge possible interactions between human and animal before death.

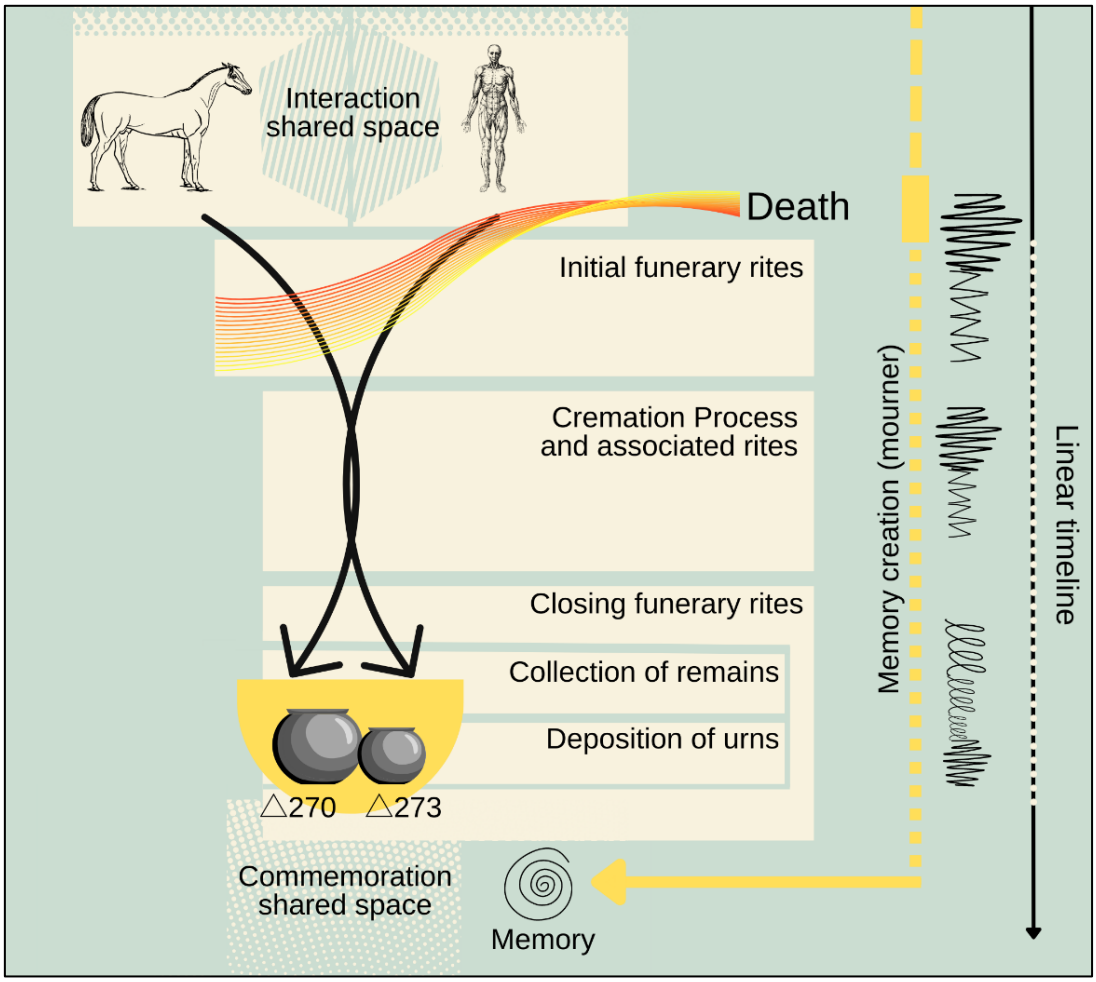

FIGURE 51 – ILLUSTRATION OF THE IDEA OF SHARED SPACE DURING THE LIFE AND SPECIFICALLY THE DEATH OF THE INDIVIDUALS IN DOUBLE BURIAL △270/△273 (HORSE/HUMAN), AND THE ASSOCIATED MEMORY-CREATION IN THE MOURNERS. THE IRREGULAR AND CURLED LINES INDICATE HIGH-ENERGY PHASES DURING THE FUNERAL WHICH MAY COME TO DOMINATE THE MEMORY OF THE MOURNERS.

It is interesting to compare the above observations with those that can be made about burial △268, where a possible male adult was placed into a highly decorated urn, intermingled with animal bone (including sheep/goat). As stated above, the Sr isotope evidence is highly suggestive of the sheep/goat having eaten similar food to the people, and/or having lived near them. The commemoration space was shared rather more intimately; the attempt at physical separation observed in the double burial △270/△273 (human/horse) is not maintained in this ritual and intermingling of the remains takes place. A third burial which included the intermingled remains of a sheep/goat and a younger adult/

adolescent (△272) was amongst the remains at Ingleby Barwick. Interestingly, it diverges from both burials described above in that the sheep/goat appears to possess a $^{87}Sr/^{86}Sr$ ratio similar to the horse △270, but the remains are not separated. The burial therefore features elements of the other two, without copying either. What may be visible here is a species-specific choice, where the comingling of animal with human remains is encouraged or chosen for some animals but not others. Unfortunately, Ingleby Barwick is too small a cemetery to explore this theory fully.

Clearly, then, ontological boundaries (modern western thought) are crossed, at the very least during the cremation rite at Ingleby Barwick – especially in the case of the horse △270. That these boundaries existed in the same way as today is highly unlikely. It is possible to suggest that the people at Ingleby Barwick were confronting or reproducing their worldview and their perception of the differences between animals and humans, and there are at least two methods practised in the same cemetery which may reflect individual decision-making processes and agency: a) rough separation of remains into two urns, and b) comingling of remains in one urn. One of these processes was likely closer aligned to the cosmological and ideological thought processes which influence mortuary behaviour (although see Williams 2001: 194). On the other hand, it should be clear that expecting to see absolute duplication and repetition of any ritual is unrealistic at best. Changes through time could also be influencing factors and account for the differences in treatment seen in these burials.

4.4 Conclusion

The mixed-rite cemetery at Ingleby Barwick is one of an exceedingly small number of early medieval cemeteries in the north containing cremated remains, and, as has been shown in this study, the northernmost example of a horse cremation in England. One of the research questions pertaining solely to this cemetery was concerned with the basic osteological and palaeopathological information; one objective was to present this data here before

exploring the mobility of the individuals, animal-human relationships, and by extension social practice. Because of the taphonomic destruction of the bone in the inhumation graves, this cemetery provides a good example of the usefulness of cremated bone to archaeological study. The small number of cremated individuals appear to reflect a relatively normal early medieval cemetery population with a proportionally high number of non-adults. The presence of pathological conditions such as periostitis and osteoarthritis is common in such populations. Although there are indications for some mobility or different food procurement areas, the cremated individuals at Ingleby Barwick appear to have been local residents, at least for the last few years before death. Through the combination of Sr isotopes with the mortuary context, it was possible to show that animals and people did not necessarily share the same space in the landscape but that they did so through cremation (to differing degrees). In the case of intermingled or associated animal-human deposits, the investigation of the mortuary process can be extended into the life of the individuals and possible relationships can be explored. This perhaps reflects the non-static nature of the non-Christian worldview which was locally variable rather than pan-Germanic (Williams 2001: 194; Fern 2010: 133).

5 CLEATHAM

This chapter is concerned with the early medieval mixed-rite cemetery at Cleatham, Lincolnshire. This is a large-scale cemetery which requires a different approach compared to the other two case study sites, both of which are much smaller. After a review of the archaeological context, the reader encounters specific research questions which are relating to those laid out in chapter 1. They are somewhat directed by the results of previous work and respect the nature of the archaeology at Cleatham. Following this, the results of the analyses are presented and discussed in different sections.

5.1 CONTEXT

The cremation cemetery of Cleatham dates to the Anglo-Saxon period in England and is one of the largest cremation cemeteries known in the country, after Spong Hill, Norfolk, and Loveden Hill, also Lincolnshire. First discoveries were made in the mid-1800s, when Trollope published fragments of urns found during road construction in 1855 (1857). Most of the urns discovered in this instance – 50 or 60 according to the report – were destroyed at the site because the workers were looking for valuable objects. The cemetery seems to have remained relatively undisturbed until it was assessed by Leahy in 1978-9. Because of designs by the landowner to commence deep-ploughing in the mid-1980s, the total excavation of the cemetery by Leahy was conducted as a rescue operation from 1985-9. In 2007, Leahy published the major site report entitled 'Interrupting the Pots', which also included a very detailed urn typology and chronological phasing based on stamp-groups in conjunction with stratigraphic information (2007). A host of downloadable raw data for independent research is available on the Archaeological Data Service (ADS) website (Leahy 2007). This data includes information on the burial location of every urn/deposit on the site grid (Fig. 52), associated grave and pyre goods, stamp groups, phasing, and relationships. The osteological analysis of 979 Cleatham cremation burials was undertaken for her PhD thesis by Squires (2011). In subsequent publications, Squires explored the connotations of

the results of her osteological analysis (2012), most pertinently in relation to social identity (2013). Since the publication of Leahy's report (2007), Perry has shown that the chronological phasing does not hold up in all instances, because some of the urns used for burial were also used in a domestic context, and therefore, while the urns in the typological groups may have been produced at the same time, they were sometimes buried in different phases (2013: 263 ff). Problems were also encountered when Perry applied Leahy's chronology to the urns from nearby contemporary Elsham cemetery – a circumstance which further emphasised the issues with the phasing. Consequently, the phasing for the Cleatham cemetery has not yet been set in stone (see section 5.1.4).

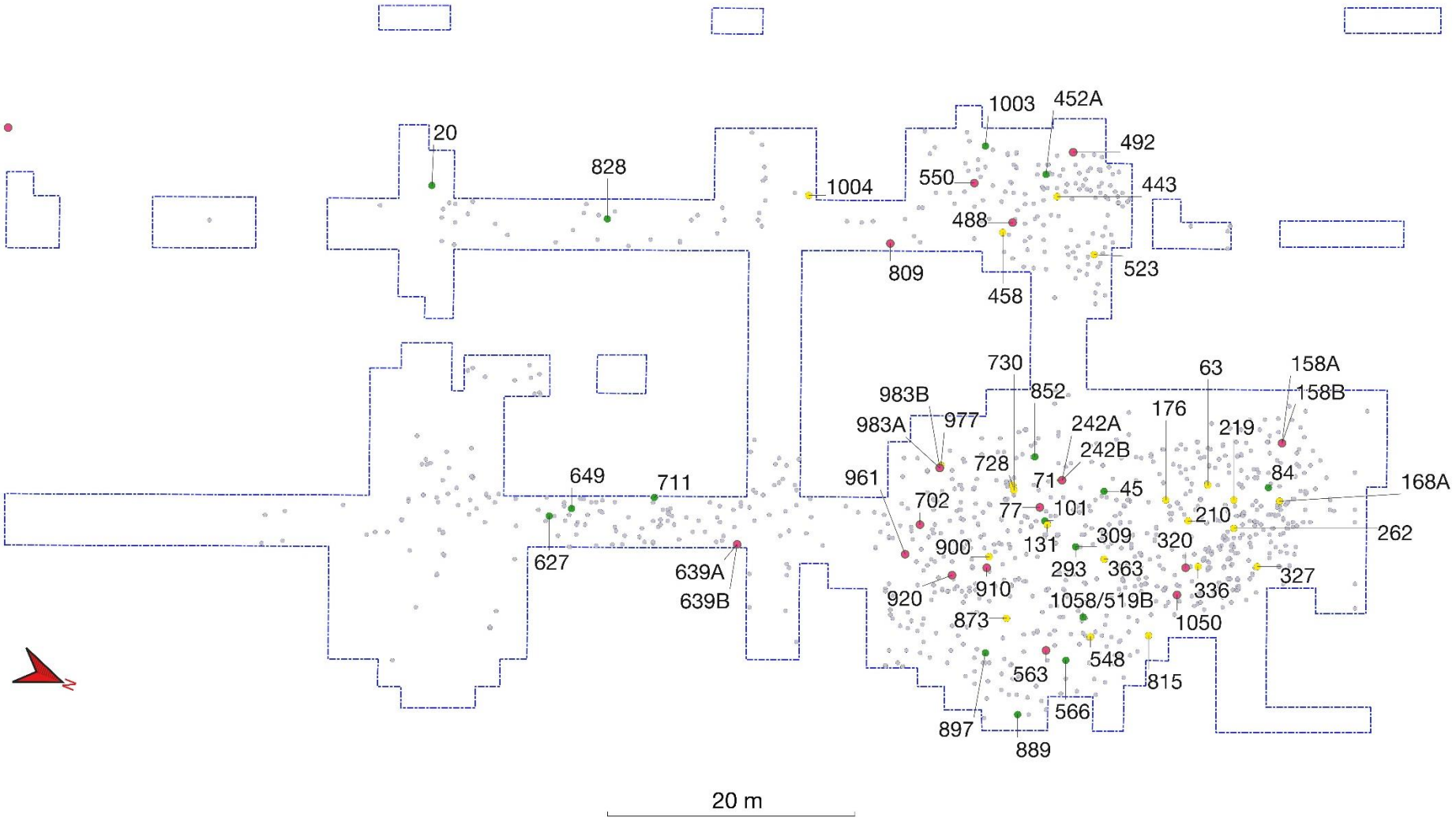

FIGURE 52 - EXTENT OF EXCAVATION TRENCH FROM LEAHY'S RESCUE EXCAVATION IN THE 1980S. CIRCULAR FEATURES RECORD URNS IN THE TRENCH; SAMPLED CREMATION DEPOSITS ARE HIGHLIGHTED IN YELLOW AND HAVE URN NUMBERS (CREMATION NR) ATTACHED. PLAN CREATED USING RAW DATA AVAILABLE AT ADS AND QGIS. GREEN – MALE OD POSSIBLE MALE; YELLOW – FEMALE OR POSSIBLE FEMALE; RED – UNKNOWN SEX.

5.1.1 THE CEMETERY IN ITS CONTEMPORANEOUS LINCOLNSHIRE CONTEXT

Cleatham cemetery was a central commemoration place for people who were cremated, and a small number of inhumed individuals (62). The former rite – cremation – was practised from the 5th to the 6th centuries, while the latter rite also seems to have been practised into the 7th century (Leahy 2007: 29). At nearby Elsham cemetery (16km northeast of Cleatham), home to approximately 569 cremation burials and eight inhumations, communities also interred their members from the 5th to the 6th centuries. These two large early medieval cemeteries were in use alongside a small number of other contemporaneous cemeteries in the vicinity, but to date (2022) they are only surpassed in size by Lovenden Hill, which is located c. 55km from Cleatham, and and 68km from Elsham in southerly direction. The 25km catchment of Cleatham cemetery contains a small number of other cemeteries at which inhumation and cremation were practised to varying degrees (Fig. 53).

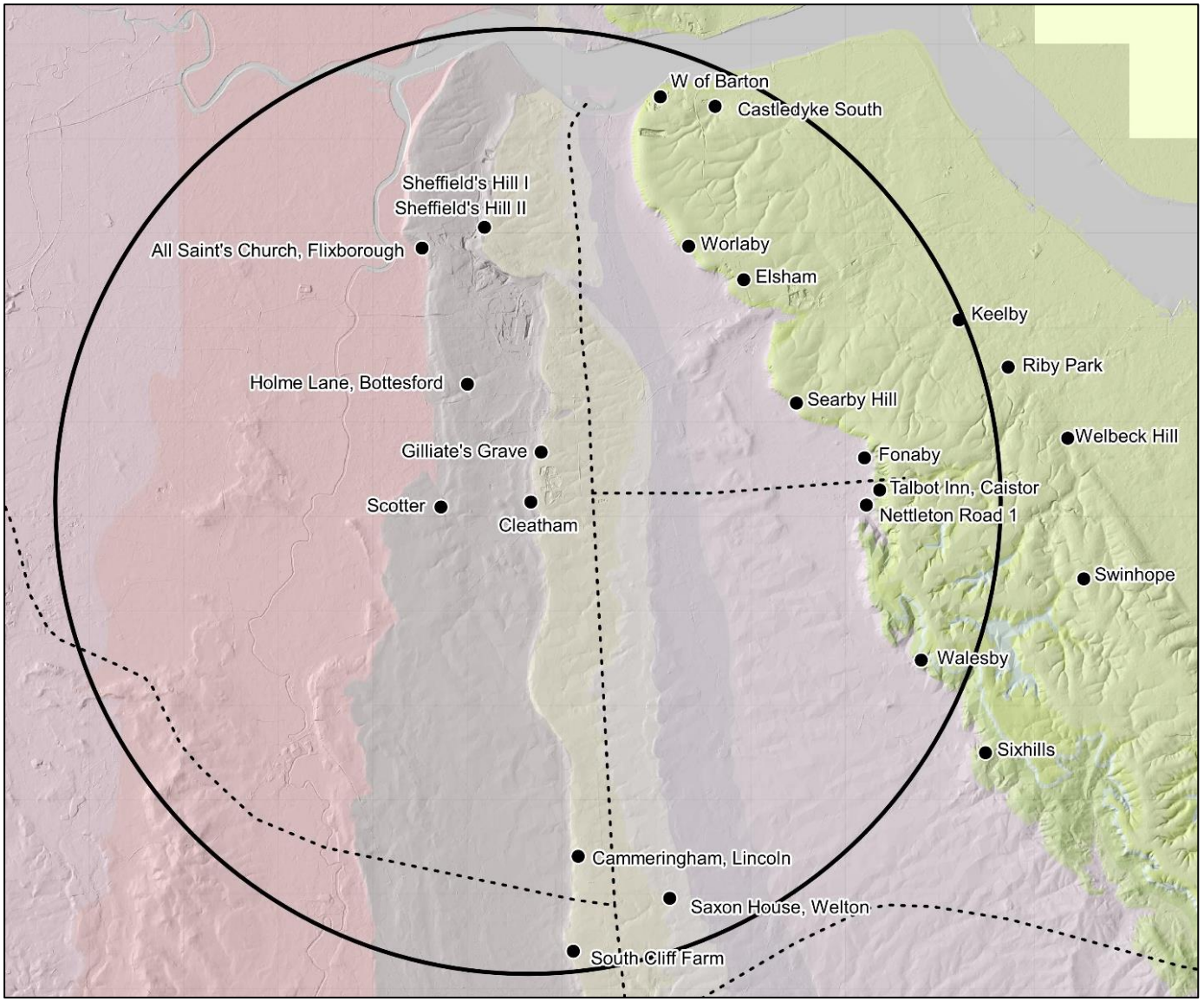

FIGURE 53 -

GEOLOGICAL MAP INCLUDING LIDAR RELIEF OF CLEATHAM CATCHMENT (25KM) WITH LOCATIONS OF OTHER EARLY MEDIEVAL CEMETERIES AND ROMAN ROADS. INFORMATION COLLECTED BY AUTHOR FROM HER LINCOLNSHIRE, HER NORTH LINCOLNSHIRE, DISREGARDING ISOLATED EARLY MEDIEVAL BURIALS. MAP CREATED USING BEDROCK GEOLOGY 625K LAYER AND LIDAR LAYER FROM

5.1.2 SELECTED CREMATION BURIALS

The table below provides an overview of the cremation burials selected in order to answer the research questions listed below. Sample IDs were given to each bone fragment analysed for Sr isotopes. More detailed information on the burials and specific samples can be found in Appendix A.7.

TABLE 9 – SUMMARY TABLE OF CREMATION BURIALS SELECTED FOR THIS PROJECT, INCLUDING BASIC INFORMATION ON PHASING, SEX, AGE, GRAVE/PYRE GOODS, ANIMAL BONE, AND THE SAMPLE IDS CORRESPONDING TO EACH BURIAL. INFORMATION MARKED WITH (*) DENOTE INFORMATION AVAILABLE PROVIDED BY LEAHY AND SQUIRES THROUGH THE ADS ARCHIVE ONLINE.

Cremation*	CremNr*	Phase (Leahy 2007)	Sex (TL)	Age (TL)	Animal bone present*	PG*	Sample ID
MT84AM	20	1	M	YA	multiple	Fe shears, bone/antler pendant, Fe tweezers, burnt Ae sheet	T026, T027, T028
MT84EE	45	1	M	YA	multiple	None	T072, T075
MT84HU	63	1	F	OMA	multiple	Fragment of an unburnt bone comb, ivory ring, 4 coral beads (b), 2 glass beads (b)	T069, T070, T071

MT84GA	71	1	F?	YA?	multiple	Fe razor, Fe tweezers, Fe shears, unburnt bone comb	T033, T035
MT84JD	77	5	Ind	ADO?	none	Point from an unburnt antler object, burnt ivory ring fragments, Ae melt, fragments of an unburnt bone comb	T123, T124, T125
MT84GJ	84	5	M?	OMA+	multiple	Bone comb fragments (ub)	T058, T059
MT84EX	101	5	M?	YA	multiple	Glass fragment, 2 pieces of glass melt, burnt ivory ring	T015, T016
MT84HZ	131	1	F?	YMA	none	Ivory ring (b), 10 glass beads (b)	T098, T099
MT84LS	158	1	M?	YA	Horse	None	T147
MT84LR	158A	1	M?	YA	multiple	None	T137
MT84AI	168A+B	1	F?	Adult	multiple	Ivory ring (b), 7 glass beads (b), bone comb fragment (ub?)	T151, T152
MT84GO	176	1	F?	YMA	multiple	Fragment of bone comb (ub), 3 glass beads (b)	T050, T051, T052
MT84KO	210	5	F?	Adult	cattle+	None	T135, T136
MT84JL	219	0	F	MA	dog	Fragments of 2 bone combs (b), decorated Ae fragment (b), ivory ring (b), 2 coral beads (b), 32 glass beads (b)	T108, T109
MT84GBb	242	1	-	-	Accessory	None	T046, T148

					vessel to 71		
MT85AA	262	1	F?	YA?	None	Fragment of bone comb (ub), 1 glass bead (b)	T117, T118, T119
MT85EG	293	1	F?	YMA	multiple	None	T100, T101
MT85EN	309	1	M	YMA	None	Fragments of a pair of Fe shears, fragments of bone comb (ub), pair of Fe tweezers	T102, T104
MT85FN	320	0	n/a	non-adult	None	None	T141, T142
MT85GZ	327	4	F?	Adult	None	None	T143
MT85GF	336	1	F?	Adult	multiple	Bone comb fragment (ub); rim sherd from Romano-British vessel	T086, T087
MT85EY	363	1	F?	YMA?	multiple	Bone comb fragment (ub)	T083
MT86OM	443	1	F?	YMA	None	Glass bead (b); Fe staple (ub)	T115, T116
MT86OK	452	4	M?	YMA/OMA?	multiple	2 bone combs (ub); Fe staple (ub)	T044
MT86SB	458	1	F	OMA?	multiple	Ivory ring fragments (b); barred bone comb (ub); decorated bone comb (b); Pb plug; Fe nail; 33 coral beads (b); 9 glass beads (b)	T111, T112
MT86SZ	488	1	n/a	non-adult	None	38 glass beads (b); ivory ring (b); foot fragment from Ae cruciform brooch (b); glass vessel (b)	T144
MT86UX	492	4	Ind	Adult	snail	Bone comb frag (ub); Ae sheet fragment (b)	T088, T089

MT86RH	523	1	F?	YMA	multiple	EBA flint scraper (b)	T105, T106, T107
MT86WK	548	5	F	YMA	None	Fe fragment	T090, T091
MT86UJ	550	0	?	Adult	med mammal	Antler whorl (ub); 3 coral beads (b); 20 glass beads (b); Fe rod fragment; ivory ring fragments (b); melted Ae	T128
MT86WB	563	0	?	Adult	None	Antler spindle whorl fragment (b)	T063
MT86OR	566	1	M	YMA/OMA?	multiple	bone/antler disc pendant (b); bone comb fragment (ub); Ae vessel edging frags x2 (b)	T065, T066, T067, T068
MT88AHY	627	1	M??	Adult	few	Ivory ring fragments (b); bone comb frags (ub); 4 glass beads (b); crystal bead frag (b)	T145, T146
MT88AEJ	639	1	?	YMA	Horse	Fe saddle fitting; bone object fragment (ub); Ae strap end; double sided bone comb (ub)	T093
MT88AEJ	639	1	-	-	Horse	Fe saddle fitting; bone object fragment (ub); Ae strap end; double sided bone comb (ub)	T149
MT88AKX	649	2	M	YA/YMA	few	perforated bone/antler disc pendant (b)	T020, T022
MT88ADA	702	2	?	YMA	None	Fe shears pair; bone comb fragment (ub); bone/antler perforated disc pendant (b); Fe knife; bone buckle fragment (b); Fe obj	T030, T031, T032
MT88ACX	711	1	M?	YMA?	multiple	Fragment of a burnt bone comb, burnt bone/antler perforated disc pendant	T018, T019

MT88AAV	728	1	F?	YA/YMA	None	1 burnt glass bead, white pottery sherd with painted decoration	T023, T024, T025
MT88AAR	730	1	F?/Ind	Adult	None	1 glass bead (b)	T012, T013
MT88ARG	809	2	?	Adult	None	Ae toilet set (ub) - pair of tweezers, spoon attached to ring	T056
MT88AKQ	815	1	F	YA	multiple	1 bone bead (b); 12 glass beads (b); ivory ring (b); pale green glass vessel fragments (b); Ae melt; antler spindle whorl (b)	T061, T062
MT88AQF	828	2	M	YMA	None	None	T095, T096
MT89BGD	852	1	M?	Adult	Shell fragments	Bone comb fragments (ub); 3 glass fragments	T130, T131, T132
MT89BDM	873	5	F?	Adult	None	Whetstone fragment (ub); bone comb (ub)	T041, T042, T043
MT89BAO	889	5	M?	YMA/OMA?	multiple	Pair of Fe shears; Fe razor; fragment of Fe tweezers; decorated bone strip (b); pale green glass vessel fragment (b); glass melt large; bone/antler pendant (b)	T007
MT89BCB	897	1	M?	YMA	None	3 glass beads (b)	T126, T127
MT89BHX	900	1	F?/Ind	OMA	multiple	None	T009, T010, T011
MT89BHW	910	5	Ind	Adult	dog?	None	T079, T080, T081

MT89BHG	920	0	-	-	Horse	None	T150
MT89BJZ	961	2	?	OMA	multiple	Pair of Fe shears; broken Fe razor; pair of Fe tweezers frags; Fe object	T039
MT89BLN	977	5	F	YMA/OMA?	multiple	3 Ae finger rings (ub); RB roof tile fragment	T076, T077, T078
MT89BLG	983	1-3	?	OMA	Bear phalanges	None	T047, T048, T049
MT89BLG	983	1-3	-	-	Bear phalanges	None	T133, T134
MT89BRU	1003	1	M	YMA	snail	Fe shears pair fragments; Fe razor; miniature Fe tweezers; Bone comb fragments (ub)	T053, T054
MT89BMX	1004	4	F?/Ind	YMA?	multiple	Bone comb fragments (ub)	T036, T037
MT85KA	1050	4	?	Adult	None	Fe staple	T139, T140
MT86WV	1058	4	M?	YMA?	None	Antler spindle whorl fragments; Ae cruciform brooch (Fe pin present); Bone comb fragment (ub); 2 glass beads (b)	T120, T121, T122

5.1.3 RESEARCH QUESTIONS

Table 9 above summarises information of samples (listed as SampleID) taken from a selection of the available cremation burials at Cleatham. As the overall number of cremation burials at the cemetery was too large to allow for a complete analysis, the number was narrowed down following strategic questions and queries. In summary, the research questions for this site are driven by the following aspects of enquiry:

1. Information from osteological analysis – Estimated sex and Age; identity; agency
2. Phasing – Temporal aspect; changes through time; identity; agency
3. Romano-British vessel – uniqueness / deviance; identity; agency; community structure
4. Animal bone and accessory vessels – human-animal connection; identity construction; agency

First, the choice was made to focus on those cremation burials which had demographic information attached. It was hoped that this would increase the interpretative potential of the site, including such information as age, sex, and pathologies of the individuals. Next, the temporal aspect of the cemetery was considered – did the level of mobility vary between the different phases of activity at Cleatham? If so, how is this reflected in the isotopes; and is it possible to determine which direction this took? Although at first it was hoped that cremated remains could be tested for all five phases, this was not selective enough and due to the financial restrictions of this project, it was decided to focus on the earliest and on the latest phases only. The individuals were divided into two groups - according to phases one and two versus phases four and five. The pre-selections were based on the databases available at ADS[1] which were created by Squires during her PhD thesis (Squires 2011).

[1] Accessible at: https://archaeologydataservice.ac.uk/archives/view/cleatham_cba_2007/ (last accessed 20.11.2021

The third level of enquiry (Question 3., see above) was aimed at the physical contextual information of the burials. Specifically, a question was raised about the mobility of the small number of individuals buried in Roman-style vessels (Table 10), and those buried inside urns with Pb plugs (Table 11). These vessels appeared in small numbers, which clearly made them stand out.

TABLE 10 – ROMAN-STYLE VESSELS AT CLEATHAM.

Cremation	CremNr	Roman vessel	Sample ID
MT88AKX	649	Yes	T020, T022
MT88ADA	702	Yes	T030, T031, T032
MT88ARG	809	Yes	T056
MT88AQF	828	Yes	T095, T096
MT89BJZ	961	Yes	T039

TABLE 11 – VESSELS WITH ASSOCIATED PB PLUGS AT CLEATHAM.

Cremation	CremNr	Pb plug	Sample ID
MT86SB	458	Yes	T111, T112
MT86OR	566	Yes	T065, T066, T067, T068
MT88AKX	649	Yes	T020, T022

The fourth level of enquiry (Question 4., see above) pertained to the accessory vessels which contained the remains of animals (Table 12). While 38% of all burials at Cleatham contained animal bone (370/1006), only nine urns were classed as ‘accessory’ deposits (Squires 2013: 162-163). The benefit was the knowledge that the accessory vessel was in direct contact with the associated human burial, either placed below the other vessel – urned or unurned - or directly next to it. For example, in the case of the accessory vessel MT84GBb (urn 242), which contained the remains of a horse, this was directly below that of the associated cremated human remains in MT84GA (urn 71). The same contextual relationship was recorded for urns MT84LS (accessory vessel with horse remains, 158B) and MT84LR (associated human remains, 158B), both with urn number 158. Here, the

vessel including the horse was again placed below the human remains. The question here is targeting the animal-human relationship in relation to spatial mobility.

TABLE 12 – VESSELS WITH ASSOCIATED HUMAN REMAINS (SEPARATE VESSEL).

Cremation	CremNr	Accessory vessel	Sample ID
MT84LS	158	Yes	T147
MT84GBb	242	Yes	T046, T148
MT88AEJ	639	Yes	T149
MT89BHG	920	Yes?	T150

Due to sampling constraints, it was not possible to sample all cremation deposit in these query groups, but an effort was made to include as many as possible, and a minimum of three examples.

A Microsoft Access database was created to collect and query all information related to this study. Osteoarchaeological information was collected independently of Squires' PhD study. Primarily this was done to look at inter-observer differences in osteological determinations, and to increase the confidence of this author in the interpretations following the isotope analysis, related to such variables as age and sex. This step also facilitated the sample selection for the destructive sampling. As Squires has discussed such parameters as warping, fissuring, shrinkage and weight and size of the cremated remains in detail for her thesis, this was not re-done. Cremated bone is brittle and repeated sieving and unnecessary handling can cause further breakage, which would in the end falsify the results. The main re-examination was conducted blind to Squires' results with a focus on the age, sex, and observable pathology of the individuals. A form was specifically created for this task and can be found in Appendix A.5.

5.1.4 PHASING ISSUES AND FURTHER CONSIDERATIONS

In his PhD thesis on the pre-burial origins of the Cleatham and Elsham urns, Perry demonstrated that the phasing based on stamp groups developed by Leahy was partially erroneous. This was based on Perry's emphasis on the structure of the designs, the execution of motifs, and the types of stamps used in a more holistic approach, rather than a more narrow focus solely on stamps (Perry 2013: 297). In two sample areas of the Cleatham cemetery, Perry identified approximately 17 groups, which he termed 'vessel groups' according to their composite assemblages of motifs, design, and stamp choice. He was able to show that certain vessels occurred more frequently in particular areas, and that some of these were demonstrably stratigraphically related. By extension, he made the argument that it was possible to identify a form of family, community, or kin plot in these cemeteries (ibid: 427). According to Perry, individual potters supplied groups with particular vessels, which they would then use in a domestic context, to be seen by others in their own community as well as further afield, which would allow for the spread of certain motifs, designs, and stamps. In this way, other potters were able to see these vessels and create their own versions and combinations in a creative way (ibid: 312). Therefore, we are looking at a much more organic development of change in the use of certain designs, which was relatively consistent through time. This means that the phasing by stamp typology employed by Leahy might not hold up in all cases, especially where chronological stratigraphic relationships cannot be proven. If a specific community held on through time to a particular design, or use of stamps and motifs, these vessels do not necessarily hold contemporary remains. This is further complicated by the fact that Perry showed how a majority of funerary vessels at Cleatham and Elsham were used in a domestic context, in the production and fermentation of foods, before they were buried to hold the cremated remains of individuals (Perry 2013). We must therefore be careful with the interpretation of the chronological differences in mobility when considering the isotope results.

5.2 Results

5.2.1 Life-Mobility-History Grading

Table 13 below summarises the sampling by indicating the frequency of the differing life-mobility grades (according to sample type combinations). This scale rests on the assumption that the sampled skeletal fragments belong to one individual (MNI as found in the osteological analysis). As can be deducted, for most individuals only a poor resolution of life-mobility-history (Grade 6) could be achieved by the sampling of one single skeletal element excluding the otic capsule of the petrous portion (29%, 17/59). However, this includes the remains of five non-humans. For approximately half of all individuals, a life-mobility-history grade of ≥3 (Good a) was noted. The colouring of the table visualises the frequency of each grade, suggesting that the distribution fell into the extremes of the spectrum (either poor/moderate or very good/excellent). For two individuals, only the otic capsule was sampled (Grade 4) because these individuals were recovered from the same burial and their remains were intermingled (168A and B).

TABLE 13 - LIFE-MOBILITY-HISTORY GRADE SUMMARY FOR CLEATHAM.

Life-cover Grade	Individuals	Percentage
1	14	23.7%
2	13	22.0%
3	1	1.7%
4	2	3.4%
5	12	20.3%
6	17	28.8%
Grand Total	59	

5.2.2 AGE AND SEX

Table 14 below reflects the results of the osteological analysis conducted for this study and plots the age and sex groups against each other. In total, 54 cremation deposits were analysed. Most individuals are possible females (31%; 17/54), followed by possible males (19%; 10/54). When possible and securely sexed individuals are added together, 41% are females and 33% are males (22/54 and 18/54 respectively). The number of individuals who could not be sexed because they were indeterminate (Ind) was lower with 9 % (5/54), while 15% of the selection (8/54) did not have sufficient sexually dimorphic traits present (?) to allow identification. In terms of age groups, the majority of individuals fell within the younger middle adult range (22%, 12/54), although the same percentage could only be identified as generic adult.

TABLE 14 - RESULTS OF OSTEOLOGICAL ANALYSIS. AGE GROUPS VS SEX OF CREMATED INDIVIDUALS – GIVEN AS NUMBER OF INDIVIDUALS AND PERCENTAGE OF SAMPLE. COLOUR SCALE INDICATES RELATIVE FREQUENCY OF INDIVIDUALS (LIGHT BLUE TO DARK BLUE).

	F	F?	F?/Ind	Ind	M?	M	?	n/a	Grand Total
Non-adult								2	2
ADO?				1					1
YA	1				1	3			5
YA?		2							2
YA-YMA		1				1			2
YMA	1	4			1	4	2		12
YMA?		2	1		2		1		6
YMA-OMA		1	1		2				4
OMA	2				1		2		5
OMA?	1								1
OMA+					1				1
OA					1				1
Adult		7		2			3		12
Grand Total	5	17	2	3	9	8	8	2	54

	F	F?	F?/Ind	Ind	M?	M	?	n/a	Grand Total
Non-adult								3.7%	3.7%
ADO?				1.9%					1.9%
YA	1.9%				1.9%	5.6%			9.3%
YA?		3.7%							3.7%
YA-YMA		1.9%				1.9%			3.7%
YMA	1.9%	7.4%			1.9%	7.4%	3.7%		22.2%
YMA?		3.7%	1.9%		3.7%		1.9%		11.1%
YMA-OMA		1.9%	1.9%		3.7%				7.4%
OMA	3.7%				1.9%		3.7%		9.3%
OMA?	1.9%								1.9%
OMA+					1.9%				1.9%
OA					1.9%				1.9%
Adult		13.0%		3.7%			5.6%		22.2%
Grand Total	9.3%	31.5%	3.7%	5.6%	16.7%	14.8%	14.8%	3.7%	100.0%

5.2.3 PATHOLOGY

The pathological conditions which were observed during the analysis, alongside the demographic information (age and sex) can be found in summarised form in Table 15

below. It is crucial to note that cremation process creates biases in the observation of pathological conditions, because areas such as the dentition are heavily affected by heat and no longer available for analysis after cremation. Pathological conditions were observed in 69% of the human individuals (37/54), excluding the animals (n=5). These ranged from severe trauma (urn 900, YMA-OMA, F?/Ind) to the presence of cribra orbitalia only (urn 20, YA, M; urn 63, OMA, F). In some instances, non-metric traits were present including vastus notches, retained metopic suture, and parietal foramen.

TABLE 15 – SUMMARY TABLE OF AGE, SEX, AND PATHOLOGY OF SAMPLED INDIVIDUALS AT CLEATHAM.

Crem	Crem nr	Age (TL)	Sex (TL)	Pathology
20	MT84AM	YA	M	Slight CO in L+R orbits (small foramina) - full extent.
45	MT84EE	YA	M	Joint surfaces in good condition, no pathology; fine lamellar striations on long bone diaphyseal fragment - non-active.
63	MT84HU	OMA	F	CO in L orbit - vascular pin-sized holes/foramina - not clearly visible in R orbit; joint surfaces generally healthy looking, but vertebral bodies appear to belong to older adult; porosity in roof of palate.
71	MT84GA	YA?	F?	Possible osteochondritis dissecans in distal joint surface of 1st MT – DD: joint surface defect; lamellar new bone on internal surface of long bone (humerus?); lamellar structure looks smooth, but porous.
77	MT84JD	ADO?	Ind	Periosteal reaction on tibia shaft fragment.
84	MT84GJ	OMA+	M?	Entheaseal changes on linea aspera of posterior femur; arachnoid granulations on endocranial surface; L sup facet of thoracic vertebra: central osteophyte (CO) + slight porosity (P) + marginal osteophytes (MO); R cervical facet: MO + CO + P; Ante-mortem tooth loss (AMTL) in R mandible at RM2+3; Periapical abscess/lesion at apex of L mandible (molar area); Dental crowding in anterior mandible - anterior surface turned laterally: RI1+2; also laterally twisted: RC1.
101	MT84EX	YA	M	Slight porosity on endocranial surface of internal occipital crest; (NMT) metopic suture retained.
131	MT84HZ	YMA	F?	None observed
158A	MT84LR	YA	M?	None observed
158B	MT84LS	YA	M?	None observed
168A	MT84AI	Adult	F?	Entheseal changes on both patellae; remodelled periosteal bone on femur + foot phalanx diaphysis - ulceration? / non-specific infection.
168B	MT84AI	Adult	F?	Entheseal changes on both patellae; remodelled periosteal bone on femur +foot phalanx diaphysis - ulceration? / non-specific infection
176	MT84GO	YMA	F?	Slight striations on femoral shaft cortex, non-active; also on tibia shaft; dens of C2 with slight MO around joint surface; periodontal disease mand RM2+3 location.
210	MT84KO	Adult	F?	None observed
219	MT84JL	OMA	F	Porosity on endocranial surface of occipital bone - on internal occipital crest approx centre; heavy dental wear on max RM1.
242A	MT84GBb	-	-	-
262	MT85AA	YA?	F?	None observed
293	MT85EG	YMA	F?	Porous and smooth lamellar bone spicules in lateral L sinus - sinusitis; occipital endocranial surface: porous, smooth lamellar bone (on central crest); porosity on femoral head and pitting - DJD; vertebral joint surfaces: good condition generally.
309	MT85EN	YMA	M	L patella with vastus notch (NMT).
320	MT85FN	Non-adult	n/a	None observed
327	MT85GZ	Adult	F?	Pitting/porosity in palate - infection?
336	MT85GF	Adult	F?	Joints appear to be in fair condition.

363	MT85EY	YMA?	F?	Pitting on palate where palate is present (small extent); periodontal disease?; entheseal changes on phalanges.
443	MT86OM	YMA	F?	Vertebral bodies with MO + P; entheseal changes on deltoid of humerus + along upper/proximal linea aspera of femur; vastus notch (NMT).
452A	MT86OK	YMA-OMA	M?	Small foramina on supraorbital rim and ridge.
458	MT86SB	OMA?	F	OA (3 indicators) on at least 3 rib heads; R cervical with MO+ P; Thoracic? Facet with mayor P and contour change - OA?; slight porosity on supraorbital rims/margins laterally.
488	MT86SZ	Non-adult	n/a	None observed
492	MT86UX	Adult	Ind	None observed
523	MT86RH	YMA?	F?	Non-active, smooth lamellar striations on tibial shaft fragments; parietal foramen (NMT)
548	MT86WK	YMA	F	Porosity on ectocranial surface, small foramina – smooth.
550	MT86UJ	Adult	?	None observed
563	MT86WB	Adult	?	None observed
566	MT86OR	YMA	M	First metatarsal (MT1) distal (head) with significant osteophytes (joint extension); entheseal changes on lateral shaft of phalanges; MO on superior dens joint surface – DJD.
627	MT88AHY	OA	M?	Cranial diploe appears thickened; diploic structure intact; Contour change on inferior body of C2; anterior body of C2 is bulging outwards anteriorly.
639A	MT88AEJ	YMA	?	Slight foramina on ectocranial surface of diploe.
639B	MT88AEJ	-	-	-
649	MT88AKX	YA-YMA	M	Parietal foramen L (NMT); No CO in R orbit, but small foramina in L; joint surfaces clear and in fair condition; Schmorl's node? on vert body.
702	MT88ADA	YMA	?	Maxillary fragment exhibits porosity in palate; porosity on ectocranial skull fragments (not all); parietal foramen x1 (L) (NMT).
711	MT88ACX	YMA?	M?	CO in L orbit (unilateral) - small foramina, small extent; small pitting on external supraorbital ridge.
728	MT88AAV	YA-YMA	F?	None observed
730	MT88AAR	Adult	F?	None observed
809	MT88ARG	YMA?	?	None observed
815	MT88AKQ	YA	F	None observed
828	MT88AQF	YMA	M	Entheseal changes on proximal femur and on humeral shaft.
852	MT89BGD	OMA	M?	Osteophytes around vertebral facet; also around distal phalanx.
873	MT89BDM	Adult	F?	Some slight porosity on R frontal bone and on ectocranial surfaces; some entheseal changes along linea aspera of femur; slight entheseal changes along tibial shaft?
889	MT89BAO	YMA-OMA	M?	DJD on vertebrae (bodies and facets); osteophytes on distal phalanges (feet?) and pseudo-facets.

900	MT89BHX	YMA-OMA	F?/Ind	This individual appears to have had a fracture/ injury in one of their longbones - probably the humerus or tibia. Disorganised areas of trabecular bone with ossification around cortical bone; the cortical structure is disorganised in some areas – osteitis/osteomyelitis?; additional smaller bone fragment (less well cremated) showing a fracture with external ossification of soft tissue; fragment of likely tibia with lamellar striations which appear sharp and fairly active - transitional new bone - periostitis? including a small nodule of lamellar-woven bone (transitional); mandibular torus (DD: button osteoma) 5mm dia, distinct nodule of dense cortical bone extending ca 3mm above normal bone surface (NMT?); cortical defect in acromion.
910	MT89BHW	Adult	Ind	Porosity (small foramina) on endocranial surface of cranium; hyper-cementation on molar and single-rooted tooth.
920	MT89BHG	-	-	-
961	MT89BJZ	OMA	?	Slight porosity on ectocranial surface of vault fragments (parietals along sagittal suture.
977	MT89BLN	YMA-OMA	F?	No CO; small foramen, porosity on ectocranial surface; vertebral surfaces of bodies in ok condition, but do not appear very young; fusion of 2 thoracic/cervical vertebrae (may be sticking together through mud?)
983A	MT89BLG	OMA	?	Heavy tooth wear and caries present (max P4 and M1).
983B	MT89BLG	-	-	-
1003	MT89BRU	YMA	M	Slight MO on superior dens joint surface; periodontal disease - extensive porosity around sockets where present.
1004	MT89BMX	YMA?	F?/Ind	Joints in good condition, no pathology observed.
1050	MT85KA	Adult	?	None observed
1058/5..	MT86WV	YMA?	M?	Low rib 11/12th head with DJD: MO+P; periodontal disease mandibular M2or M3 socket – porosity extensive.

In Table 16 below, the numbers of individuals and crude prevalence rates of affected individuals sampled for this study are listed, separated into the different pathologies. This information was compiled from the osteological analysis for this sample to facilitate comparison with the overall rates and numbers recorded by Squires for her PhD (2011).

TABLE 16 – CRUDE PREVALENCE OF PATHOLOGICAL CONDITIONS OBSERVED IN SAMPLE.

Pathology	Number of individuals	Percentage (CPR)
Cribra orbitalia	4	7
Osteoarthritis	1	2
Degenerative joint changes (DJD)	11	20

Degenerative changes to the vertebral bodies (DDD)	7	13
Schmorl's nodes	7	13
Periosteal reaction /Periostitis	3	6
Fracture	1	2
Woven bone/ Non-specific infection	0	0
Normal striation	3	6
Osteochondritis dissecans (OD)?	1	2
Entheseal changes	8	15
Dental abscess	1	2
Dental caries	2	4
Ante-mortem tooth loss (AMTL)	1	2
Cranial lesion / porosity	13	24
Non-metric traits (NMT)	6	11
Periodontal disease	6	11
Sinusitis	1	2
Thickened diploe	1	2
Hyper-cementosis of dental root	1	2

5.2.4 SR ISOTOPE RESULTS

5.2.4.1 PLANTS

The highest $^{87}Sr/^{86}Sr$ ratio was measured for a tree sample (1-c) on the Triassic sandstone just west of the catchment circle at the height of Cleatham (Table 17). In fact, the consistently highest $^{87}Sr/^{86}Sr$ ratios derived from this geological formation, although the grass and shrub samples are closer to 0.7105. The lowest $^{87}Sr/^{86}Sr$ values derived from Sample location 4B. Here, both grass and tree samples produced a Sr ratio of 0.70830, similarly to tree sample 6-c on the chalk in the east towards the North Sea. The measurement for the shrubs at 4B will be included in a future run with grass samples from Ingleby Barwick. Sample locations 4 and 4B have been combined in the table and box-plot

(Table 17). For the most part, the five additional measurements from Evans *et al.* (2010, 2018) fell within the newly sampled plants for this study.

TABLE 17 – CLEATHAM CATCHMENT -87SR/86SR RESULTS AND ASSOCIATED 2 SIGMA ERROR FOR PLANT SAMPLES.

Sample location	Geological Formation	Sample type	Sample ID	$^{87}Sr/^{86}Sr$	2 SE
1	Triassic sandstone and conglomerate	Grass	1a	0.710250	0.000009
		Shrub	1b	0.710448	0.000012
		Tree	1c	0.711649	0.000011
2	Triassic mud-, silt-, and sandstone	Grass	2a	0.709082	0.000007
		Shrub	2b	0.709185	0.000011
		Tree	2c	0.709834	0.000011
3	Late Triassic - Mid Jurassic mud-, silt-, lime-, and sandstone	Grass	3a	0.709087	0.000010
		Plant	Hull-6*	0.709691	not available
		Shrub	3b	0.709127	0.000010
		Tree	3c	0.711305	0.000009
4+4B	Mid Jurassic lime- and sandstones (Inferior Oolite Group)	Grass	4a	0.708597	0.000012
			4Ba	0.708296	0.000009
		Shrub	4b	0.708968	0.000010
		Tree	4c	0.708816	0.000009
			4Bc	0.708298	0.000009
5	Late Jurassic mud-, silt-, and sandstone (West Walton Formation, Ampthill Clay Formation And Kimmeridge Clay Formation)	Grass	5a	0.708865	0.000009
		Shrub	5b	0.708837	0.000008
		Tree	5c	0.709469	0.000008
		Water	GBASE_410091*	0.709127	not available
6	Late Cretaceous chalk (White Chalk Subgroup)	Grass	6a	0.709763	0.000010
		Shrub	6b	0.708929	0.000011
		Tree	6c	0.708313	0.000008
		Water	GBASE_405907*	0.708790	not available
			GBASE_406357*	0.709440	not available

5.2.4.2 Cremated Animal and Human Bone

Table 18 below lists the complete results of the Sr isotope analysis undertaken for Cleatham cemetery during this study. The $^{87}Sr/^{86}Sr$ ratios are given with 2SE for the measurement. The highest $^{87}Sr/^{86}Sr$ ratio measured was 0.7140 for sample T111, the rib of an older woman (cremation nr 458). The lowest $^{87}Sr/^{86}Sr$ ratio returned for sample T072, the femur of a young adult male ($^{87}Sr/^{86}Sr$ = 0.7087; cremation nr 45). Variation is thus quite wide, especially when the local Sr isoscape is considered.

TABLE 18 – $^{87}SR/^{86}SR$ AND [SR] (NORMALISED TO 40% CA; EXPRESSED AS SR PPM) RESULTS OF THE CLEATHAM CREMATED REMAINS, INCLUDING HUMAN AND NON-HUMAN BONE. SEQUENCE FOR EACH SAMPLE: 87SR/86SR RESULT, 2SE BELOW, AND SR PPM. RESULTS DIVIDED BY TYPE OF SAMPLE AND CREMATION NUMBER AND SAMPLE ID. NHB – NON-HUMAN BONE.

Crem	Crem nr	ID	Otic	Femur/tibia	Cranium	Rib	NHB
20	MT84AM	T026				0.709723 0.000012 76	
		T027			0.709803 0.000008 153		
		T028		0.709711 0.000008 132			
45	MT84EE	T072		0.708649 0.000009			
		T075			0.708752 0.000011 166		
63	MT84HU	T069				0.709737 0.000010 115	
		T070	0.710146 0.000008 156				
		T071				0.709701 0.000010 93	
71	MT84GA	T033				0.709256 0.000010	
		T035				0.709196 0.000010 108	
77	MT84JD	T123				0.709585 0.000010 157	
		T124		0.709367 0.000008 134			
		T125	0.709996 0.000012 111				
84	MT84GJ	T058				0.709079 0.000010 85	
		T059		0.709341 0.000010 167			
101	MT84EX	T015			0.709051 0.000009 174		
		T016				0.709014 0.000010 150	
131	MT84HZ	T098				0.709248 0.000010 140	
		T099	0.710674 0.000008 119				
176	MT84GO	T050				0.709877 0.000009 121	
		T051		0.709842 0.000009 102			
		T052	 163				

210	MT84KO	T135			0.709833 0.000010 86		
		T136		0.709775 0.000006 82			
219	MT84JL	T108				0.711175 0.000008 107	
		T109		0.711243 0.000008 97			
242	MT84GBb	T046					0.713221 0.000010 925
		T148					0.713346 0.000010 563
262	MT85AA	T117		0.709875 0.000010 93			
		T118			0.709493 0.000013 53		
		T119	0.711689 0.000008 88				
293	MT85EG	T100			0.710415 0.000009 80		
		T101	0.711104 0.000008 113				
309	MT85EN	T102				0.709192 0.000010 135	
		T104	0.709450 0.000009 172				
320	MT85FN	T141			0.709456 0.000009 124		
		T142	0.709448 0.000011 118				
327	MT85GZ	T143			0.709767 0.000010 69		
336	MT85GF	T086		0.709820 0.000009 116			
		T087	0.712771 0.000009 142				
363	MT85EY	T083			0.710083 0.000008 198		
443	MT86OM	T115		0.710317 0.000009 178			
		T116	0.712838 0.000010 165				
458	MT86SB	T111				0.713977 0.000013 75	
		T112	0.712746 0.000010 112				
488	MT86SZ	T144			0.709932 0.000011 86		

492	MT86UX	T088		0.709699 0.000008 118			
		T089				0.709818 0.000010 142	
523	MT86RH	T105				0.709672 0.000007 120	
		T106		0.709687 0.000010 74			
		T107	0.710396 0.000008 142				
548	MT86WK	T090		0.709465 0.000008 137			
		T091			0.709640 0.000007 136		
550	MT86UJ	T128			0.709574 0.000010 120		
563	MT86WB	T063				0.709785 0.000008 96	
566	MT86OR	T065				0.709600 0.000010 83	
		T066		189			
		T067	0.709407 0.000008 179				
		T068			92		
627	MT88AHY	T145				0.709511 0.000008 141	
		T146	0.710252 0.000012 150				
639	MT88AEJ	T093				0.709335 0.000010 148	
		T149					0.709766 0.000006 336
649	MT88AKX	T020				0.709736 0.000008 150	
		T022	168				
702	MT88ADA	T030				0.709401 0.000012 67	
		T031		0.709362 0.000008 66			
		T032	0.709483 0.000008 146				
711	MT88ACX	T018				0.709686 0.000011 174	
		T019	0.709489 0.000007 135				

728	MT88AAV	T023				0.709691 0.000009 198	
		T024		0.709702 0.000009 186			
		T025	0.710041 0.000010 128				
730	MT88AAR	T012			0.709678 0.000014 109		
		T013				0.709246 0.000009 93	
809	MT88ARG	T056			0.711931 0.000009 208		
815	MT88AKQ	T061				0.708853 0.000008 87	
		T062	0.709310 0.000011 117				
828	MT88AQF	T095			0.710189 0.000009 133		
		T096		0.710148 0.000008			
852	MT89BGD	T130				0.709132 0.000009 63	
		T131		0.709186 0.000008 98			
		T132	0.709447 0.000010 116				
873	MT89BDM	T041				0.709914 0.000009 107	
		T042		0.709918 0.000009 153			
		T043	0.710262 0.000009 127				
889	MT89BAO	T006				0.709651 0.000008 146	
		T007		0.709449 0.000009 85			
		T008	0.709475 0.000007 107				
897	MT89BCB	T126				0.709614 0.000011 66	
		T127	0.709355 0.000010 114				
900	MT89BHX	T009				0.709209 0.000008 121	
		T010		0.709947 0.000010 119			
		T011	0.709433 0.000011 197				

910	MT89BHW	T079				0.709040 0.000011 155	
		T080		0.709192 0.000009 181			
		T081	0.709594 0.000010 180				
920	MT89BHG	T150					0.709087 0.000010 633
961	MT89BJZ	T039				0.709251 0.000009 192	
977	MT89BLN	T076				0.709856 0.000009 212	
		T077		0.709800 0.000009 195			
		T078	0.709303 0.000007 209				
983	MT89BLG	T047		0.709749 0.000010 235			
		T048			0.709769 0.000010 122		
		T049	0.710129 0.000008 147				
		T133					0.710589 0.000011 269
		T134					0.710568 0.000011 479
1003	MT89BRU	T053				0.709327 0.000011 142	
		T054		0.709327 0.000008 275			
1004	MT89BMX	T036				0.709530 0.000009 155	
		T037		0.709788 0.000010 86			
1050	MT85KA	T139			0.709740 0.000013 53		
		T140	0.709390 0.000011 104				
168A	MT84AI	T151	0.709954 0.000011 126				
168B		T152	0.710402 0.000008 195				
158A	MT84LR	T137			0.709748 0.000010 65		
158B	MT84LS	T147					0.709909 0.000011 585
452A	MT86OK	T044			0.709728 0.000009 104		

1058/519B	MT86WV	T120				0.709571 0.000011 126
		T121			0.709587 0.000009 153	
		T122	0.710133 0.000011 107			

5.3 DISCUSSION

5.3.1 PLANTS

All $^{87}Sr/^{86}Sr$ results can be observed in Fig. 54 below, where they are listed at their geographical sampling location. In Table 17 and Fig. 54, all samples are plotted according to the geological formation that they originate from, in order to show the $^{87}Sr/^{86}Sr$ variation for each formation. The tree sample 3-c from the Cleatham cemetery site was elevated compared to the shrub and grass samples from the same location. One possibility to explain the rogue tree sample is to consider its geographic location near large-scale anthropogenic interventions in the landscape. The sampling area – a small copse - was near an extensive quarry site. Dust particles from this quarry may have been deposited on the leaves of the trees, which may have caused it to reflect the exposed bedrock nearby, rather than that of the topsoil in the copse. The grass and shrub samples were picked from within and around the tree cover and may have been protected to a greater extent from windblown deposits. Two additional samples from Evans *et al.* (2010; 2018) were located on the Late Triassic/Mid Jurassic sedimentary rocks within the catchment, although one of these was a dentine sample (FLIX-1d; 0.70901) and might not appropriately reflect the local BASr due to its incorporation of biogenic as well as diagenetic Sr - it was therefore excluded (Madgwick *et al.* 2019: 229). Although similar in character, the Triassic sandstones from sample locations 1 and 2 exhibit different ranges of $^{87}Sr/^{86}Sr$. According to Evans *et al.* (2018), expected values for this type of geology range from 0.7098 to 0.7127 (n=9). While those from location 1 exhibit variation from 0.7103 to 0.7117, those at location 2 fall in-between 0.7091 and 0.7098. While the former samples measured for this study fall

within the expected range, the latter do not conform to this and lie below the minimum measured value for Triassic sandstone. It is likely that there is some area-specific variation present in the area, with slightly lower-than-expected $^{87}Sr/^{86}Sr$ around sampling site 2. It would be useful to collect and measure a higher sample density at a future date to characterise these discrepancies further.

When all the samples are considered, then, there is a slight trend apparent which appears to reflect slightly more elevated $^{87}Sr/^{86}Sr$ ratios in the west of the catchment from the Triassic sedimentary bedrock, and lower ratios from the Oolites (Sample locations 4 and 4B). The Cretaceous chalk and limestone outcrops in the east of the catchment are well characterised by Evans *et al.* (2018; n=85; 0.7075-0.7101), and the new samples fall into the upper spectrum of this range (0.7083-0.7098).

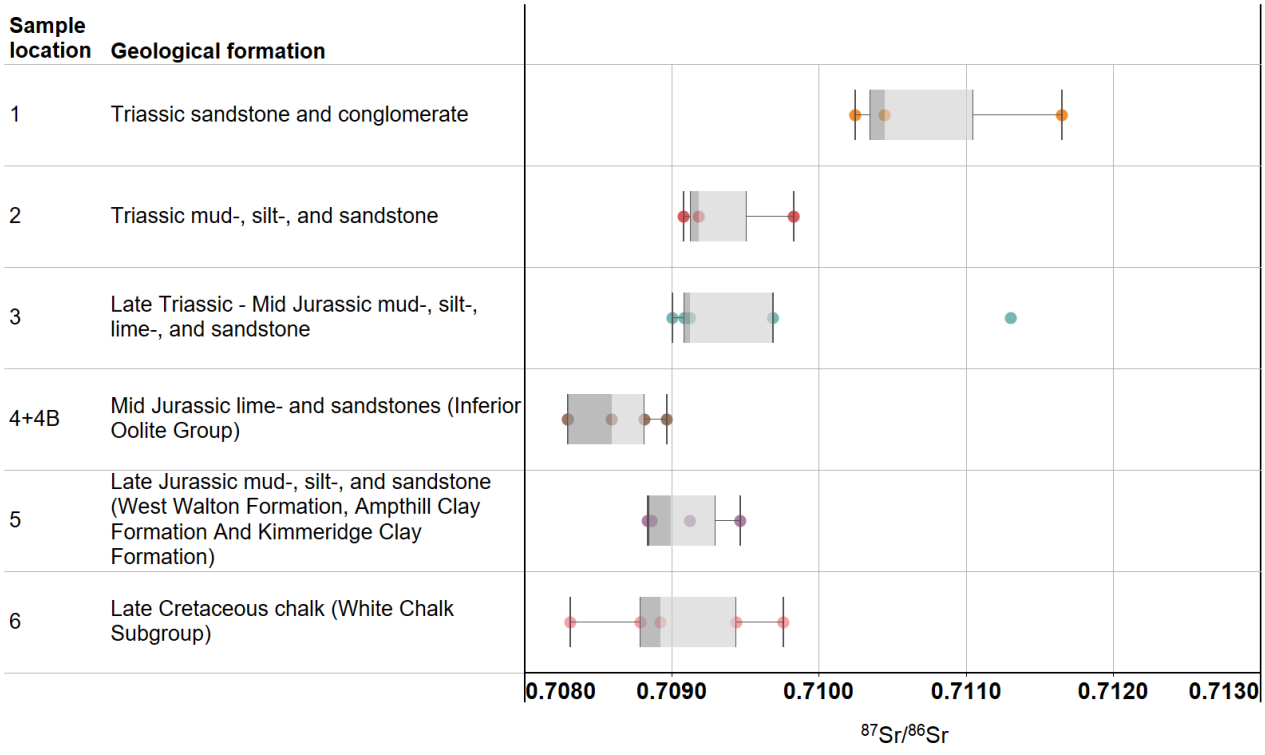

FIGURE 54 - BOX AND WHISKER PLOT OF $^{87}SR/^{86}SR$ VARIATION FROM DIFFERENT GEOLOGICAL FORMATIONS IN 25KM CATCHMENT AREA. PLOT INCLUDES AVAILABLE DATA FROM EVANS ET AL. (2018). BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES. SINGLE POINTS ARE EXTREME OUTLIERS.

5.3.1.1 BASR CLEATHAM

An individual raised in the Cleatham catchment – or residing there for a long time before their death – would be expected to fall within a $^{87}Sr/^{86}Sr$ range of approximately 0.7083 to 0.7101. Should they have procured most of their diet from the west of the catchment area, they are likely to have elevated $^{87}Sr/^{86}Sr$ of up to 0.7116. In this way, it might be possible to determine where the individuals buried at Cleatham derived major food sources from, or by extension where they lived.

5.3.2 Cremated Animal and Human Bone

5.3.2.1 Phasing

Overall, 35 individuals fall into the first two phases (65 % of overall human sample, n=54), and 14 into the last two (26%). Four unphased urns are also included in the sample (7%), and one urn was sorted into phases one to three (2%) (Fig. 55). This means that there likely is a bias in the representation when the sample is considered across the phases. It is important to consider this caveat in the interpretation of the results, because especially the small number of individuals from the later phases may lead to misinterpretations. For this reason, phases one and two, and phases four and five will be considered together during the analysis as an 'early phase' and a 'late phase'.

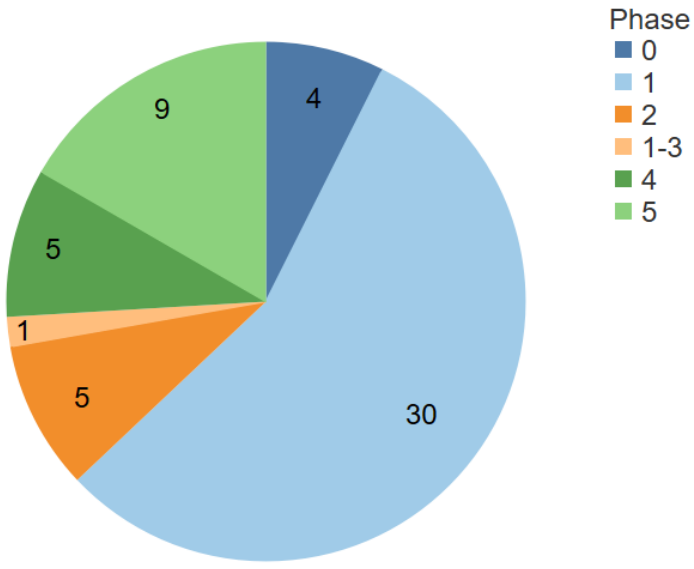

FIGURE 55 – PIE CHART OF SAMPLE DISTRIBUTION OVER THE FIVE PHASES DETERMINED BY LEAHY (2007). NUMBERS OF INDIVIDUALS INSIDE THE RESPECTIVE CHART AREA (N=54). *CHART EXCLUDES FOUR ANIMAL INDIVIDUALS.*

5.3.2.2 SEX

Table 19 below summarises the data from Squires' 2011 PhD research on the 1009 individuals from Cleatham, and Fig. 56 summarises the data for the sample used in this study (n=54) for comparison. As can be determined from the two illustrations, a majority of sexed individuals in both cases fell into the 'female' or 'possible/probable female' categories. This may be a true reflection of some cemeteries in the early medieval period where such discrepancies have been noted in Britain as well as on the continent, amongst inhumation and cremation burials (McKinley 1993(a): 294; 1994: 69; Squires 2011: 257; Squires 2012: 335; Rösing 1994: 199; Groves *et al.* 2013). While this is not exclusively the case and there have been cemeteries noted which fall outside of this pattern, the matter has been discussed elsewhere in detail (Squires 2012: 335-337). Generally, the observed early medieval predominance of females in cemeteries is explained by preservation bias of the remains themselves (although this is likely to only have a small effect, if any), by 'separate-sphere' approaches where men are more mobile in the context of providing for their families, and by the high mortality rate of women during pregnancy and childbirth. Additionally, men are more likely to die away from 'home' due to their participation in warfare. It should be added to this that when we are concerned with pre-Christian societies it is possible that practices such as polygamy or concubinage existed in one form or another. While this is usually understood to involve violence and practices of oppression (i.e. Clunies Ross 2000; Raffield *et al.* 2017a; Raffield *et al.* 2017b), it might also have involved elements of relationships that defy early modern western ideas (and ideals) of exclusivity and that are subject to fluidity. By extension, the presence of a higher number of females at certain cemeteries is not necessarily surprising or unexplainable.

The selection of the sample for this study was in part based on the potential to assign the individuals a sex, and Squires' work was essential in this undertaking. Therefore, most of the selected sample individuals were sourced from the 328 individuals who Squires had sexed previously (see section 5.1.3 above).

TABLE 19 – SEX PROFILE OF INDIVIDUALS ASSIGNED TO ESTIMATED SEX CATEGORIES AT CLEATHAM OVERALL (N=328; SQUIRES 2012: 326 – AS TABLE 10).

Sex category	Number and percent (%) of individuals
Male	32 (9.8%)
Female	58 (17.7%)
Probable male	17 (5.2%)
Probable female	40 (12.2%)
Possible male	33 (10.1%)
Possible female	81 (24.7%)
Indeterminate	67 (20.4%)
Total	328 (100%)

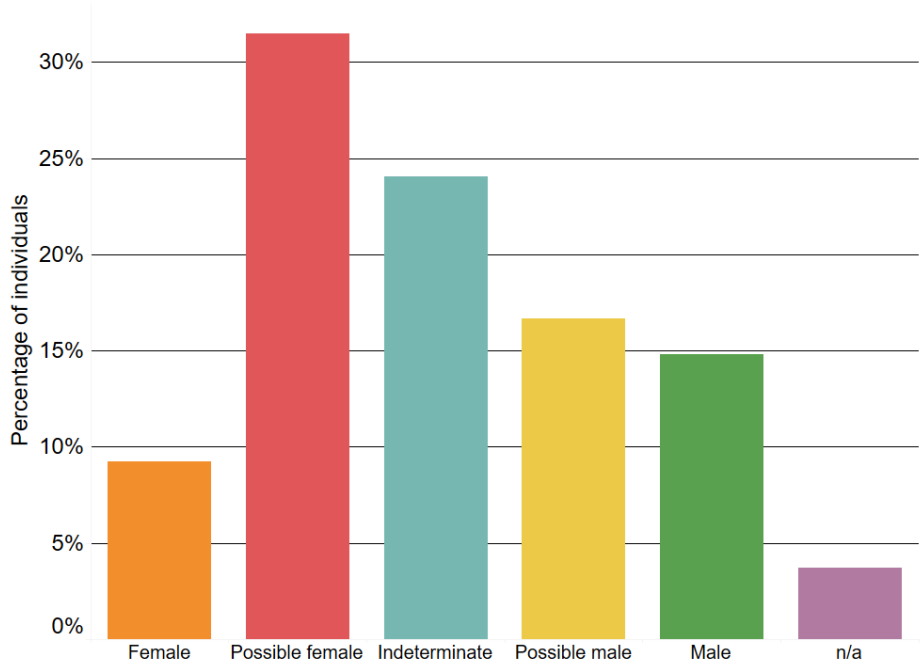

FIGURE 56 – ESTIMATED SEX PROFILE OF INDIVIDUALS FROM SAMPLE (SIMPLIFIED – "F?/IND" AND "?" WERE SORTED INTO "IND" CATEGORY).

Although fewer numbers of estimated males are represented in the sample (Fig. 56), the attempt was made to have approximately equal numbers of males vs females available for

study. One issue was the re-sexing by the current author during the osteological analysis which resulted in the assignment of a different sex for a small number of individuals. It was also attempted to have approximately equal numbers of both sexes across the five phases of cemetery use identified by Leahy (2007) (see Fig. 57). In the end, the ratio was 3:4 (12 M : 16 F) covering phases one and two, and 1:1 (5 M : 5 F) for phases four and five.

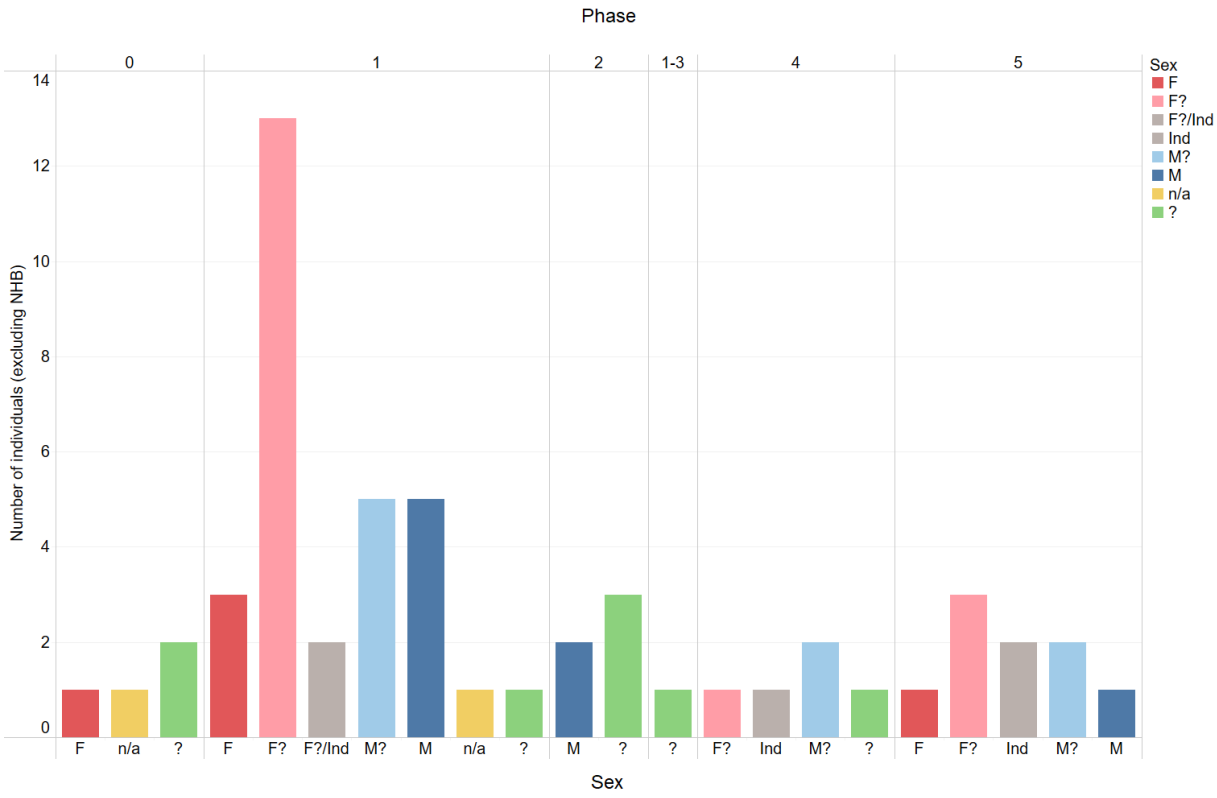

FIGURE 57 – SEX OF INDIVIDUALS ACROSS ALL CEMETERY PHASES (0 DENOTES UNKNOWN PHASE), BASED ON LEAHY (2007 PHASING).

5.3.2.3 AGE

At Cleatham, Squires found during her osteological analysis of all 1009 individuals that many of those practising cremation fell into the young adult and mature adult age categories (Fig. 58). The same trend is mirrored in the sample of 54 individuals selected for this study, although the number of non-adults overall is much lower (Fig. 59).

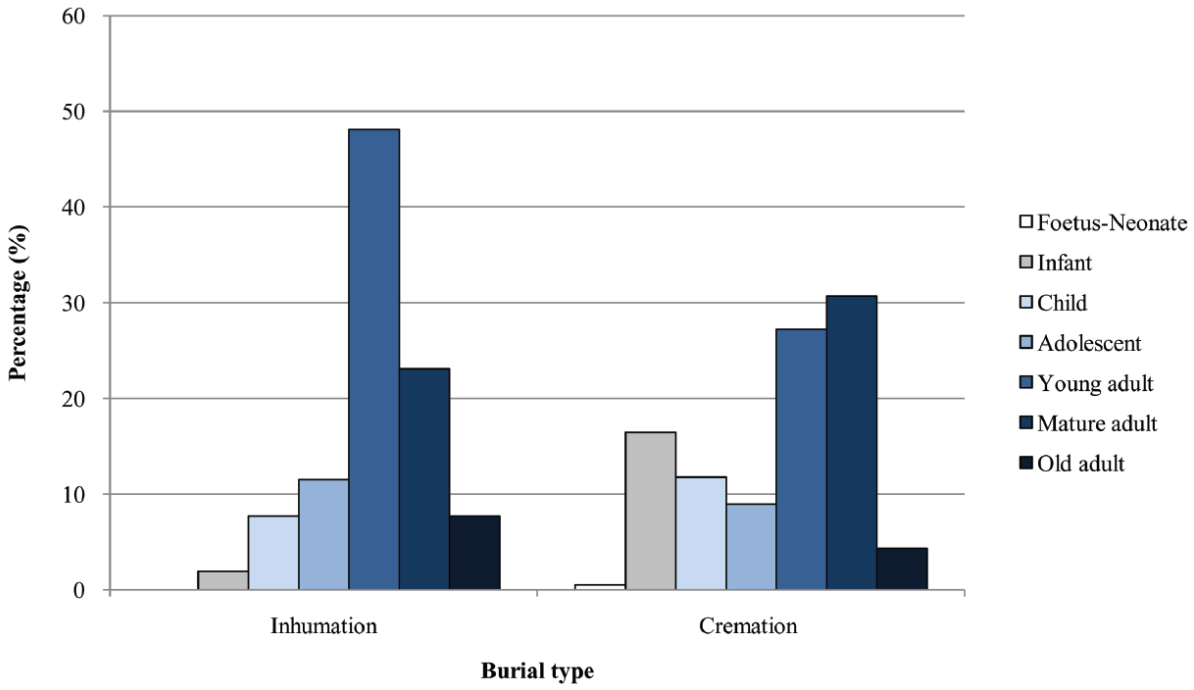

FIGURE 58 – AGE PROFILE OF INDIVIDUALS BURIED AT CLEATHAM CEMETERY (SQUIRES 2012: 330 – AS ILLUSTRATION 1)

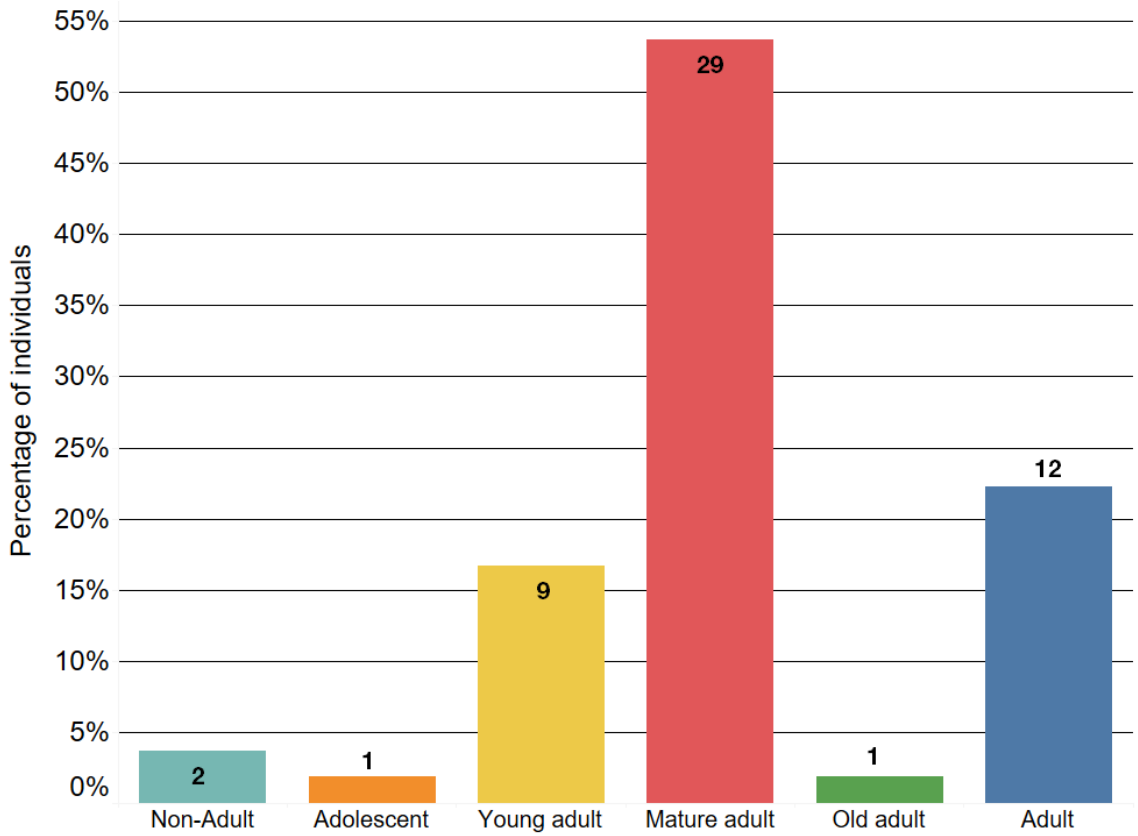

FIGURE 59 – AGE PROFILE OF INDIVIDUALS SAMPLED FOR THIS STUDY (SIMPLIFIED GROUPINGS). NUMBERS ON BARS INDICATE INDIVIDUALS.

While the different age groups are represented across all phases (Fig. 60), similar difficulties as in the sex distribution were encountered during sample selection and osteological analysis. A majority of the sample population falls into the younger middle (or mature) adult (YMA) category, and unfortunately it was not possible to be more precise about the age of a small number of individuals categorised as 'Adult'. While questions pertaining to age groups may be asked about the earlier phases at the cemetery, they will be much less answerable for the later phases. However, the age groups will still be useful during the individual assessment of mobility and where contextual information is drawn into the discussion.

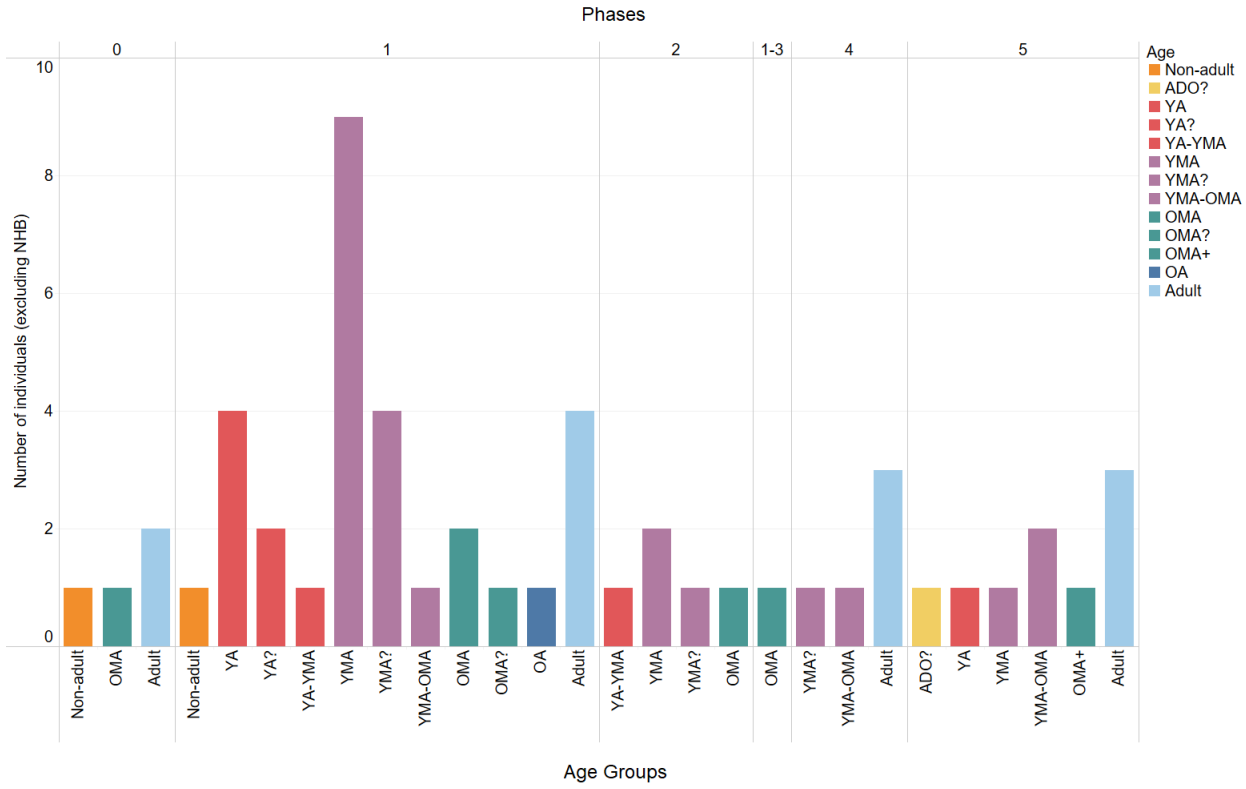

FIGURE 60 – BAR CHART OF DISTRIBUTION OF AGE GROUPS ACROSS THE FIVE PHASES (BASED ON LEAHY 2007).

5.3.2.4 SPATIAL VARIATION OF $^{87}Sr/^{86}Sr$ - REVIEW

The plant sampling in the 25km catchment around the burial site suggests that any individual who grew up here will exhibit minimum $^{87}Sr/^{86}Sr$ values of 0.7083 and 0.7101. However, it was observed that plant samples which were collected from the western region

in the catchment yielded slightly higher $^{87}Sr/^{86}Sr$ values up to 0.7116 (see sections 5.2.4.2 and 5.3.1). The suggestion is that individuals who exhibit these values may originate/have lived or derived food from this area to a higher degree than those individuals who did not.

5.3.3 Sr isotopes at Cleatham cemetery

Fig. 61 below shows the variation in [Sr] and $^{87}Sr/^{86}Sr$ ratios amongst the different skeletal element groups. Non-human bone (NHB) is listed separately. As can be observed in the plot of [Sr], there exists almost no overlap between the concentrations measured for humans and non-humans, with the exception of one femoral value from urn 1003 (YMA male). This highlights the trophic-level difference between the two groups in terms of diet – humans as omnivores with a significant protein component, and the represented animals primarily as herbivores (especially in this case: four horses, one bear). The lowest of the Sr concentrations amongst the animals was measured on a bear phalanx (urn 983), which is perhaps not surprising, seeing as most bear species are omnivorous and therefore their diet contains a certain percentage of animal protein.

The lighter green band on the $^{87}Sr/^{86}Sr$ plot indicates the local biosphere, while the darker green band represents the plant samples taken primarily from the west of the cemetery. It is likely that individual measurements which fall into the latter range are either produced in this more westerly region or represent specific food procurement from there. As can be observed in the box-and-whisker plot (Fig. 61), this seems to be especially the case for childhood values measured in the otic capsule. To recapitulate – this part of the petrous portion forms from 16-18 weeks *in utero* until approximately two years of age, after which hardly any turnover is apparent (Sørensen 1994; Harvig *et al.* 2014; Veselka *et al.* 2021). In fact, at Cleatham the otic capsule $^{87}Sr/^{86}Sr$ values are subject to much larger variation than any other human skeletal sample type used for this study, which suggests that origins – or indeed maternal origins – are diverse at this site. These varied $^{87}Sr/^{86}Sr$ ratios are coupled with a much more restricted variation in [Sr], where a likely factor is infant nutrition and especially breastfeeding.

The same trend is observable in the measured values for the non-human animal bone, where [Sr] variation is limited (see above) and $^{87}Sr/^{86}Sr$ variation is great. The implication is that the animals buried at Cleatham have grazed on different pastures (i.e. the horses) from each other. They do not appear to have come from one specific area in the vicinity of Cleatham, and one horse even appears to have grazed outside the 25km catchment (urn 242). The bear (urn 983) may have originated to the west of Cleatham (discussed below). The $^{87}Sr/^{86}Sr$ data points falling outside of the green bands indicate longer-distance mobility.

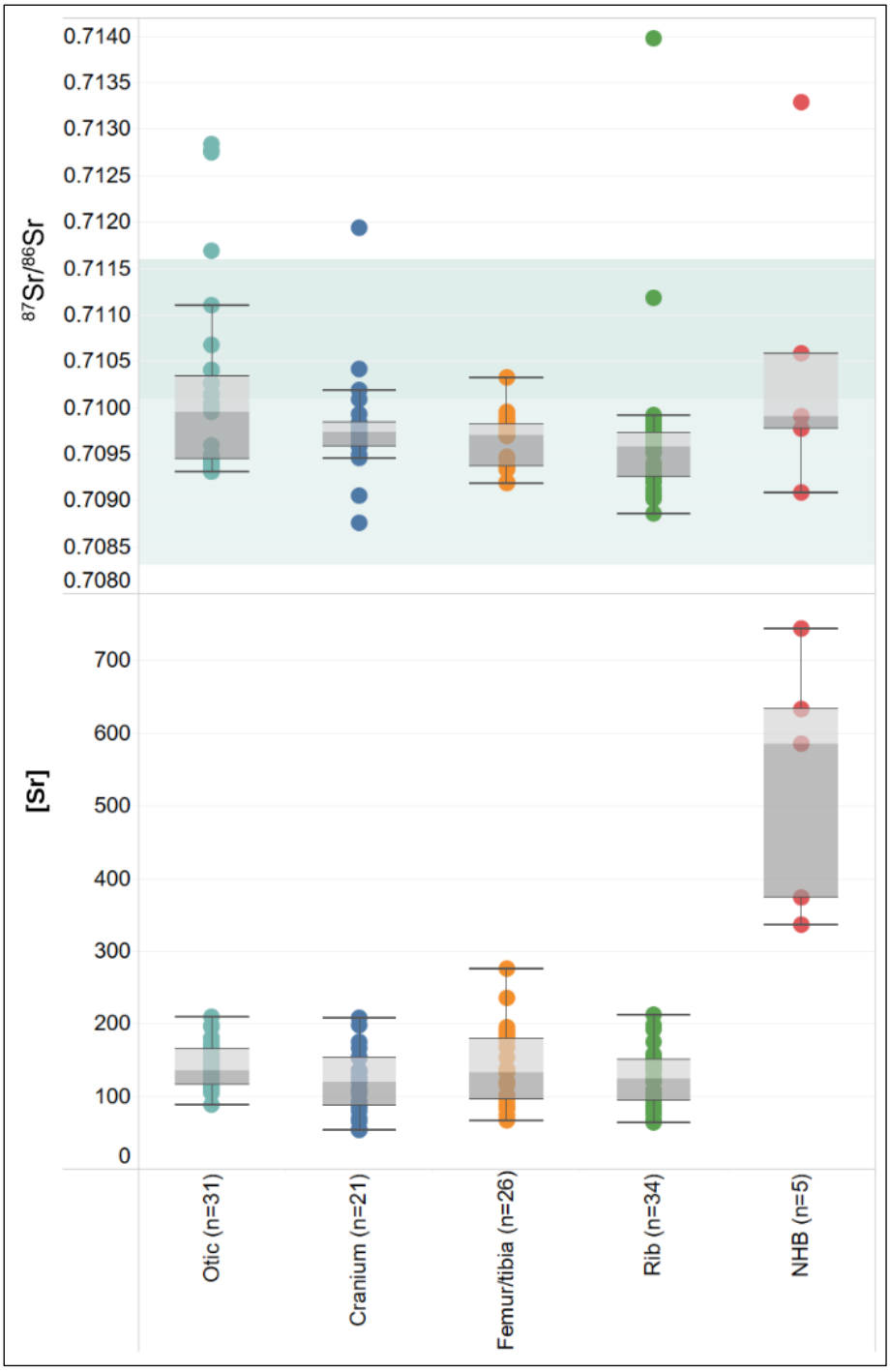

FIGURE 61 - BOX-AND-WHISKER PLOT HIGHLIGHTING RANGE OF $^{87}SR/^{86}SR$ *AND [SR] (PPM)* VARIATION AMONGST DIFFERENT SKELETAL ELEMENTS, AND HUMANS VS NON-HUMANS. LIGHT GREEN BAND INDICATES LOCAL BIOAVAILABLE $^{87}SR/^{86}SR$ RANGE, DARKER BAND INDICATES MORE WESTERLY AREAS INSIDE THE CATCHMENT *(AND BEYOND)*. *NHB = NON-HUMAN BONE.* BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES. SINGLE POINTS ARE EXTREME OUTLIERS.

Based only on Figures 61 and 62, several general observations can already be made about the burial population at Cleatham:

a) The $^{87}Sr/^{86}Sr$ values of the otic capsules indicate varied childhood origins of the human individuals, with evidence for longer-distance mobility.

b) A large percentage of childhood origins appear to derive from the western area of the catchment (dark green band in plot), though other areas are clearly possible beyond the 25km catchment area (Evans *et al.* 2010).

c) Adult $^{87}Sr/^{86}Sr$ values from rib samples fall almost exclusively into the range expected for most of the 25km catchment (lighter green area in graph) and are limited in variation which suggests that most individuals buried at Cleatham whose ribs were analysed for $^{87}Sr/^{86}Sr$ spent the last years before death in this area.

d) The cranial and long bone diaphyseal samples are indicative of $^{87}Sr/^{86}Sr$ input from the western area of the catchment (or elsewhere with similar $^{87}Sr/^{86}Sr$).

e) [Sr] of the human individuals in the femoral, cranial, and rib samples are consistently varied, which may be due to differential diets, mobilities, pathological conditions, chronological or other sampling factors.

f) Non-human animal mobility from outside the 25km catchment and the western region is also evident at Cleatham, although only few individuals are represented in the plot.

g) The trophic level is clearly apparent through the comparison of [Sr] between animals and humans.

In the plot in Figure 62 below, the $^{87}Sr/^{86}Sr$ ratios of all samples is plotted against the [Sr] (expressed as 1/Sr ppm x 1000). Although this scatter plot is useful to observe the general distribution of the data and shows the interesting variation in the otic capsule samples and the high [Sr] of the animal bone, the plot requires breaking down according to the research questions.

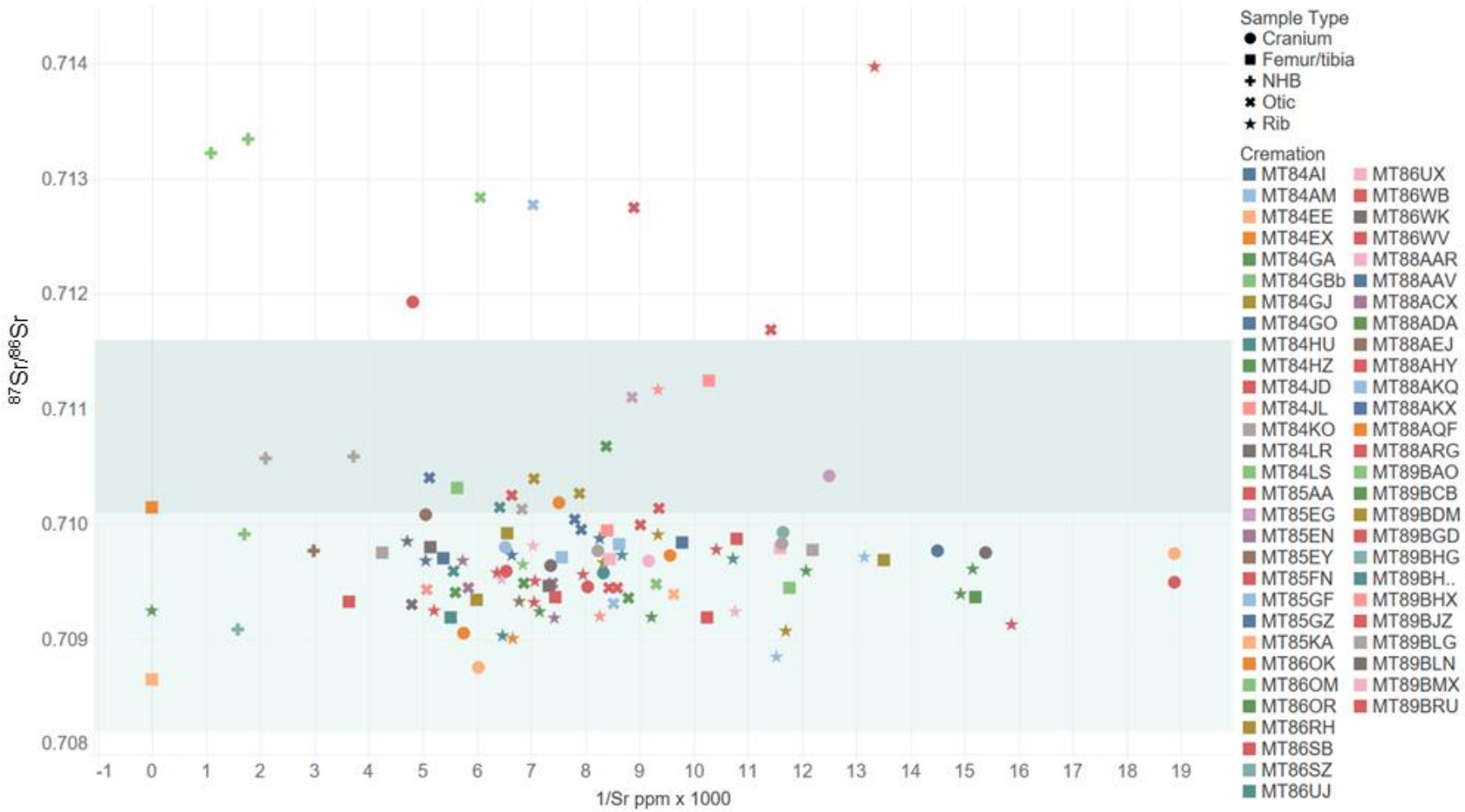

FIGURE 62 - $^{87}SR/^{86}SR$ VS [SR] SCATTER PLOT INCLUDING ALL SAMPLES AND COLOUR-CODED BY INDIVIDUAL CREMATION. SAMPLE TYPE BY SHAPE.

5.3.4 SEX

Starting with the objective to examine and define the differences observable in mobility based on the sex of the individuals, Figs. 63 contains the distribution with this aspect as sole focus. The data shows the connections between the different sample types for each individual sexed female or possible female. This means that trajectories can be highlighted based on the bone turnover and remodelling rates of the differing elements. Where available, the otic capsule samples of each individual provides the starting point of the trajectory (square frames) as a representation of infant $^{87}Sr/^{86}Sr$, after which available femoral, cranial, or rib $^{87}Sr/^{86}Sr$ values are targeted. In some cases, cranial and femoral $^{87}Sr/^{86}Sr$ values are connected by a dotted line, because they represent a similar longer-term accumulation of $^{87}Sr/^{86}Sr$. The plot also includes the cremation numbers for identification of certain individuals. Upon consideration of both plots (Fig. 63 and Fig. 64) the difference between female and male mobility appears striking. All of the individuals falling outside of the local Sr biosphere range ($^{87}Sr/^{86}Sr$ >0.7116) are sexed possible female or female. Because it was possible to sample other skeletal elements for these three individuals (urns 443, 336, 458, 262), the trajectories to later-forming bone make unambiguously apparent that at least individuals 443, 336, and 262 made their way to the catchment around Cleatham. Unfortunately, the age group for 336 could only be assessed as 'Adult', which means that it is not possible to place the difference of $^{87}Sr/^{86}Sr$ values between the skeletal elements into an age-context. Individual 262 died as a young adult but her femoral $^{87}Sr/^{86}Sr$ ratio is firmly nestled in the cemetery catchment, but outside of the western area (dark green band). This means that the individual likely relocated fairly early in life during childhood, facilitating the complete representation of 'local' $^{87}Sr/^{86}Sr$ from the new place of residence in the femoral cortex. Individual 443 is a young middle adult (YMA). The femoral $^{87}Sr/^{86}Sr$ value plots inside the biosphere range expected from the western area of the catchment. However, because this individual died as a younger middle adult, it may be that the femoral $^{87}Sr/^{86}Sr$ value reflects a residual $^{87}Sr/^{86}Sr$ component from a childhood spent elsewhere. In this scenario, the femoral cortex has not fully turned-over since

relocation to the Cleatham catchment (non-western regions with slightly lower bioavailable $^{87}Sr/^{86}Sr$). Alternatively, soon after two years of age the individual may have lived in a settlement to the west of the cemetery, which is a likely point of origin for a small number of other individuals. These individuals are also predominantly sexed possible female or female (urns 293, 131, 523, 873, ?168B, 63). Most of them (urns 63, 523, 873, ?168B) have infant $^{87}Sr/^{86}Sr$ values which plot just above the bioavailable $^{87}Sr/^{86}Sr$ range for the non-westerly areas of the Cleatham catchment ($^{87}Sr/^{86}Sr$ <0.7101), but mobility – or a shift in food procurement areas - is implied by the consistent decrease of $^{87}Sr/^{86}Sr$ in the later-forming skeletal samples. In fact, the observation that 95% (34/36 individual samples) of the rib samples (most recent $^{87}Sr/^{86}Sr$ average before death) plot in the $^{87}Sr/^{86}Sr$ range between 0.7089 and 0.7099 suggests that most individuals buried at Cleatham likely spent at least the later years of life in the non-western catchment of Cleatham, or consumed food sources from here, and that we may be seeing the influence of marine-derived $^{87}Sr/^{86}Sr$ (0.7092). We will revisit this in a wider comparison in section 7.2 of this thesis.

This study included three (?four) female/possible female individuals with otic capsule which appear to reflect an infancy in the non-western catchment of Cleatham (urns 977, 815, 728, ?168A). Of these, 977 and 728 have both been analysed for femoral and rib Sr isotopes. These are both remarkably similar in $^{87}Sr/^{86}Sr$ and [Sr], although the otic capsule $^{87}Sr/^{86}Sr$ values of these two differ by 0.0007. An interesting trajectory can be observed in individual 815, whose rib and otic $^{87}Sr/^{86}Sr$ values are the lowest ones measured of these two sample types overall. However, the difference in $^{87}Sr/^{86}Sr$ values in this individual are not marked and the larger variation occurs in the horizontal sphere (x-axis) pertaining to the [Sr]. The latter may indicate a change in diet throughout the life of the individual. For four further individuals (urns 176, 730, 548, 71) it was not possible to sample the otic capsule, and therefore life-coverage was relatively poor. Based on the results it is possible to determine that all of these individuals likely spent their adulthood in the catchment of Cleatham (except in the west). A special mention is necessary for the individual from urn 458, whose

otic capsule $^{87}Sr/^{86}Sr$ plots unambiguously outside of the local $^{87}Sr/^{86}Sr$ range alongside urns 443 and 336. This individual was of likely advanced age when she died (OMA?). Based on the similarity of otic $^{87}Sr/^{86}Sr$ with 443 and 336 (all three $^{87}Sr/^{86}Sr$ = 0.7128) these three individuals may have been born in the same place. However, while the later forming and continuously overturning bone samples from individuals 443 and 336 are much lower and appear to adapt to the 'local' Sr biosphere, the rib sample from individual 458 reflects $^{87}Sr/^{86}Sr$ elevated (0.714) relative to the otic capsule, combined with lower [Sr]. The rib sample therefore indicates residential mobility elsewhere outside the Cleatham catchment during the life of this individual. Perhaps she moved to the area shortly before death or was cremated elsewhere and her remains were transported to this cemetery as final resting place. In any case, the turnover of the rib was not rapid enough to accumulate enough $^{87}Sr/^{86}Sr$ from the area to reflect this last re-location. As a second possibility, we must consider that the urn may have included the remains of two individuals with differing origins/residences, and that this is the reason for the strongly diverging results.

Still, based on these $^{87}Sr/^{86}Sr$ results it is argued that longer-distance mobility occurred during the lifetimes of at least four of the female/possible female individuals buried at Cleatham. This group is comprised of those buried in urns 443, 336, 458, and 262. Interestingly, the closest possibilities within Britain for these $^{87}Sr/^{86}Sr$ ratios are small areas of Herefordshire and Wales, the Lake District and the Yorkshire Dales, and some areas close to the Scottish border. Regional mobility in the sense of movement from the western area of the catchment around Cleatham may be observed for the individuals buried in urns 219, 293, 131, 873, 523, 168B, and possibly 63. It must be considered that there are many other areas in Britain and indeed on the continent which produce $^{87}Sr/^{86}Sr$ values seen here, and therefore origins elsewhere cannot be strictly excluded. Still, the plotted values are consistent with the 'local' biosphere to the west of Cleatham and therefore the observation stands. Local origins – that is, origins inside the Cleatham catchment excluding the western region – are likely for those individuals whose otic capsule $^{87}Sr/^{86}Sr$ falls into the range from

0.7083 – 0.7101. This is the case for those individuals buried in urns 728, 977, and 815, whose secondary bone samples do not differ greatly from the otic measurement. This suggests that these individuals grew up and stayed within the region throughout their lifetimes. For six other individuals who were sexed female or possible female (176, 730, 548, 71, 210, and 363) only secondary bone elements (later forming) were sampled, but these are similarly consistent with the local Sr biosphere and differ mostly on the horizontal sphere ([Sr]; x-axis). Special mention should be made here of the individual buried in urn 900 (YMA-OMA, F?/Ind), who had suffered a fracture during their lifetime (healed, but poorly). This individual was sexed possible female, but with a high degree of uncertainty. Notable is that the individual appears to have lived locally all their life (all skeletal samples plot similarly). Considering the issues that they likely faced regarding physical movement as a consequence of the badly healed fracture, we might assume that some care was provided to them. If this fracture occurred early in life and had an impact on the mobility of the individual, this might be why there is no movement evident within their lifetime. It is certainly possible that this was part of a more extensive injury and that this is why we perceive immobility.

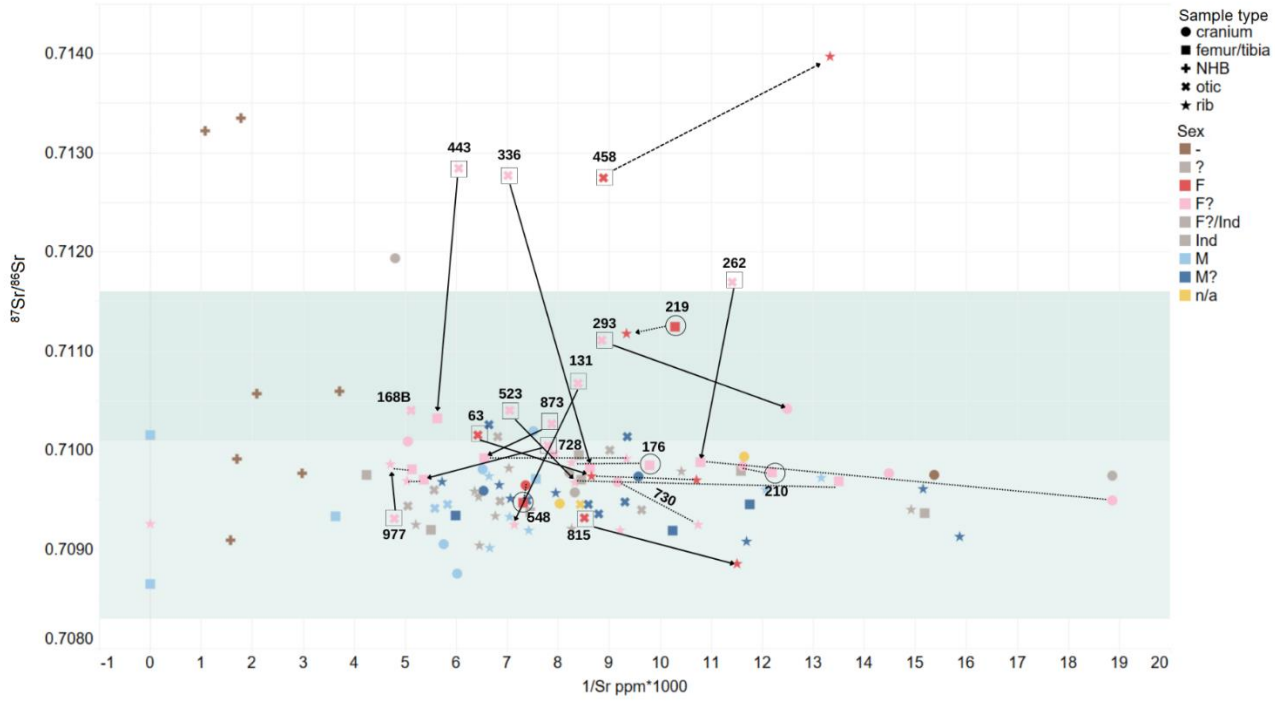

FIGURE 63 – $^{87}SR/^{86}SR$ VS [SR] PLOT: INDIVIDUAL MOBILITY OF PEOPLE WHO WERE SEXED POSSIBLE FEMALE OR FEMALE. ARROWS USED TO INDICATE TRAJECTORY BASED ON APPROXIMATE TURNOVER RATES OF SKELETAL ELEMENTS. ERRORS LIE WITHIN THE SYMBOLS.

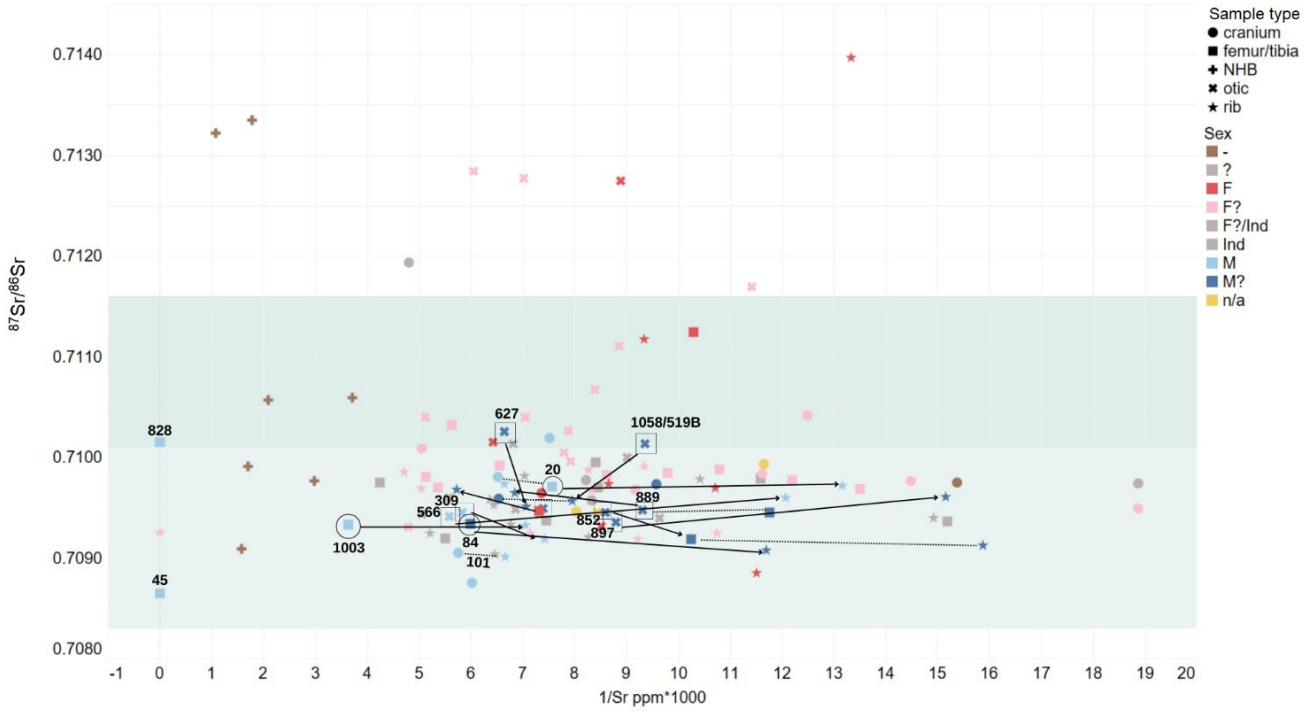

FIGURE 64 - $^{87}SR/^{86}SR$ VS [SR] PLOT: INDIVIDUAL MOBILITY OF PEOPLE WHO WERE SEXED POSSIBLE MALE OR MALE. ARROWS USED TO INDICATE TRAJECTORY BASED ON APPROXIMATE TURNOVER RATES OF SKELETAL ELEMENTS. ERRORS LIE WITHIN THE SYMBOLS.

When it comes to the mobility evident through $^{87}Sr/^{86}Sr$ in the individuals sexed possible male or male, the plot appears markedly different (Fig. 64. It should be noted that only eight such sexed individuals could be sampled for their otic capsule, and therefore it is much more difficult to draw wider conclusions than for those sexed female. It may be that the sample is biased because of its small size, and this caution should be considered in the interpretation of the data. Nevertheless, the pattern that emerges is indicative of much more limited mobility amongst the men buried at Cleatham. There are only two individuals (urns 627 and 1058/519B) whose otic capsule $^{87}Sr/^{86}Sr$ value appears to contain some input from the western catchment area. According to their rib $^{87}Sr/^{86}Sr$ value, both of these individuals resided (or derived food from) the other catchment areas. The other six male/possible male

individuals whose otic capsules were measured (309, 566, 852, 889, 897, 711) are unambiguously similar and nestle in-between 0.7093 and 0.7095; they differ solely in terms of [Sr], although this is not substantial. It is interesting to observe the difference between the rib samples and earlier forming bones, as some of the former are much lower in [Sr]. These large horizontal trajectories could indicate either a change in diet to one rich in marine resources (seaweeds, seasalt, etc) because most of these rib samples also cluster around the seawater $^{87}Sr/^{86}Sr$ (0.7092), or mobility to more Ca-rich lithologies (for example the Sussex White Chalk Formation outcrop cutting through the catchment in the east). Certainly, apart from individuals 627, 1058/519B, and 711, the decrease in [Sr] in the rib fragments is definite. In individual 852, the $^{87}Sr/^{86}Sr$ value decreases slightly (from 0.7095 to 0.7092) with a combined increase in [Sr] (from 116 ppm to 98), and then drops in [Sr] (from 98 ppm to 63 ppm) while remaining even in terms of $^{87}Sr/^{86}Sr$ (at 0.7091). This individual was older (OMA) when he died, and it is possible that he spent some time before his death in a different location to where he grew up. Alternatively, he may have procured food sources from elsewhere. A similarly stark drop in [Sr] between the femoral (or otic) values and the rib $^{87}Sr/^{86}Sr$ is present in individuals from urns 20, 566, 1003, 84, and 897. Where such a difference occurs in the female sample, this may either be in the same direction (873, 730?) or in the opposite one with an increase in [Sr] between femur and rib (see 523, 176). A strange dynamic seems to underlie the life-history of 889, where femoral and rib [Sr] values are located horizontally on either side of the otic value. This may either be due to a measurement error, a biological process, repeated changes of diet, mobility, or possibly an underlying and undetected disease process. Mobility – any form of it - is much harder to describe for the sample of individuals sexed male (or possible male) presented here, than in the female sample from the same site. However, it can be suggested that the marked decrease in [Sr] which is consistently observable in the former is indicative of possible regional re-location. It is interesting that this pattern appears persistently, and it would be interesting to add more male individuals for a future study to investigate this occurrence further.

5.3.5 AGE

When $^{87}Sr/^{86}Sr$ is plotted against [Sr] with consideration of the represented age groups at Cleatham, one of the most prominent patterns that emerges is that non-adults and likely adolescents all plot within the expected local $^{87}Sr/^{86}Sr$ biosphere (Fig. 65). At the same time, only three individuals fall into these two age groups, and therefore the data cannot be considered representative for the entire population. Certainly, while individual 320 reflects almost identical $^{87}Sr/^{86}Sr$ and [Sr] in their otic capsule as in their cranium, the same cannot be said for individual 77, who's otic $^{87}Sr/^{86}Sr$ value is higher than the later forming femoral and rib values (0.7100, 0.7094, and 0.7096 respectively (Fig. 66). A small increase in [Sr] can also be noted, but this is not prominent. This difference is likely the result of a switch in food sources rather than mobility. It is also possible that the otic capsule $^{87}Sr/^{86}Sr$ value reflects the diet of the mother to a certain degree, although studies looking specifically at this have not yet been undertaken. Logically it makes sense that a younger individual is more likely to originate in the area where they are buried, but where this is not the case, it might be possible to highlight very early mobility. In a future study, it is envisaged that remains of more non-adults are included for $^{87}Sr/^{86}Sr$ and [Sr] analysis. Amongst those who died when they were young adults there are several individuals who exhibit such difference (in $^{87}Sr/^{86}Sr$ and [Sr]) in otic vs secondary bone samples, that this might be explained by regional mobility - for example in the case of urn 20 (Fig. 67). The young adult who was buried in urn 262 does not appear to have come from the Cleatham catchment, but they moved here long enough before their death to allow the femur to reflect the local $^{87}Sr/^{86}Sr$ range. Presumably, as death occurred between the approximate ages of 18 and 28, this must have happened during puberty at the latest in order for the modelling and re-modelling of bone to incorporate sufficient $^{87}Sr/^{86}Sr$ from the new location to reflect this. The cranial sample from the same individual will be re-measured in the future to assess whether the [Sr] is an outlier or a reliable datapoint. The cranial samples from individuals 45

and 101 reflect similar values for $^{87}Sr/^{86}Sr$ and [Sr], and there is an argument to be made that these two individuals either ate similar food and/or lived in the same area. The femoral sample from 45 will be measured for [Sr] in a future study and will hopefully complement the other datapoint. Because young middle (or mature) adults (YMA) are the best represented age group at Cleatham, and because by this age people are most likely to have gone through several lifecycle-related changes necessitating mobility, diet change and/or dealing with physical stress, this plot is relatively busy (Fig. 68). In order to maintain an overview, individuals were not labelled with cremation numbers, but the trajectories were colour-coded based on their direction. Purple trajectories are indicative of a decrease in [Sr], which is frequent at Cleatham (especially amongst males). Red arrows are indicative of a large increase in [Sr]. Dotted arrows describe the connection between femur and rib or between cranium and rib, while normal arrows always originate from the otic capsule and target first the femur (in the absence of this the cranium, and last the rib). It is noticeable that several of the purple trajectories point towards femoral samples. In two of these individuals, and in two further individual whose otic capsules were not present, there is a red trajectory 'doubling back' indicating an increase in [Sr] during at least the last five or so years of life (rib turnover). While it is not possible to explain this pattern with any certainty at this point, it is hoped that further sampling will create a more significant dataset which may allow for these patterns to be explained - or at least better defined. More generally, long-distance mobility is apparent among this age group from outside the catchment, as well as from the western region. The long purple and red horizontal trajectories are possibly suggestive of closer, intra-regional connections and movement of individuals. Indeed, there are hardly any 'static' individuals, perhaps with the exception of 977 whose rib and femoral $^{87}Sr/^{86}Sr$ value and [Sr] are fairly identical, and 309, where minimal change was detected between otic capsule and rib (although based on some of the other individuals' femoral $^{87}Sr/^{86}Sr$ values, it would be misleading to take absence of evidence for evidence of absence, i.e. 523, 889). For the even older age category - the older middle (or mature) adult age range (OMA) – few individuals were present. However, out of six individuals, at least

three (458, 63?, 983?) appear to have originated outside of the Cleatham catchment, while one more might have spent their life further west (219). If the purple trajectories between the samples indeed indicate intra-regional mobility or a switch in food procurement areas inside the catchment, then this is the case for at least two further individuals (852, 84).

To summarise, the examination of mobility across the age groups has been of use but needs to be treated with caution based on the poor representation in some of these groups (i.e non-adults/adolescents, older adults). Indications are that non-adults are less likely to exhibit mobility than any of the following age groups. This is likely related to the fact that bone modelling and remodelling operate much faster in this age group and that the measured Sr ratios are representative of much shorter timespans. If relocation occurred in very early life, bone might not reflect this early Sr any longer. An argument can also be made that people were less likely to move during early childhood. A small proportion (urns 262, 20?, 2/8; 25%) of the young adults buried at Cleatham already exhibit indications of having re-located from outside the catchment and possibly within it. Within the younger middle adult age group mobility is encountered frequently, although the 'influx' into the catchment appears to have originated most often in the west (or indeed elsewhere with similar lithologies). In this group, a pattern appears to crystallise which reflects a decrease in [Sr] during youth (femur sample), followed by an increase in [Sr] in at least the last five years of life (reflected in rib sample). This is not ubiquitous, however. Mobility is also evident in the older age group (OMA), where 458 is a prominent outlier (Fig, 69). A second (and possibly third and fourth) individual falls into the bioavailable $^{87}Sr/^{86}Sr$ range for the area west of the catchment. The large decrease in [Sr] indicated by the purple trajectory is present for three of the seven individuals (43%). Overall, it can be stated that people moved to the Cleatham catchment predominantly when they were young, at least two cases may reflect mobility of older individuals (for example 458, 219). Their rib samples do not reflect 'local' $^{87}Sr/^{86}Sr$, which illustrates their alien status. Of course, these older individuals may have died elsewhere; cremation may also have taken place elsewhere, rendering the

cadaver much more portable. We *do* know that they had a connection to Cleatham because they were buried here.

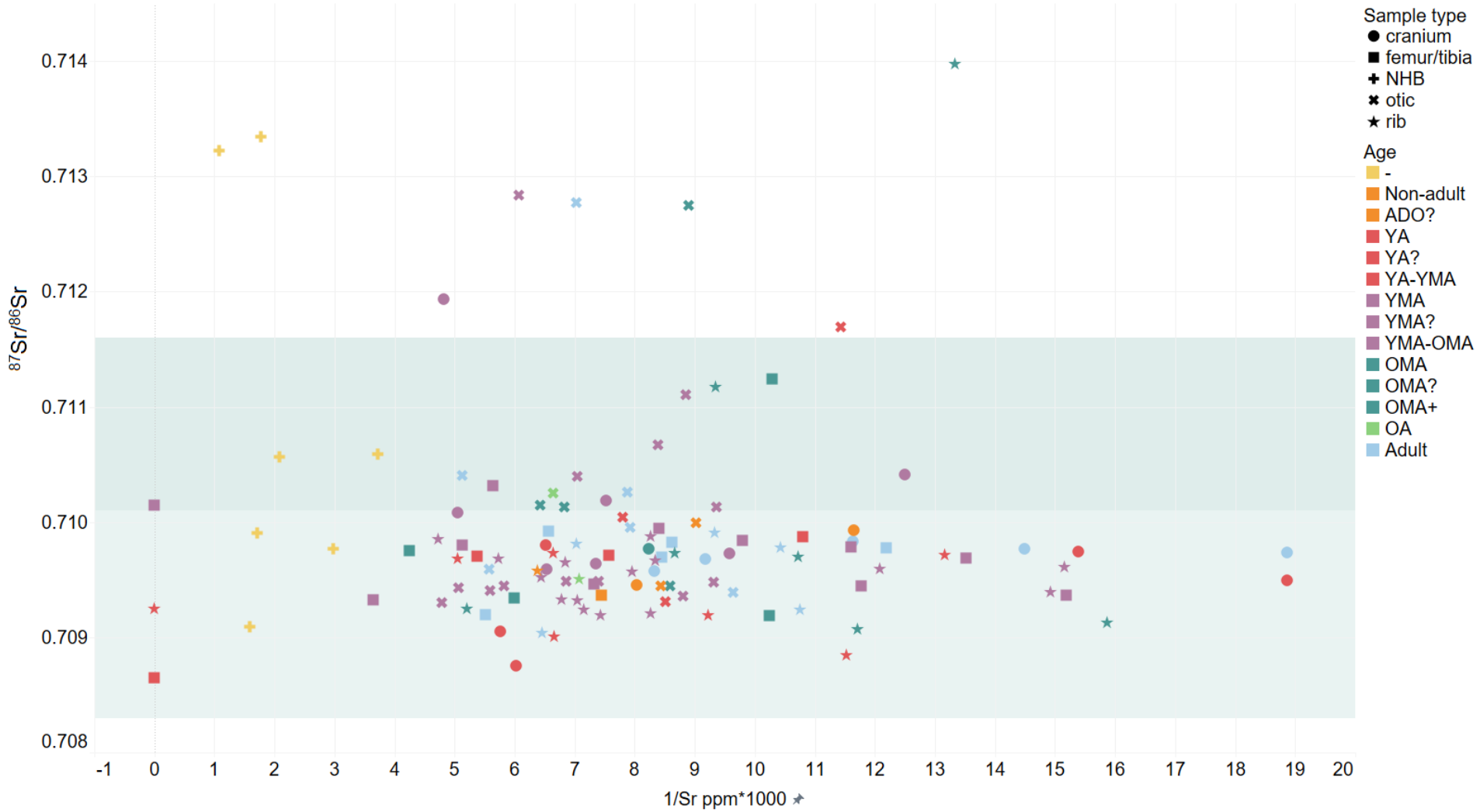

FIGURE 65 - $^{87}SR/^{86}SR$ VS [SR] PLOT HIGHLIGHTING AGE GROUPS AND SKELETAL ELEMENTS. ERRORS LIE WITHIN THE SYMBOLS.

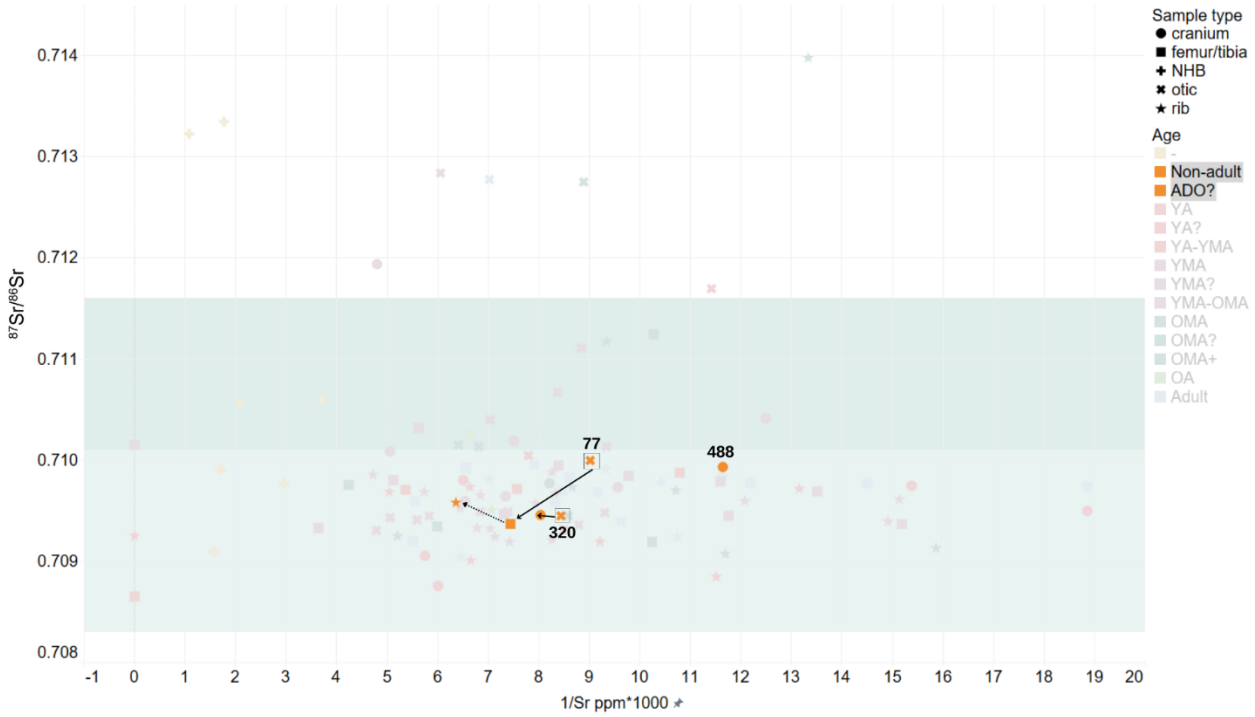

FIGURE 66 – AGE-AT-DEATH: 87SR/86SR VS [SR] PLOT HIGHLIGHTING MOBILITY IN THE NON-ADULT (INCLUDING ONE ADOLESCENT) AGE GROUP.

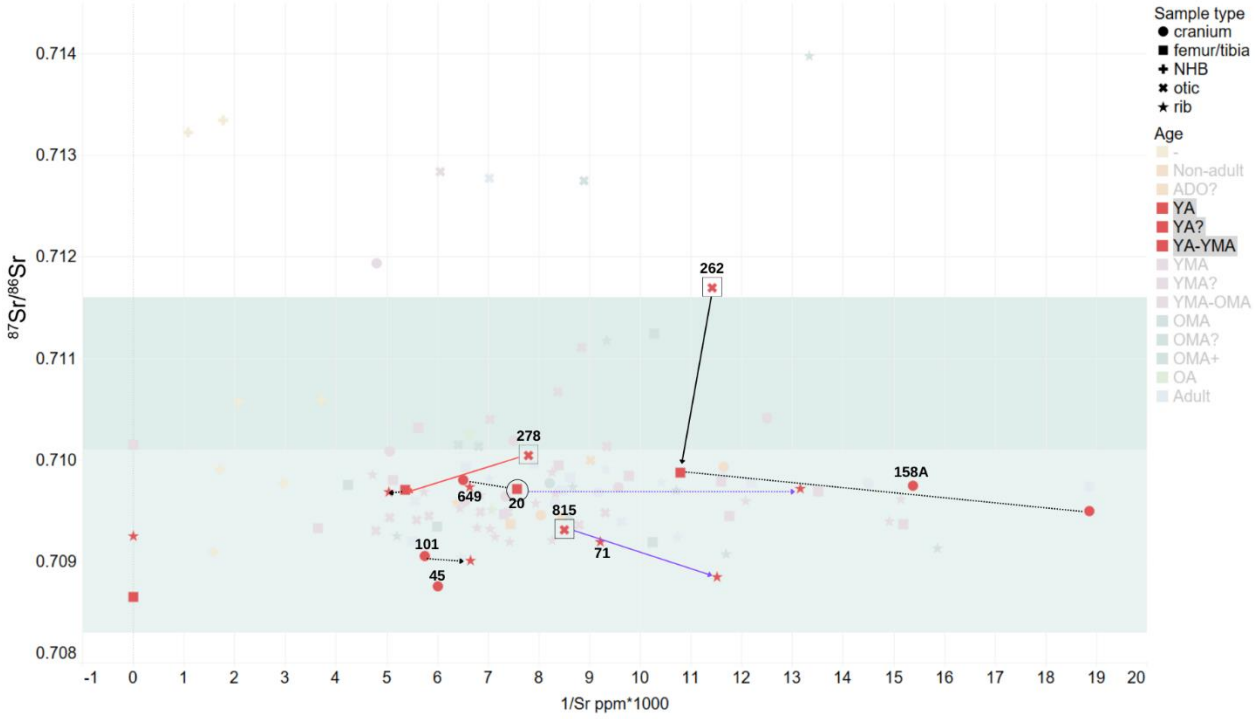

FIGURE 67 – AGE-AT-DEATH: 87SR/86SR VS [SR] PLOT HIGHLIGHTING MOBILITY IN THE YOUNG ADULT AGE GROUP. PURPLE TRAJECTORIES INDICATE A LARGE DECREASE IN [SR] BETWEEN SAMPLES, RED ONES DENOTE AN INCREASE IN [SR].

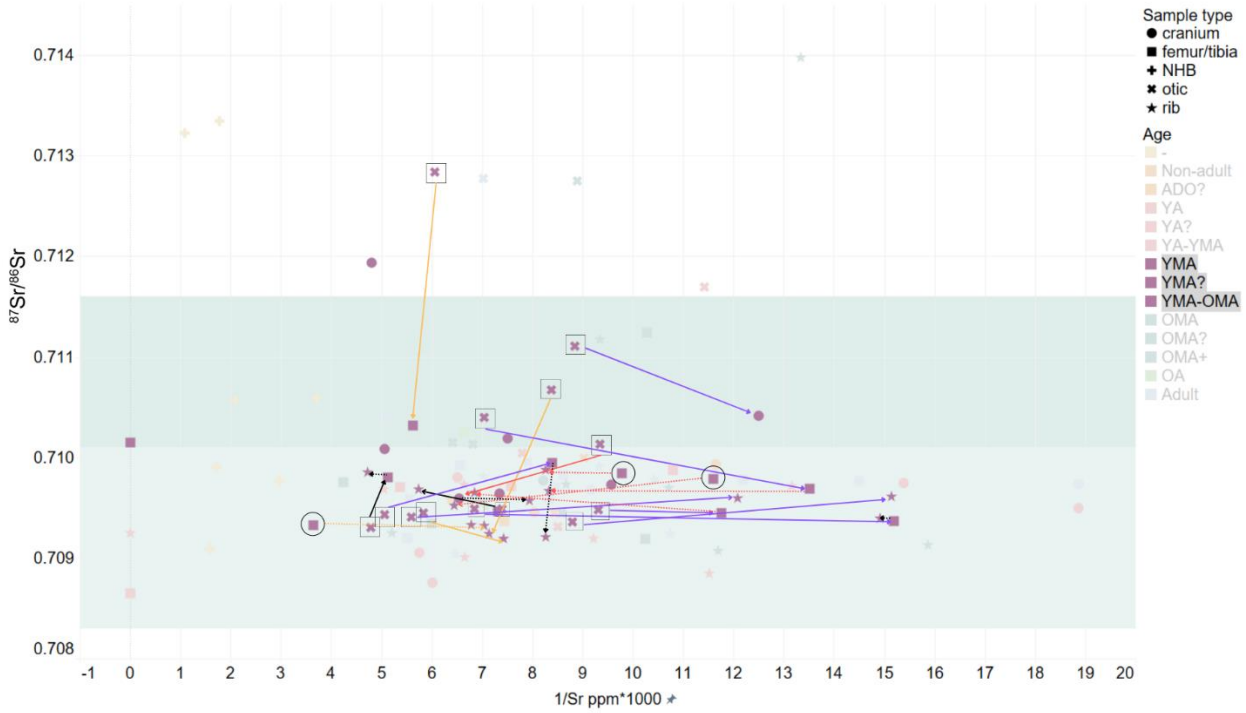

FIGURE 68 – AGE-AT-DEATH: 87SR/86SR VS [SR] PLOT HIGHLIGHTING MOBILITY IN THE YOUNGER MIDDLE ADULT AGE GROUP. PURPLE TRAJECTORIES INDICATE A LARGE DECREASE IN [SR] BETWEEN SAMPLES, RED ONES DENOTE AN INCREASE IN [SR].

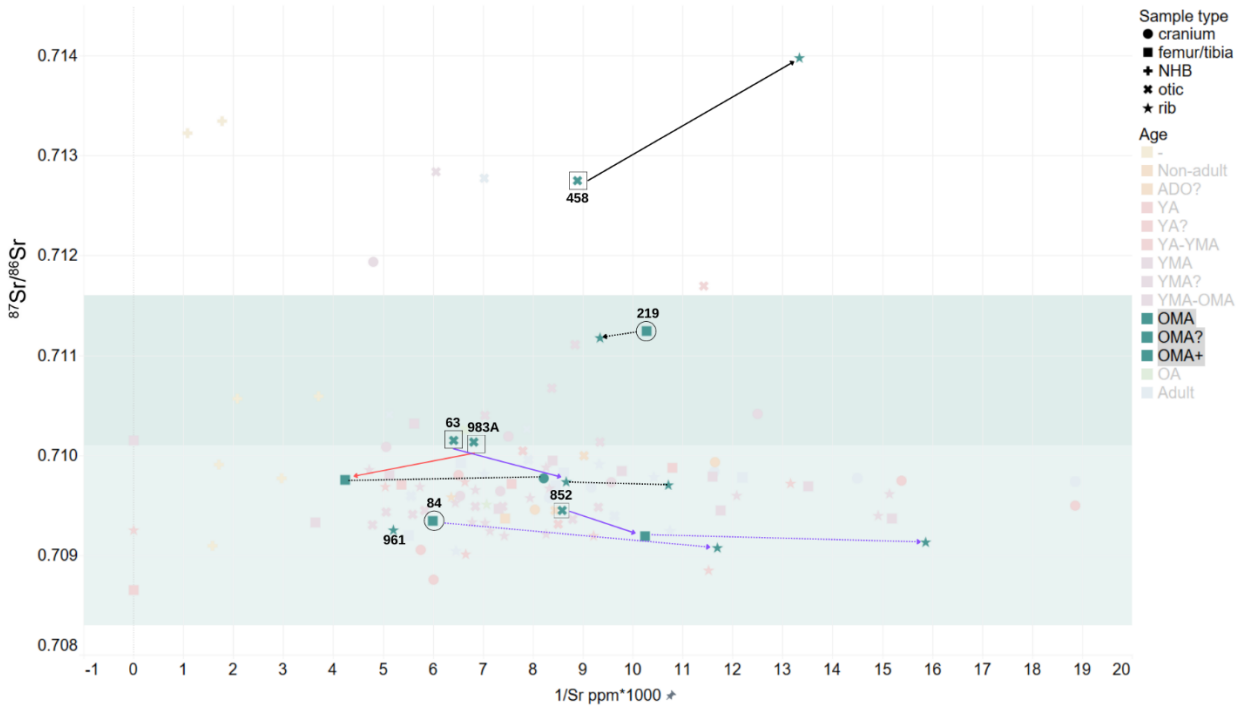

FIGURE 69 – AGE-AT-DEATH: 87SR/86SR VS [SR] PLOT HIGHLIGHTING MOBILITY IN THE OLDER MIDDLE ADULT AGE GROUP. PURPLE TRAJECTORIES INDICATE A LARGE DECREASE IN [SR] BETWEEN SAMPLES, RED ONES DENOTE AN INCREASE IN [SR].

5.3.6 MOBILITY ACROSS THE PERIOD OF USE

Figures 70 and 71 below plot mobility at Cleatham according to Leahy's phases one, and phases three and four combined due to the small sample size. With annotations (coloured trajectories), it becomes immediately apparent that mobility from outside of the Cleatham to the area was more frequent in what Leahy determines to be the first phase of the cemetery (Fig. 70). The yellow arrows identify trajectories from outside the catchment, and they are tethered to secondary bone samples which are indicative of adaption to the 'local' $^{87}Sr/^{86}Sr$ range. Mobility from outside is therefore not only evidenced by the otic capsule samples which are found across and above both green bands, denoting diverse origins, but also in the accumulation of rib samples clustered in the area considered 'local'. Still, at some point during the use of the cemetery, before phases three and four, the nature of mobility to and from the area appears to have changed (Fig. 71). Otic capsule samples appear to fall amongst the rib samples, and most of these are consistent with the 'local' bioavailable $^{87}Sr/^{86}Sr$ range (0.7083 to 0.7101). When colour coded trajectories are considered, similar patterns occur within this $^{87}Sr/^{86}Sr$ range. Movement is primarily horizontal, with increases (red arrows) and decreases (purple arrows) in [Sr] along the X-Axis. Proportionally, it can be stated that decreases in [Sr] throughout life are more frequently observed in the early phase of use of the cemetery, whereas there seems to exist an equilibrium in phases four and five. This may support the notion that the difference in [Sr] is indeed related to intra-catchment mobility, and that these trajectories are related to mobility between communities in the area: influx of people from further afield (yellow trajectories) may trigger mobility of 'local residents' at the new settlement, hence the large number of purple trajectories. The relatively equal proportions of horizontal trajectories during phases four and five may reflect

more balanced mobility amongst catchment communities. However, the small numbers of samples should be remedied before a clearer definition of this mobility is formulated.

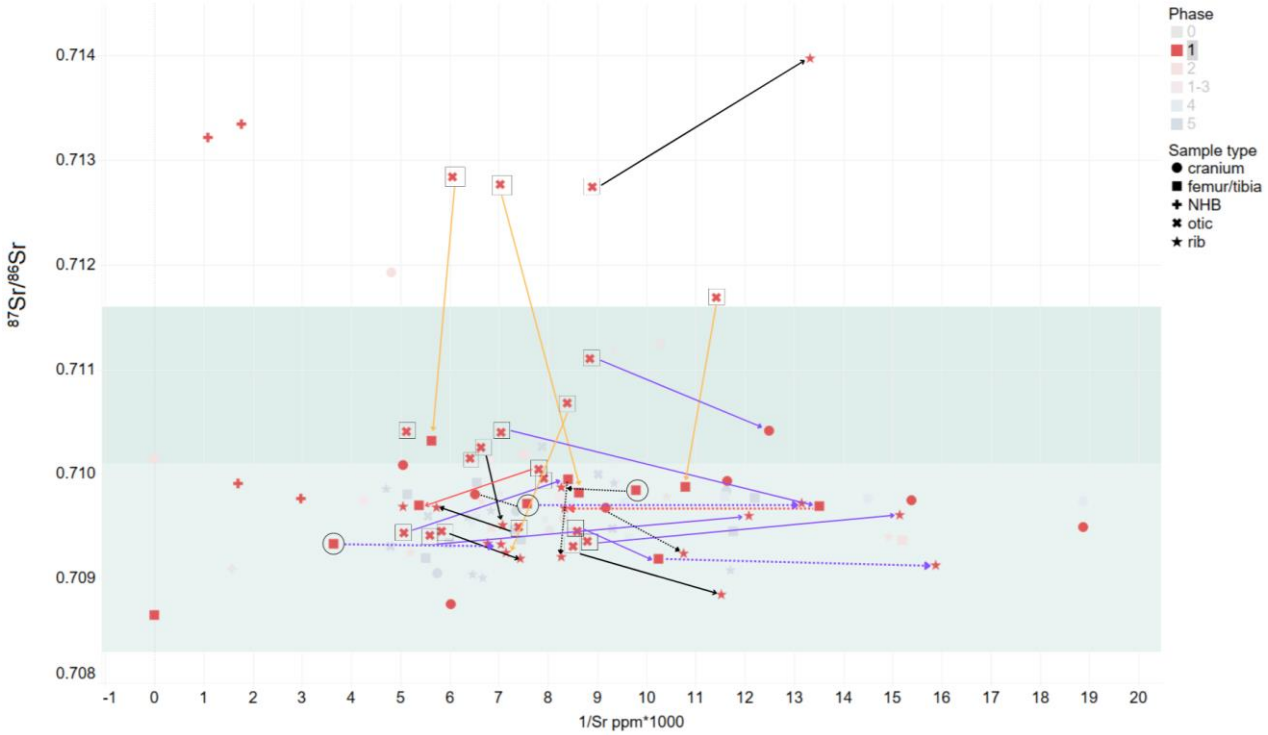

FIGURE 70 – MOBILITY AT CLEATHAM IN THE FIRST PHASE OF USE (ACCORDING TO LEAHY 2007). PURPLE TRAJECTORIES INDICATE A LARGE DECREASE IN [SR] BETWEEN SAMPLES, RED ONES DENOTE AN INCREASE IN [SR], YELLOW ARROWS SHOW A DROP IN $^{87}SR/^{86}SR$. ERROR WITHIN THE SYMBOLS.

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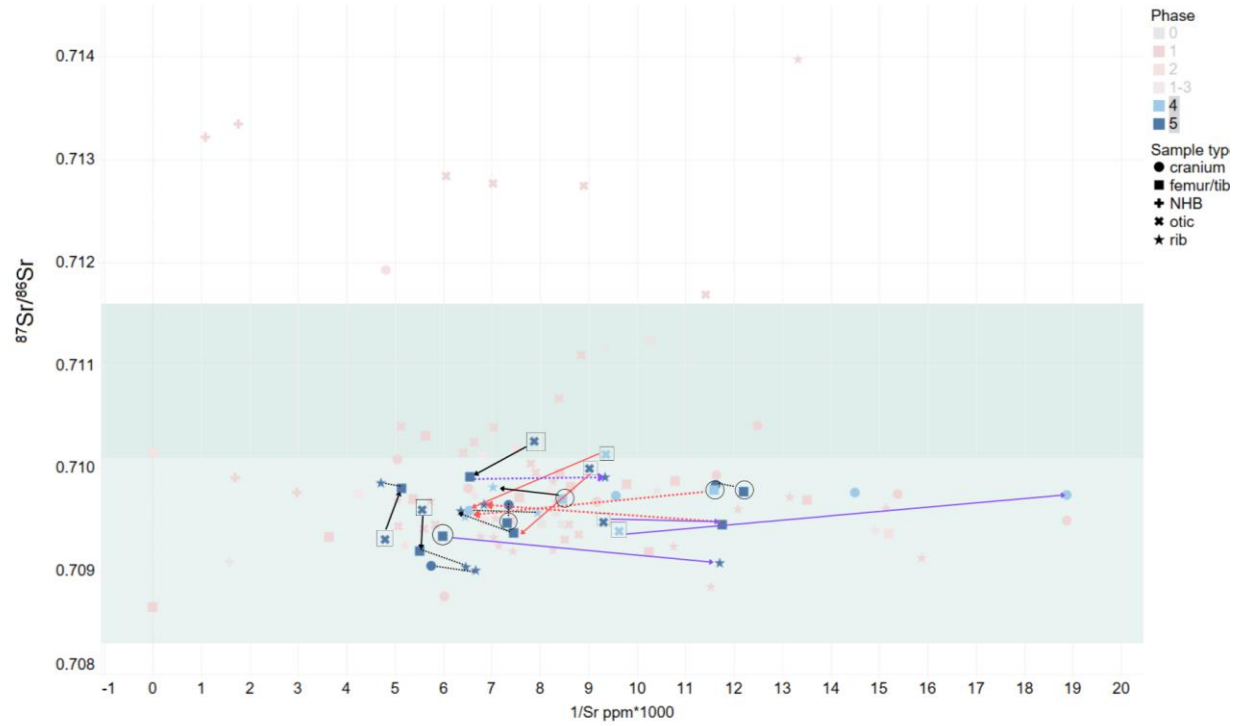

FIGURE 71 - MOBILITY AT CLEATHAM IN THE 4TH AND 5TH PHASES OF USE (ACCORDING TO LEAHY 2007). PURPLE TRAJECTORIES INDICATE A LARGE DECREASE IN [SR] BETWEEN SAMPLES, RED ONES DENOTE AN INCREASE IN [SR]. ERROR WITHIN THE SYMBOLS.

5.3.7 ANIMALS, RELATIONSHIPS, AND ASSOCIATED FINDS

Five animals were sampled for $^{87}Sr/^{86}Sr$ and [Sr] (seven samples in total) (Fig. 72). The number consists of four horses and one bear, who was represented by at least ten phalanges and was probably included as fur on the pyre. In this section, each of the burials will be discussed in detail with consideration of the burial context, pathologies, phasing, and the sex of the human individuals who shared the same burial space in one form or another (‘accessory’ vessels, intermingled, associated, etc.).

As stated above, all animals have unambiguously higher [Sr] than the human individuals buried at Cleatham. This horizontal separation in the plot between the animals and the humans is in stark contrast to the vertical distribution, in which animals almost mirror human dispersal in range and proportion. Only one of the animals (horse in urn 242; 0.7132) is far removed from the ‘local’ $^{87}Sr/^{86}Sr$ biosphere range, the bear (983) falls into the slightly

elevated $^{87}Sr/^{86}Sr$ range of the darker green band indicating a possible life spent on the lithologies to the west of Cleatham, and three of the other horses plot within the 'local' bioavailable $^{87}Sr/^{86}Sr$ range. Overall, the selected animals except the horse in urn 920 (unknown phase) are considered to belong to the early use phases of the cemetery (all from phase one, but 983A+B from phases one to three).

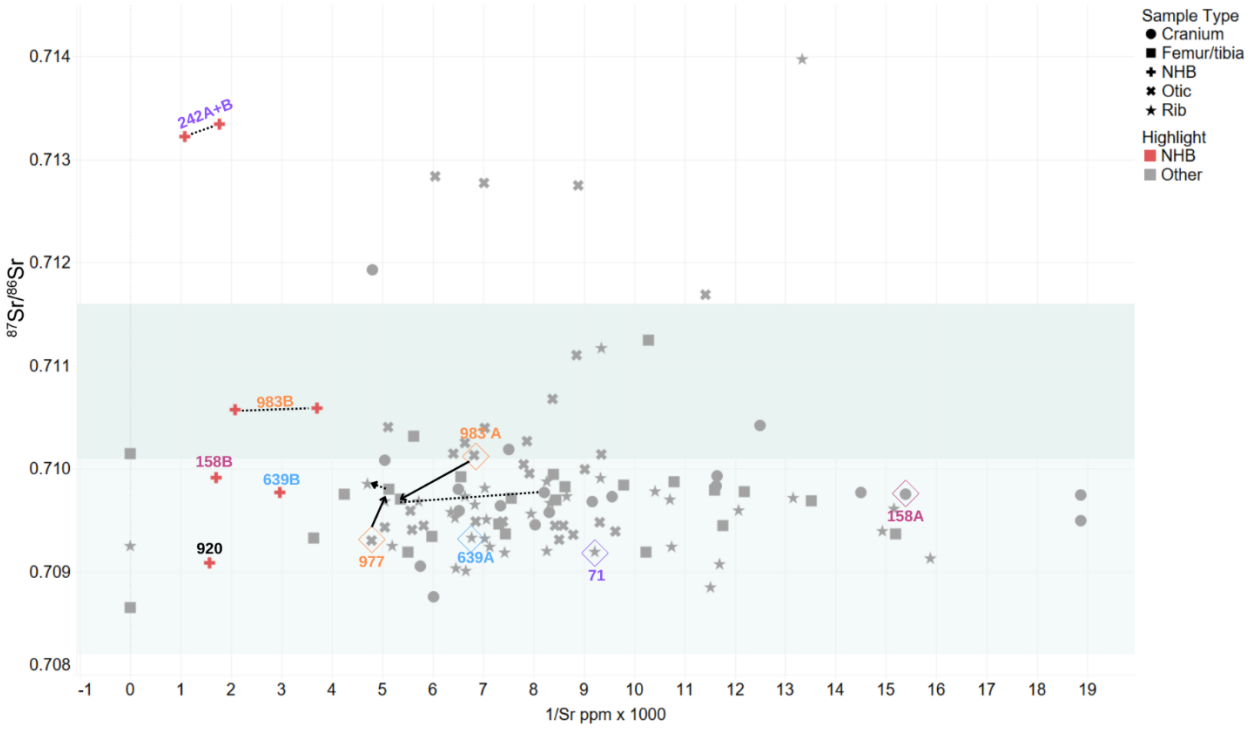

FIGURE 72 – MOBILITY OF ANIMALS AND HUMANS IN $^{87}SR/^{86}SR$ VS [SR] PLOT.THE PLOT IS COLOUR-CODED FOR ASSOCIATIONS BETWEEN THE ANIMALS AND HUMANS, WITH HUMAN SAMPLES BRACKETED WITH DIAMOND-SHAPED FRAMES.

When the $^{87}Sr/^{86}Sr$ vs [Sr] plot is considered in context of the information contained in Table 20 below, a number of interesting observations can be made about the individuals practising cremation at Cleatham.

TABLE 20 – SUMMARY TABLE OF ANIMAL-HUMAN ASSOCIATIONS AT CLEATHAM.

ANIMAL	ANIMAL TYPE	ASSOCIATED HUMAN	ADDITIONAL URN/DEPOSIT	PHASE	HUMAN AGE	HUMAN SEX	RELATIONSHIP DESCRIPTION	OTHER GRAVE OR PYRE GOODS
158B	horse	158A	no	1	YA	M?	Animal was a separate deposit next to urn filled with 158A	no
242A +B	horse	71	no	1	YA?	F?	Urn 71 was placed immediately on top of urn 242	Urn 71: Fe toilet set (tweezers, razor, shears) lying on top of bone comb, on top of urn
639B	horse	639A	624	1	YMA	?	Burnt bone deposit under and associated with urn 639A	Urn 639: horse saddle fitting made of Fe, a double-sided bone comb (unburnt), a bone handle? also unburnt, Ae strap end
920	horse	no	no	0	n/a	n/a	Sherds from urns 1196 and 1197 found with this urn, but no evidence of human remains	no
983B	bear	983A	977 - phase 5? (YMA-OMA, F?)	1 to 3	OMA	?	Urn 977 found right next to 983 with a Romano-British tile fragment between the two. Three unburnt finger rings in 977	no

Starting with the bear contained in urn 983 which was intermingled with the human remains of an OMA of unknown sex, it is of interest that the bear was only represented by ten phalanges and it is therefore suggested that the human in 983 was cremated on the pyre with a bear skin. This practice is known from the early medieval period, although there are only eight sites in total known to contain bear (*Ursus arctos)* remains. All these, apart from one, are anthropogenic sites, meaning they are related to human activity – four are early medieval cemeteries including Cleatham and nearby Elsham (Squires 2011; Squires 2013), Sancton (McKinley 1993(a): 310; Squires 2011), and the largest known cremation cemetery

of the period in Britain, Spong Hill (McKinley 1994; Bond 1996; O'Regan 2018: 92). The presence of a bear phalanx at Eynsham Abbey in Oxfordshire, and a metacarpal at West Stow have also been recorded (Crabtree 1989: 25; Hardy & Dodd 2003; O'Regan 2018). Perhaps the most intriguing find is a cervical vertebra from a cave in North Yorkshire which has been dated to AD 425-594 in 2007 (Taylor *et al.* 2007; O'Regan 2018). Because this is a non-anthropogenic arena, the bear was likely a wild example and this evidence provides an indication that these animals were rare, but not completely extinct during the early part of the early medieval period. Other researchers have argued that bears were extinct – or nearly extinct – by this time and imports must have been the main reason for the presence of bear skins at these cemeteries (Yalden 1999: 113; Squires 2011: 274). By this reasoning, such finds could be considered to signal high social standing – the presence of an *elite* (Pluskowski 2010: 117). Taking this argument further by pointing towards the historical and pre-Christian importance of bears should help to understand that high status alone is not what is represented. As has been discussed previously, Old Norse mythology and cosmology contains some compelling ontological barrier-transgressions which can still be found in historical and ethnographic sources. Kirkinen, with a special reference to practices related to bear hunting and skinning, has emphasised how the 'fuzziness of human and non-human classifications in non-western cultures has been related closely to shamanism and the animistic worldview as 'relational identity/consciousness,' which instead of fixed identities reflects the transformation from one class into another, that is, through partiality, dividuality, and metamorphosis' (2017: 22). Here at Cleatham, we almost certainly encounter an element of this liminality in the context of the transformation (or metamorphosis) of the cadaver on the pyre, the breaking down of the recognisable physical form into something more partial and/or dividual. The end result – intermingled cremated remains of human and non-human animals – almost certainly had such thought processes attached.

No grave or pyre goods were found in the urn, which perhaps suggests that at this point in time, the bear skin had a special place in the funerary ritual which rendered other items less important. When the other six phased occurrences of bear phalanges (out of a total of ten) in cremation burials at Cleatham are examined closer, it seems that additional grave and/or pyre goods appear only in the third to fourth phases (burials 577, 876). In phase five there is no evidence for further bear remains. Given that the number of individuals is low this might not necessarily mean much, especially because the phasing is not always reliable, but this is an intriguing avenue to follow in future research.

Looking closer at the Sr isotope results of the bear and the human in burial 983, it can be observed that both individuals plot in the dark green band indicating the slightly more radiogenic $^{87}Sr/^{86}Sr$ range located to the west of Cleatham. Now, if the consistently encountered opinion that bear skins were imports from the continent at this time is correct, then the bear likely stems from an area with similar lithologies to those of the Triassic sandstone and conglomerate to the west of Cleatham. Unfortunately, this is as precise as one can be with only one isotope proxy ($^{87}Sr/^{86}Sr$ = 0.7106). Another scenario entails the demise of the bear in Britain, especially considering that there is evidence – small as it may be – for the survival of some of the animals past the Roman period in North Yorkshire.

For the human individual (983A) it was possible to analyse an otic capsule, a femoral fragment, and cranium. A decrease in both $^{87}Sr/^{86}Sr$ and [Sr] is notable, and the trajectory places the bones reflecting adult $^{87}Sr/^{86}Sr$ into the local catchment. Interestingly, the femoral $^{87}Sr/^{86}Sr$ and [Sr] values of individual 983A (0.7098; 235ppm) are almost identical to the femoral and the rib values of the possible female individual buried in urn 977 (0.7099; 195ppm and 0.7099; 212ppm respectively). The two urns were in the ground next to each other, separated only by a Romano-British tile fragment. The rib value of 977 suggests that this individual died ‘locally’. Leahy placed this urn into phase five, while urn 983 was sorted into phases one to three. This may either indicate that the phasing does not hold up in this

case (Perry has examined neither urn for his PhD thesis to state otherwise), or that this burial reflects a relationship between the individuals across time. If a grave marker was used for the burial of 983, then 977 could have been a later insertion motivated by kinship ties. The $^{87}Sr/^{86}Sr$ values appear to show that the origins of the two individuals is not the same, however. The otic capsule of 983A is pointing towards an environment with slightly more radiogenic $^{87}Sr/^{86}Sr$ than that of 977 (0.7101 and 0.7093 respectively). By the time the two individuals had died in adulthood, their femoral $^{87}Sr/^{86}Sr$ had adapted to the 'new' location, which means that they likely settled in the same place. The urn burial of 977 included three finger rings, two of which were made with coiled wire (Fig. 73) (Leahy 2007: 172). Leahy has noted parallels of these rings to one found at West Heslerton (Grave 113), Yorkshire Wolds, and these have previously been dated to the 6th and 7th centuries (ibid; Budd *et al.* 2003; Montgomery *et al.* 2005). The individual was a young adult female and had childhood $^{87}Sr/^{86}Sr$ (0.7082) consistent with the bioavailable $^{87}Sr/^{86}Sr$ range at West Heslerton (ibid).

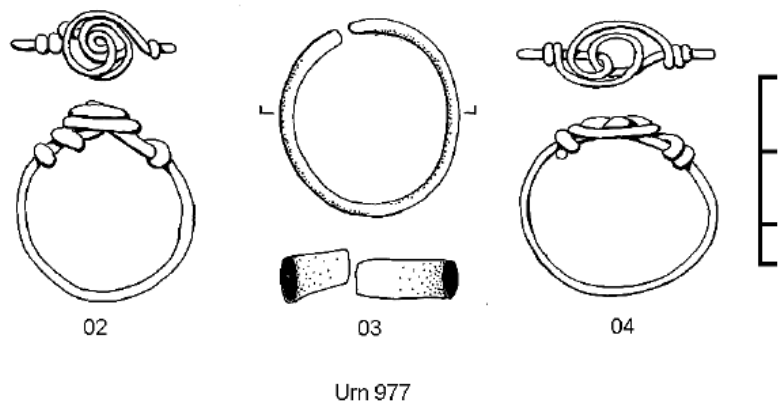

FIGURE 73 – THE THREE RINGS FROM BURIAL 977 AT CLEATHAM WHICH PARALLEL THE RING AT WEST HESLERTON IN G113 (LEAHY 2007: 152 – AS FIG.72).

West Heslerton, contemporary with Cleatham, has been noted to have been home to first generation migrants as well as locals, and these were interspersed in terms of burial location – perhaps in groups denoting kinship affiliation or households (Montgomery *et al.* 2005: 131-132). In any case, the burials of 983 and 977 are intriguing, as they are from

individuals of differing origins who seem to have settled in the same place or derived their food from the same place later in life. This probably happened at different times as 983 was dated earlier than 977. We might assume that this implies a continuity through time, where relationships were displayed in space by emphasising proximity within the cemetery.

The other four animals under investigation in this section were all identified as horses. The horse in urn 242 exhibited remarkably radiogenic $^{87}Sr/^{86}Sr$ isotopes (0.7133 and 0.7132) which could not have been incorporated into the animal's bone from grazing inside the catchment around Cleatham. The chalk outcrops to the east which would produce much lower $^{87}Sr/^{86}Sr$ ratios, and the possible influence of seaspray at the coastline obviously preclude these areas as well. In short, this horse likely travelled long-distance to arrive in Cleatham. When Fig. 74 is consulted, it is noticeable that the $^{87}Sr/^{86}Sr$ of the horse plots at approximately the same height as the otic capsule samples from urns 443, 336, and 458, but nowhere near the rib value from urn 71 (0.7092) with which it was buried?. The suggestion here is that the horse buried in urn 242 arrived at Cleatham and died relatively soon after, considering that neither the horse's cranium, not their sesamoid bone adapted to the bioavailable $^{87}Sr/^{86}Sr$ range around the cemetery (although it is unclear how fast bone turnover proceeds in different skeletal elements of horses). The rib sample of 71 suggests that this individual lived here for several years before death at least, but because the deposits within the urns were partially intermingled (Squires 2011: 217-218) we must assume that cremation took place at the same time spatially separated on the same pyre. Seeing as there appears to have been mobility from elsewhere to Cleatham, it may be that the horse was brought along as well. As we only have a sample of the rib for individual 71, there is a chance that this person also travelled long-distance to the Cleatham catchment. Because the human individual was a possible young adult, the modelling process of bone during growth may reflect a relatively recent period in the rib, and this journey may have been undertaken during late childhood or adolescence. Tribute was paid to the fact that there was a horse contained in urn 242 by the stamp design, which included small

horseshoe impressions. A toilet set consisting of tweezers, a razor, and shears were placed on top of a bone comb on the surface of the cremated human remains deposit of 71 (Leahy 2007: 79, 225).

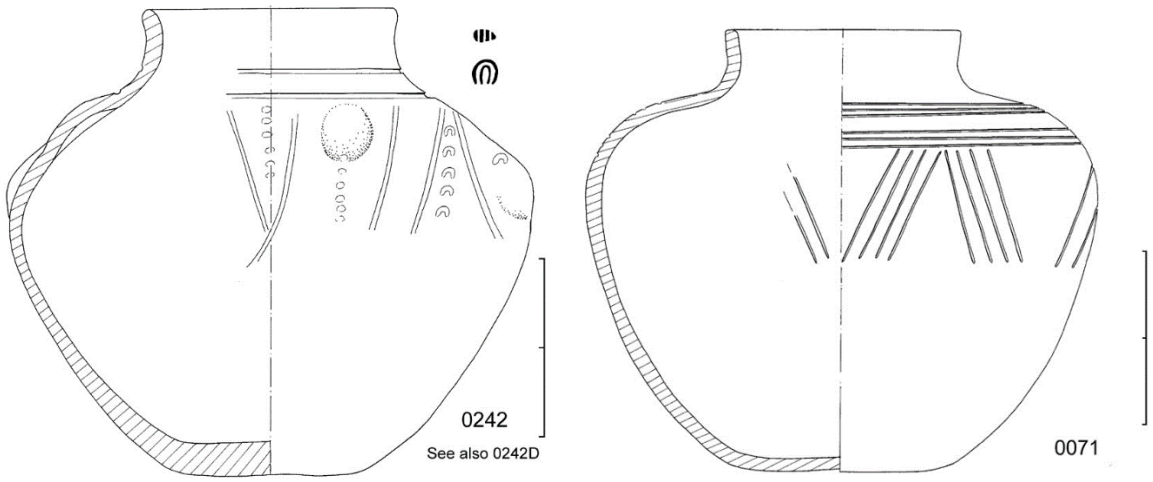

FIGURE 74 – URNS 242 AND 71 FROM CLEATHAM. 71 WAS PLACED ON TOP OF URN 242, AND 242 INCLUDED PREDOMINANTLY HORSE BONE.

The only other urn observed to feature this horseshoe pattern was urn 639 (Fig. 75), which contained the remains of a younger middle adult of unknown sex (639A). The urn was placed next to and on top of a deposit with what appeared to be mostly horse remains (639B) although a small amount of human remains which could have belonged to 639A were intermingled (Squires 2011: 217-218).

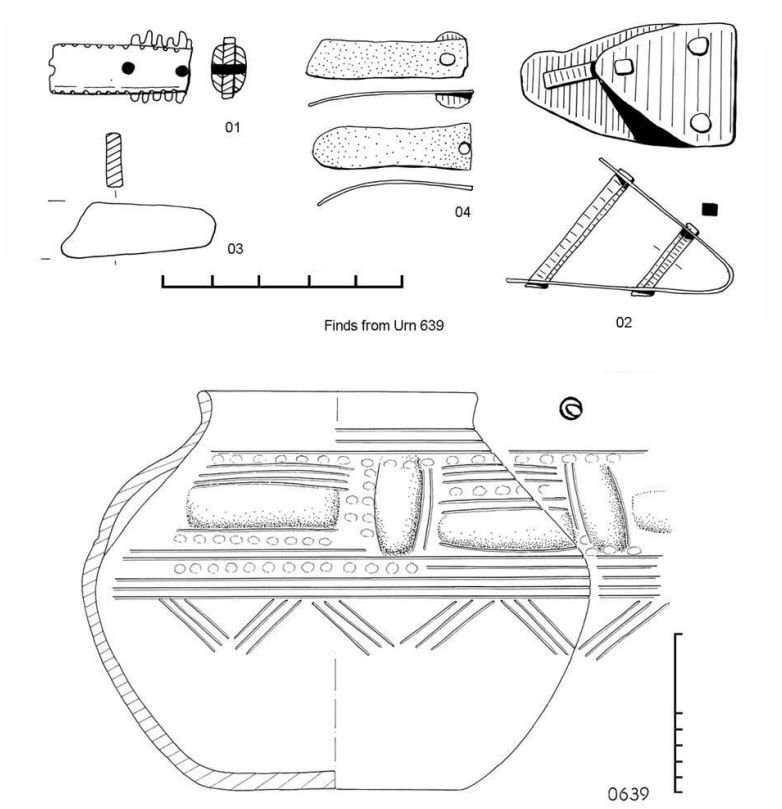

FIGURE 75 – URN 639 WHICH CONTAINED A HUMAN AND HORSE REMAINS ALONGSIDE FINDS FROM INSIDE THE URN (LEAHY 2007: 219 – AS FIG. 110).

In terms of $^{87}Sr/^{86}Sr$ isotopes, the horse in this urn does not appear to come from elsewhere outside of the catchment. However, because we do not know exactly how fast the bones of horses turn over, a similar problem to the previous burial of 242 with 71 exists: rapid growth during puberty and/or adolescence of the young adult may camouflage $^{87}Sr/^{86}Sr$ input from elsewhere during childhood. Without an otic capsule sample, it is not possible to determine this. The narrative must also consider the $^{87}Sr/^{86}Sr$ exhibited by the horse bone (sesamoid), which could – in theory – have adapted to the bioavailable $^{87}Sr/^{86}Sr$ ratios around Cleatham. In any case, horse and human shared a burial space, and further grave goods were found inside the urn: an iron saddle fitting clearly highlighting the association with a horse, a double-sided unburnt bone comb, a two-leaf strap end, and an object made of bone which might have been a handle (Leahy 2007: 154, 201, 218, 219). The presence of horse-riding equipment hints at the presence of a tacked horse on the funerary pyre. This is an

interesting decision to make because tacking is specialist equipment, often adjusted to a specific horse, and may not be used for other horses after.

Drawing comparisons between this burial and the previously discussed one, we have an apparent separation of the human and the animal in the latter, and a partial intermingling in the former. The urn containing the human was stacked on top of the urn with the horse (242 and 71) – almost like a person riding a horse. In a way this is also the case here (639), where the urn was placed atop a partial deposit of unurned cremated horse remains (some were also contained in the urn itself). In the case of 242 with 71, the individuals were not fully intermingled or placed next to each other, possibly denoting an ontological boundary. The same was not necessarily the case with 639, where even the horse tack was intermingled with human and horse.

Urn burial 158 contained the remains of a horse and a human, whose $^{87}Sr/^{86}Sr$ ratios were similar (0.7099 and 0.7098 respectively). Unfortunately, only one sample was measured per individual. The major difference between them persists in the [Sr], which is unambiguous. The [Sr] observed for the horse is expectedly high (585ppm), while that if the human appears to be very low (65ppm). This difference may in part be explained by the differing diets but could potentially also reflect the underlying bedrock and its calcium content. The $^{87}Sr/^{86}Sr$ of the human is too high to have lived on the calcium-rich chalk outcrop to the east which may produce such [Sr] but is not radiogenic enough. A similar burial context to the one observed for 639 could be described for 158, where a separate deposit of cremated horse remains was found below the urn (Squires 2011: 218). However, horse bone was also found within the urn itself, intermingled with those of the possible male young adult. The urn itself did not feature any equine decorations, however, and was rather more similar in design to urn 71 (Fig. 76). No other finds were present for this burial.

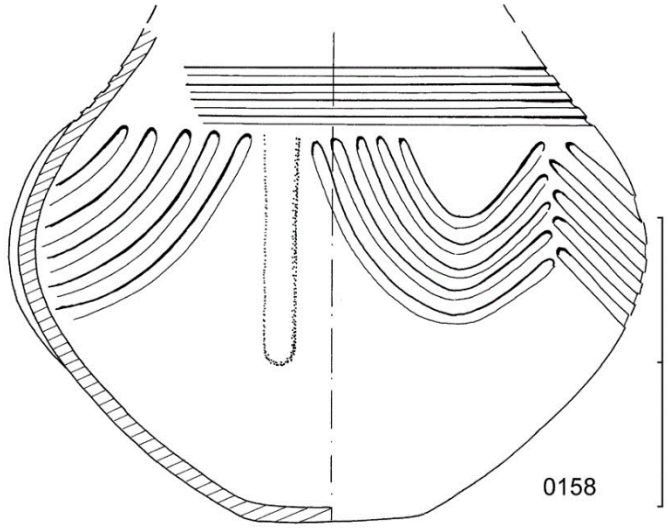

FIGURE 76 – ILLUSTRATION OF URN 158 WHICH CONTAINED THE CREMATED REMAINS OF A HORSE AND A HUMAN.

The last animal burial under investigation for this study was an isolated urn which appeared to only include the remains of animal (920). Despite the fact that it contained a small number of sherds from two nearby urns (1196 and 1197), it was not strictly associated with any other burials, contained no grave goods, and could not be placed into a phase by Leahy. The occurrence of 'accessory vessels' containing only (or a majority of) animal bone was noted in nine instances for Cleatham and in 14 at nearby Elsham (Squires 2011: 145, 217). However, in most of these cases the burials related to another burial. As it stands, 920 appears fairly isolated, although it may have been provided as an 'accessory vessel' for 1196 and/or 1197. In terms of its $^{87}Sr/^{86}Sr$ and [Sr], 920 plots with relatively high [Sr] at 633ppm and low $^{87}Sr/^{86}Sr$ (compared with the other individuals from Cleatham) at 0.7091. This $^{87}Sr/^{86}Sr$ ratio is suggestive of the individual feeding on the sedimentary Jurassic lithologies around Cleatham, or perhaps indicative of the influence of seaspray on chalk along the coastline further east. The urn itself was undecorated but placed within the main cluster of cremation deposits at Cleatham – indicating its belonging. Clearly then, Fern's assessment that 'in the early Anglo-Saxon mind the horse stands out as a motif with socio-political, heroic and spiritual significance' (2010: 128) is reflected in the burials at Cleatham. The variable handling and presentation of the remains shows that despite possible

overarching communal ideological beliefs regarding these animals, the interpretation was to some degree left up to individuals. The cremation and deposition of urn 920 in its apparent isolation may have been a commemoration practice for the entire community interred at the cemetery. At the same time, we should not disregard the possibility that the horse was afforded a funeral for its own sake. If individuals are recognised to possess inherent value, or if they are individuals representing a whole community, then the emotive investment afforded to them during mortuary rituals validate and uphold these relationships. This is indeed where agency can be found at Cleatham in relation to the presence and the treatment of animals. In future, after a comprehensive zooarchaeological study has been undertaken on *all* animal remains, further Sr isotope analyses should help to examine broader patterns of these relationships. That there are very interesting relationship and commemoration dynamics at work at Cleatham during the early medieval period is impossible to denounce.

In the following section the association of cremated remains with the presence of certain burial context, grave or pyre goods will be discussed. The focus lies on cases where coral beads or ivory rings were provided in the burial, and those where cremated remains were placed into Romano-British vessels. Starting with a discussion of the latter: Four urns at Cleatham were wheel-thrown and Romano-British in design (Fig. 78), and one more (809) was tentatively placed into the same group. Only one of the vessels, 649, was sorted into a phase based on its association with a phase two vessel (Leahy 2007: 126), although this obviously does not mean that all of the burials date to this phase, or indeed that the vessels themselves were produced at this time. Leahy has pointed out that within the wider region they are paralleled only Newark at the Millgate cemetery (ibid; Kinsley 1989: 12). In Figure 77 the individuals buried in these vessels are highlighted and labelled according to the urn number. Only the individual in urn 702 has $^{87}Sr/^{86}Sr$ and [Sr] measurements for their otic capsule alongside their femoral and rib $^{87}Sr/^{86}Sr$. Comparing the rib values for individuals 649, 702, and 961 with the cranial $^{87}Sr/^{86}Sr$ from 809 and 828 (also their femoral $^{87}Sr/^{86}Sr$) is

already illuminating that there is significant variation in the mobility histories of the individuals. Although the rib samples suggest that the three individuals could have been local to the catchment, there is variation amongst them in terms of [Sr] as well as $^{87}Sr/^{86}Sr$ ratios. The older middle adult in urn 961 is closest to the seawater $^{87}Sr/^{86}Sr$ of 0.7092 (with 0.7093) and 192 Sr ppm, which is quite high. This may indicate, in combination, that the individual ate plants dominated by seawater $^{87}Sr/^{86}Sr$, grown along the coastline, preserved foods with sea salt, or indeed seaweeds and/or animals grazing in these areas. The remains were accompanied by a toilet set which included tweezers, a razor, and shears made of iron (Leahy 2007: 126, Table 35).

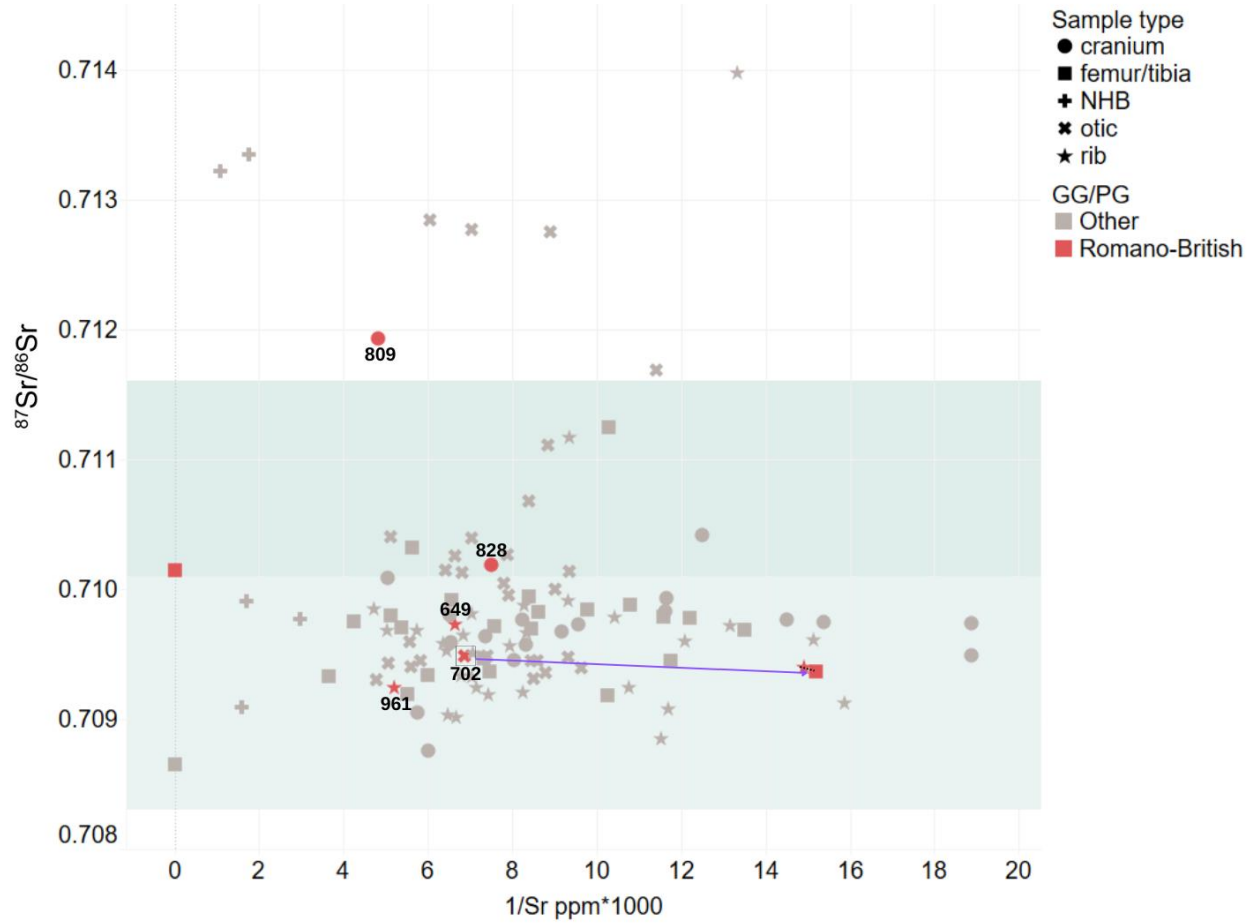

FIGURE 77 – MOBILITY OF INDIVIDUALS WHOSE CREMATED REMAINS WERE BURIED IN ROMANO-BRITISH VESSELS.

The $^{87}Sr/^{86}Sr$ ratio measured in the rib of 649 is slightly higher than that of either 702 or 961 and plots at 0.7097, which suggests that the younger adult (or YMA) male may have spent

the last few years before his death on the lithologies immediately west of Cleatham. The individual buried in urn 702 exhibits almost identical $^{87}Sr/^{86}Sr$ ratios across all analysed elements (0.7095 – otic; 0.7094 – femur and rib), but there is a significant decrease in [Sr] observable, which could represent a shift in diet or location between the formation of the otic capsule and that of the femur. Certainly, because this individual was also a younger middle adult, a change of place would have taken place during youth. There is hardly any change present between femur and rib, suggesting that this individual resided in one place after relocation and/or had a relatively consistent diet. The grave goods contained inside this urn encompassed a toilet set, a spindle whorl and bone buckle fragment, and a bone comb fragment (ibid).

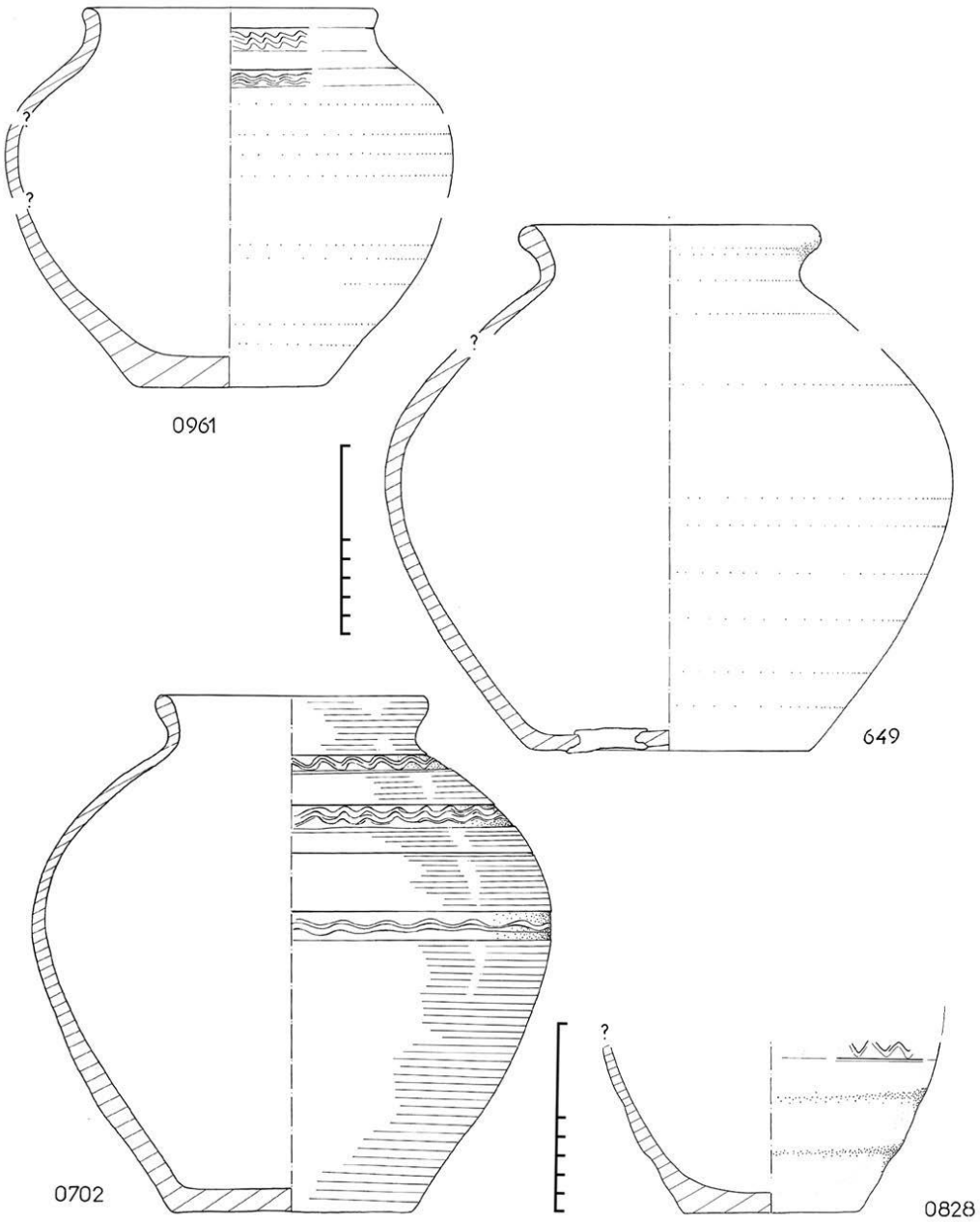

FIGURE 78 – ILLUSTRATION OF THE ROMANO-BRITISH VESSELS FOUND AT CLEATHAM (LEAHY 2007: 121 – AS FIG. 63).

The young middle adult male buried inside urn 828 likely spent his later youth on the Triassic lithologies to the west of the Cleatham catchment as the $^{87}Sr/^{86}Sr$ ratios in both cranium and femur are slightly more elevated (0.7102) than the majority of individuals, and plots just inside the darker green band. A clear outlier is 809, whose cranium reflects a $^{87}Sr/^{86}Sr$ value of 0.7119. Their [Sr] is on the higher end relative to the other individuals at

Cleatham, which suggests that their diet was likely predominantly plant-based. Without further infant Sr values from the otic capsules it is unfortunately not possible to more clearly define the mobility biographies of the people under investigation. It is possible to state, however, that most of those placed into the Romano-British vessels were on the younger age spectrum. A second observation holds that there is clearly variation in the mobility-histories of those buried inside these urns, and this includes locals and non-locals in approximately equal numbers.

Ivory rings were relatively frequently observed at Cleatham (n=159). These items are relatively large and are likely part of a pouch or bag (Owen-Crocker 1986: 69; Squires 2011: 283). The material itself likely derived from Africa and comes from elephants, although this should be confirmed by a zooarchaeologist (Hills 2001: 132; Leahy 2007: 204). Interestingly, a relatively high number of the individuals buried with ivory who were analysed for Sr isotopes in this sample appear to have originated outside of the catchment or came from the more radiogenic western lithologies (Fig. 79).

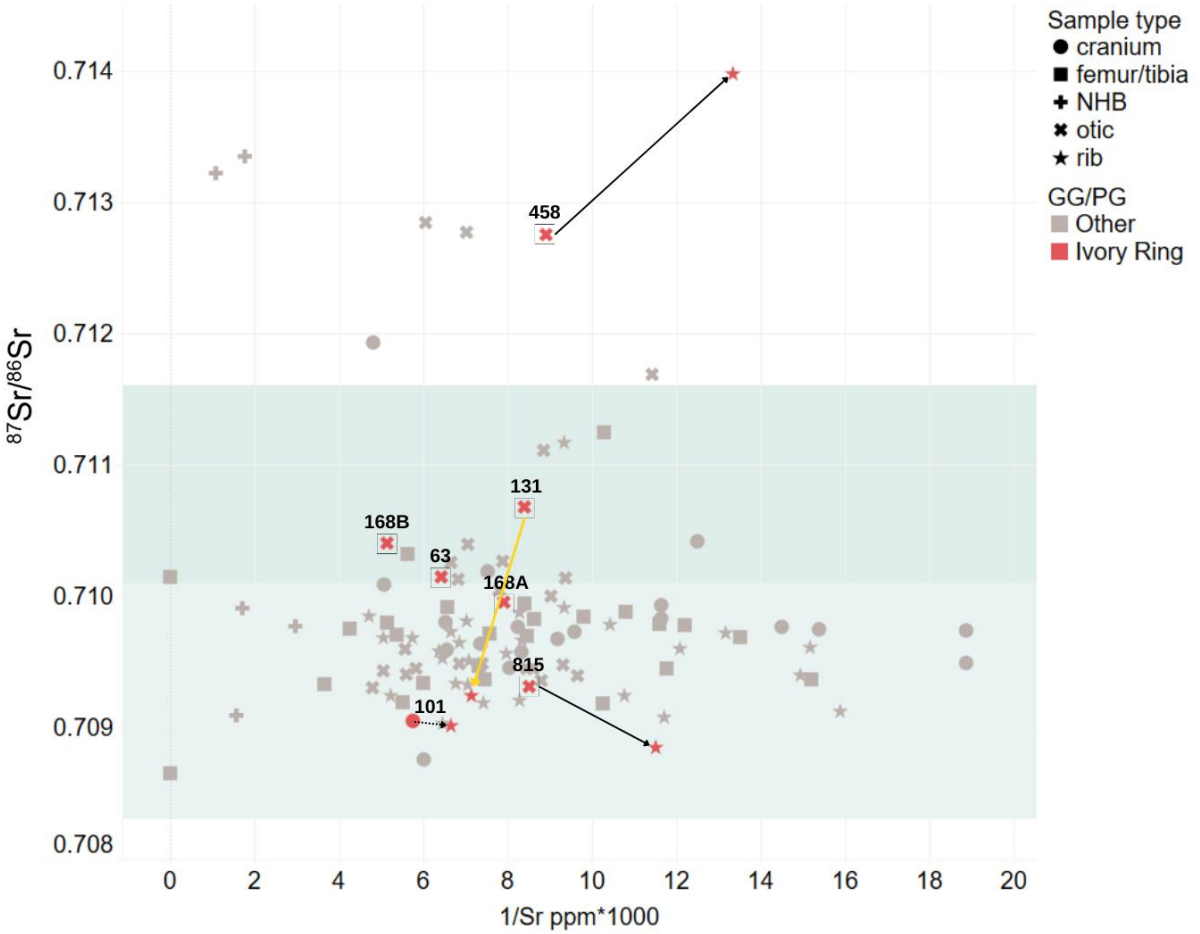

FIGURE 79 – MOBILITY OF INDIVIDUALS WHO WERE BURIED WITH EXOTIC IVORY RINGS.

Amongst these was 458, an old middle adult female whose otic and rib samples are both outliers. Her infancy and last few years of life were therefore spent on more radiogenic lithologies than those underlying Cleatham. The old middle adult female in urn 63 and the young middle adult female(?) in urn 131 both likely spent infancy to the west of the Cleatham catchment, as well as 168B, who was buried with 168A (because this was a double burial, it is unclear whether both individuals were female, or who was buried with the ivory ring). A mobility trajectory is observable for 131, who must have moved closer to Cleatham during her life – at the latest several years before death. Her rib $^{87}Sr/^{86}Sr$ at 0.7092 is closely aligned with the $^{87}Sr/^{86}Sr$ ratio of seawater, which perhaps suggests a life near the sea along the coastline. Remains of an ivory ring were also found with a young adult male (101) who's rib $^{87}Sr/^{86}Sr$ ratio 0.7090 was slightly lower than that of seawater. A local origin

is almost certain for this individual. The individual in urn 815 is a young adult female and she likely originates near Cleatham (otic – 0.7093; rib – 0.7089). The slightly lower rib value may indicate a move to the chalk lithologies east of Cleatham later in life. Within the sample, five out of six individuals with ivory rings as grave goods were sexed female which reflects the overall pattern observed at Elsham and Cleatham (Squires 2011:283), and all of these were sorted into phase one by Leahy. Individual 101, a young adult male, was sorted into phase five. Mobility was frequently apparent amongst this sample of individuals, which may indicate that mobile individuals of the early phase especially were more likely to own a pouch with an ivory ring. However, this may indeed be sample bias (early phase was noted to have more mobility from outside catchment by females) which can only be remedied with a future study targeting more of the individuals who were given these rings as grave goods.

The very rare occurrence of coral beads in early medieval cemeteries demanded the enquiry into evidence for mobility in the individuals who were afforded with such grave goods in death. Only 110 beads made of coral were present at Cleatham and these were distributed amongst 11 urns (Leahy 2007: 165, Table 64). Two of these (458 and 63) were sampled for $^{87}Sr/^{86}Sr$ and [Sr] and the results are highlighted in Fig. 80 below. The former urn contained 32 beads and the latter only four, and this variation of quantity is consistent across the 11 burials (ibid). In terms of origins, coral beads must have been imported from abroad, and suggested origins include India (or Indian ocean) (Squires 2011: 282; Leahy and Coutts 1987: 7). Both individuals are old middle adult females and do not appear to have spent their infancy near Cleatham, although 63 may have originated west of the catchment. In fact, 458 did not reside near Cleatham before her death either, and the only connection that can be deduced may be that her otic capsule $^{87}Sr/^{86}Sr$ ratio (0.7128) resembles that of two other individuals (336 and 443) who appeared to have moved to Cleatham catchment during their lifetime. This old middle adult female was also noted to have been given an ivory ring bag as pyre good alongside a barred bone comb (unburnt), a bone comb fragment (burnt), and nine glass beads (also burnt). In terms of mobility, both

individuals from this sample are non-locals. Because the sample is so small, however, caution is necessary in the interpretation.

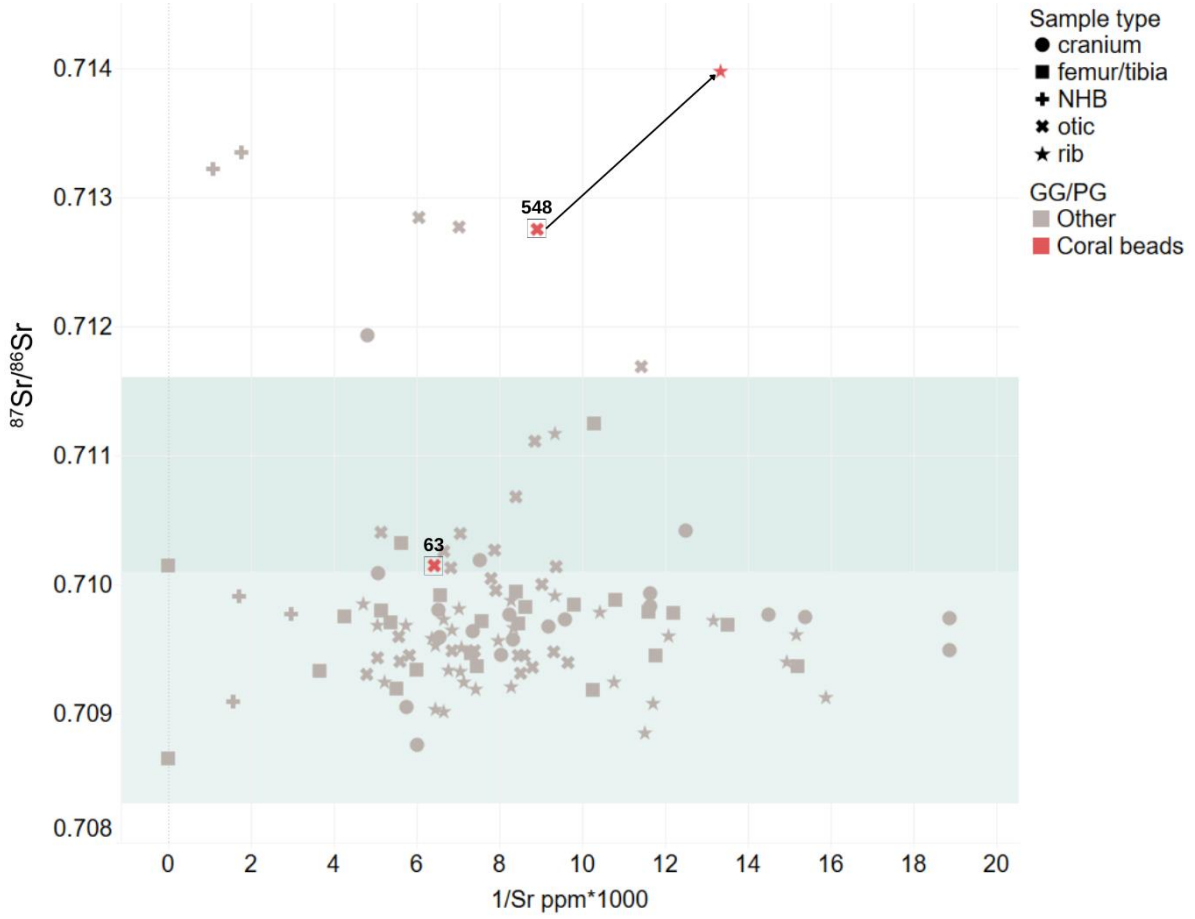

FIGURE 80 – MOBILITY OF INDIVIDUALS BURIED WITH CORAL BEADS.

In summary, then, there appears to be a high rate of mobility evident amongst the individuals who were provided with such exotic objects as ivory pouches or coral beads. However, Squires already noted the preponderance of females to own such items (Squires 2011: 282), and from the overall mobility assessment we know that females were more mobile than men, especially during the first phase of use of the cemetery. This observation may in part be influenced by the small sample size. On the other hand, it was also possible to note that at least two of the individuals buried inside the Romano-British vessels were sexed male, at the younger age spectrum, and that their mobility histories and/or diets were varied. The only discerning consistency in terms of mobility therefore lies in variation.

Perhaps the Romano-British vessels were provided to individuals who did not have their own families or households. Unfortunately, it is not possible to be more definite without the otic samples of the buried individuals.

5.4 CONCLUSION

This chapter has looked at the level of mobility evident on an individual scale at Cleatham cremation cemetery. In short, it was possible to determine that the earlier phases of use were marked by greater influx of people from outside of the catchment. It was also possible to show that most of the longer-distance incomers were females or possible females. It was determined that the non-adult and adolescent age groups were consistent with the local $^{87}Sr/^{86}Sr$ biosphere, but that long-distance and possibly intra-regional mobility were observable across all other age groups. Representations of especially older and younger age groups was poor and may therefore require additional sampling in a future project. However, the analysis of $^{87}Sr/^{86}Sr$ and [Sr] has been exceptionally useful in visualising the life mobility histories of some of the individuals, which may even show regional and intra-catchment mobility. The examination of animal bone with some of the burials showed that these animals – predominantly horses – derived from a variety of places, spanning a similar $^{87}Sr/^{86}Sr$ range to the humans. The results of the enquiry into the mobility-histories of associated animals was also illuminating: At least one horse was brought from outside the Cleatham catchment where it appears to have died soon after. There appear to have been differing ways of dealing with the cremated remains, some allowing for intermingling in the same urn, and some emphasising separation between species. In this way, ontological boundaries were broken up and reconstructed in different ways throughout the funerary rite. The presence of coral beads and ivory rings for pouches appears to be a good indicator for mobility, but it is recognised that this sample is too small to confirm that this is the case more generally. Finally, with a higher sampling density, it may be possible to more clearly define the nature of the connection to a place with lithologies producing $^{87}Sr/^{86}Sr$ ratios of approximately 0.7128, where a small number of individuals (mostly female) spent their infancy before heading to the Cleatham area.

6 HEATH WOOD

6.1 CONTEXT

This chapter deals with the chronologically latest case study site investigated for this thesis: the 9th century barrow cemetery at Heath Wood, in Derbyshire. Given that the context for this site is specifically situated during the Scandinavian incursions into Britain, I will take into account primary source material such as the *Anglo-Saxon Chronicle.* The chapter first presents the historical and archaeological context of the site, after which the results of the Sr analyses are laid out and discussed. The research questions laid out in the introduction lead the inquiry first into the mobility of the individuals buried under the barrows, and then take the questioning further to look at animal-human relationships and social practice.

The Anglo-Saxon Chronicle, our primary contemporary source, records that in AD 865 a Viking Great Army landed in East Anglia (Whitelock *et al.* 1961). Previously, raids had followed a pattern of hit-and-run, attacking vulnerable coastal monasteries, but this new army remained longer, overwintering at camps set within the heart of England. Over the following decade this force moved rapidly, travelling by land and water, and fighting each of the Anglo-Saxon kingdoms in turn, its strategy changing from the quest for portable wealth to the seizure of land for permanent settlement. In AD 873, the Anglo-Saxon Chronicle records that 'In this year the army went from Lindsey [in modern Lincolnshire] to Repton and took up winter quarters there' (Whitelock *et al.* 1961). An earthwork-enclosed area containing Scandinavian-style inhumation graves has been excavated at Repton (Fig.81) by Biddle and Kjølbye-Biddle (1992). To the west of the enclosure lay an early medieval mausoleum which contained the disarticulated charnel of at least 264 adult individuals (Biddle & Kjølbye-Biddle 2001; Jarman *et al.* 2018). Recent metal-detected finds, including characteristic lead gaming pieces and Islamic coins, as well as weights, now suggest that the area known as Foremark, situated between the village of Repton and the cremation cemetery at Heath Wood, was also part of the landscape that made up the camp at Repton

(Jarman 2021). In this historical and spatial context, however, it is Heath Wood which stands out through its unparalleled nature in the entirety of the British Isles. It is a unique Scandinavian cremation cemetery which features 59 mounds, and dates to a period by which Christianity had been firmly established in England, and inhumation was the exclusive burial rite – the 9th and early 10th centuries (Table 21). Heath Wood fundamentally contrasts with the generally more archaeologically invisible presence of Scandinavians in England, a matter of continuing interest in academic research (Richards 2000).

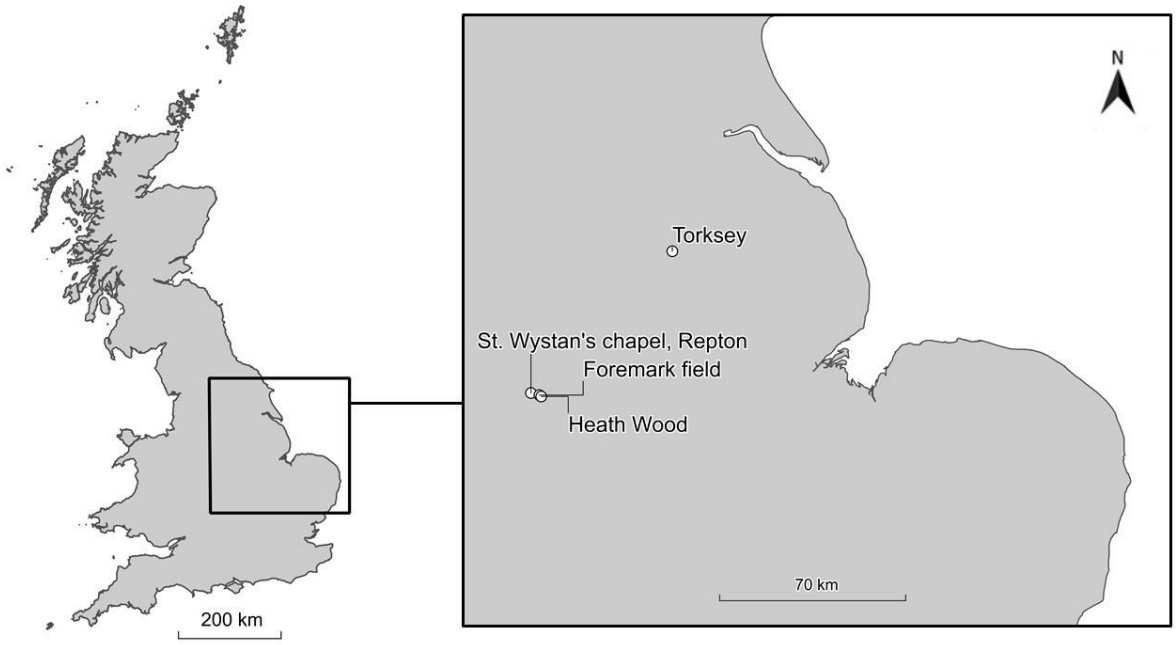

FIGURE 81 - MAP OF SITES MENTIONED IN THE TEXT.

At Heath Wood, a total of 59 mounds are separated into four clusters (Fig. 82). Only 20 of the mounds have so far been investigated, and most of this excavation took place in the 1940s and 50s (Clarke & Fraser 1946; Posnansky 1956) (see Fig.83 for more detail). Calcined remains found within three of the mounds were radiocarbon dated to the eighth to 10th centuries AD (Richards *et al.* 2004) (Table 21). All three dates are consistent with the Heath Wood cemetery being contemporaneous with the arrival and presence of the Viking Great Army at Repton in AD 873-4 as reported in the Anglo-Saxon Chronicle. At the same time, the mound burials, cremation pyres, and animal remains accompanying the deceased

are in stark contrast to the Viking inhumations around St Wystan's shrine at nearby Repton. It has been suggested that the adoption of various mortuary rites may reflect the different warbands which made up the army (Richards *et al.* 2004). Indeed, the Anglo-Saxon Chronicle records that on its departure from Repton in the spring of AD 874, the army split in two.

TABLE 21 – RADIOCARBON DATES FOR THE CREMATED REMAINS FROM MOUNDS 11, 50 AND 56 AT HEATH WOOD (RICHARDS ET AL 2004).

Mound	11	50	56
Material	cremated human bone	cremated human bone	cremated human bone
Lab code	OxA-12698	OxA-12700	OxA-12699
Result (Conventional Radiocarbon Age)	1247 ± 27 BP	1191 ± 26 BP	1163 ± 26 BP
Calibrated age (95.4%)	AD 680-880	AD 770-950	AD 770-980

The excavations revealed that the mounds fall into two or three categories; while some include layers of burnt material including soil, charcoal and bone indicative of *in situ* pyres, others were apparently empty or included only a small amount of cremated bone. The latter have been interpreted as token deposits, which represent a body cremated elsewhere (Richards *et al.* 2004).

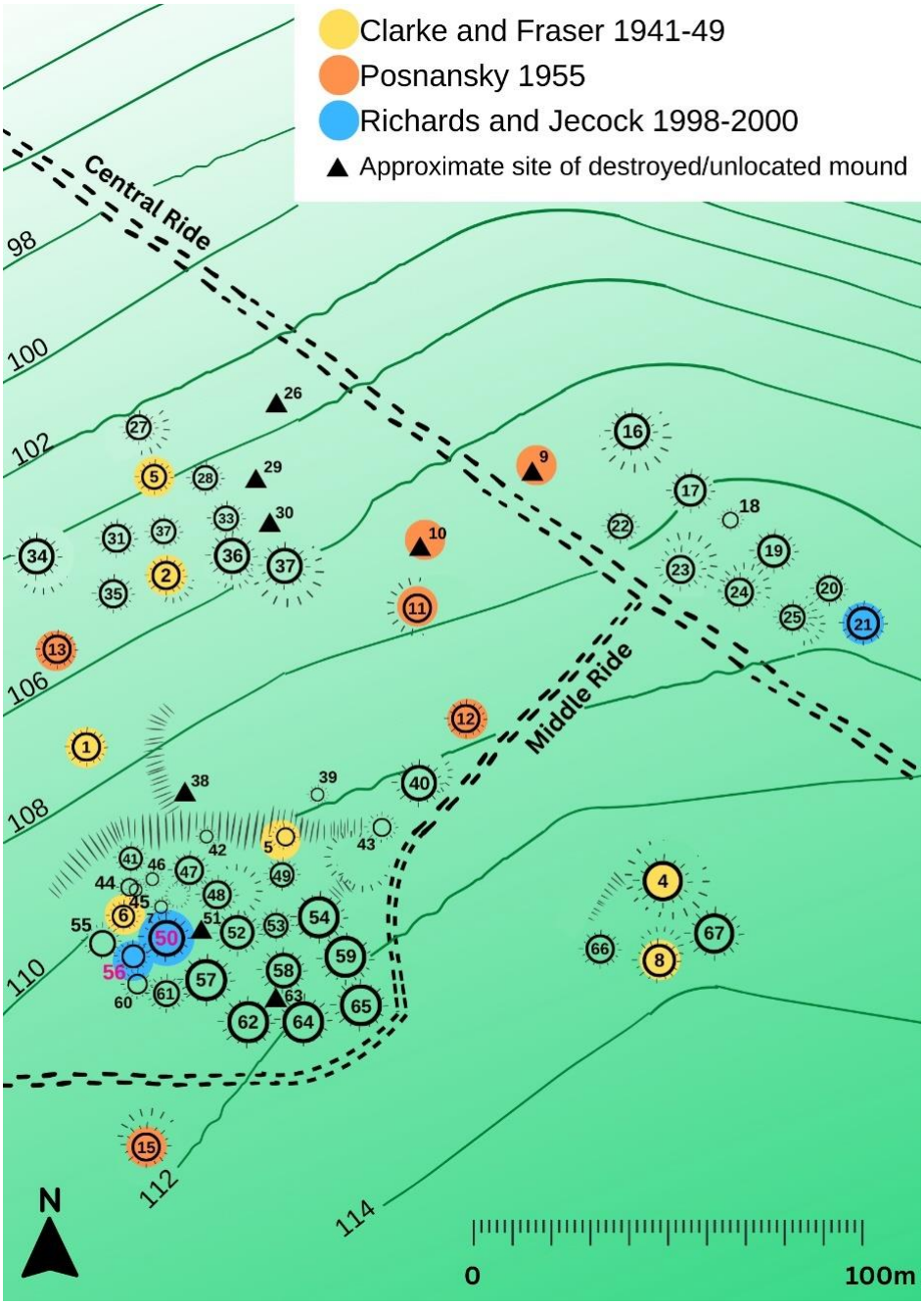

FIGURE 82 – PLAN OF THE HEATH WOOD SITE INCLUDING ALL KNOWN MOUNDS. COLOUR CODING INDICATES EXCAVATED MOUNDS DURING THE DIFFERENT SEASONS (BASED ON PLAN FROM RCHM ENGLAND).

During the excavations in the 1950s (Posnansky 1956), only Mound 11 was noted to have an *in situ* cremation hearth at its centre, and subsequent analysis of the cremated remains by specialists McKinley, Bond, and Worley confirmed that these belonged to a human adult, a horse, a dog, and a sheep/goat (Richards *et al.* 2004). A similar selection of animals and humans was recovered during the excavation of two further mounds – 50 and 56 –

conducted by Richards and Jecock between 1998 and 2000 (Richards *et al.* 2004). Not all the excavated mounds contained artefacts, but evidence for weaponry, with fragments of swords and shields, as well as dress accessories, nails, and other iron objects have all been recorded from the earlier excavations (Fig. 83). Unfortunately, the only remaining cremated bone still available at Derby Museum derives from the latest phase of excavation. However limited this small sample of individuals may be – it holds the potential to illuminate our understanding of the site for the first time in decades, as a result of recent advances in isotopic analysis of cremated human remains (Snoeck *et al.* 2015; Cavazzuti *et al.* 2019; Veselka *et al.* 2021).

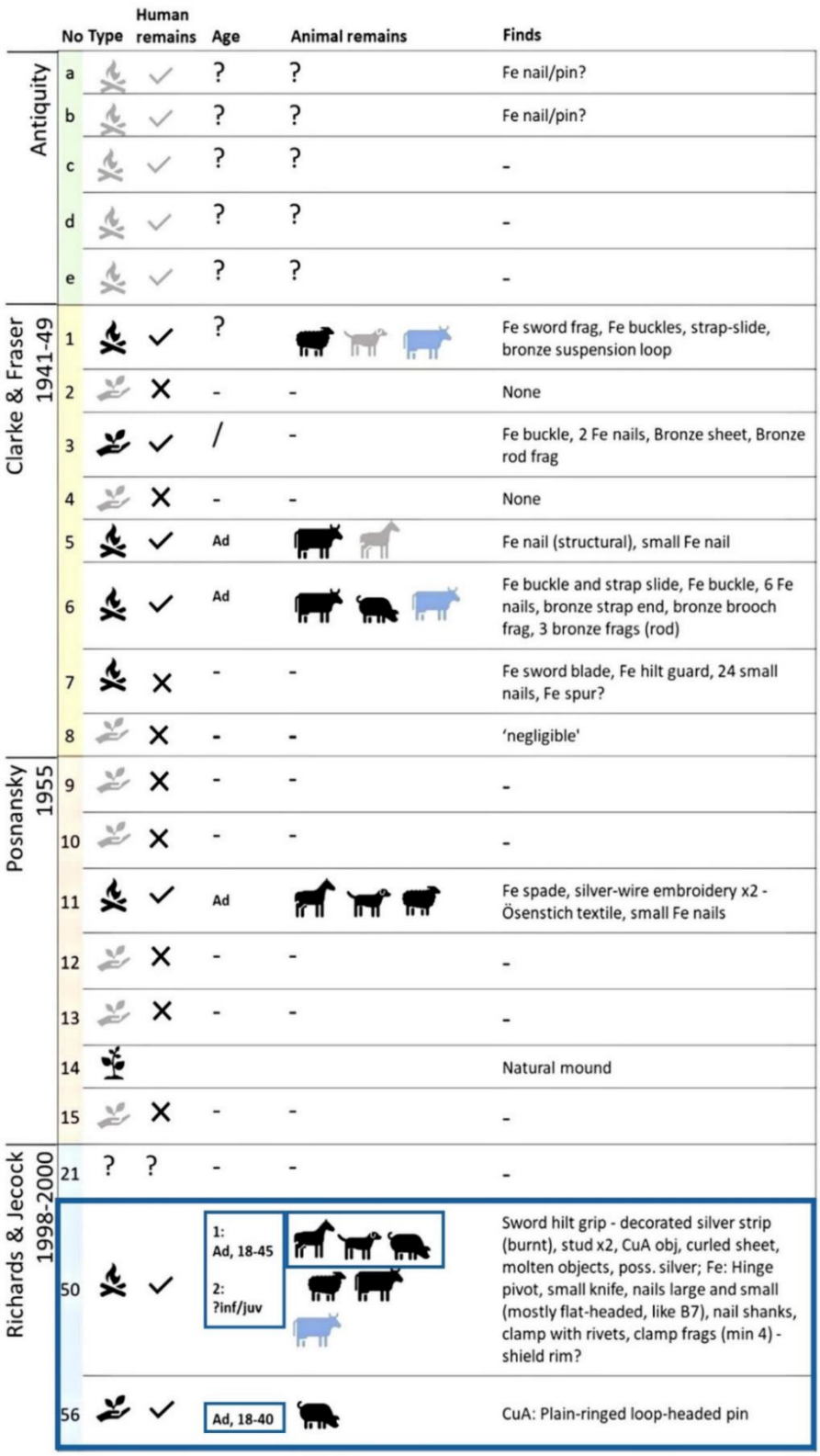

FIGURE 83 – SUMMARY OF CONTENT OF MOUNDS AT HEATH WOOD, COLOURS OF MOUND NUMBERS/LETTERS INDICATE EXCAVATION (CLARKE & FRASER 1946; CLARKE *ET AL.* 1949; POSNANSKY 1956; RICHARDS *ET AL.* 2004); - TOKEN BURIAL; - PYRE IN SITU; - NAT. MOUND; GREY

SYMBOLS INDICATE A LEVEL OF UNCERTAINTY. LIGHT BLUE ANIMAL SYMBOLS INDICATE UNBURNT BONE. AD – ADULT; INF – INFANT; JUV – JUVENILE.

A study by Budd *et al*. (2004) included the oxygen (O) and Sr isotope analysis of four individuals recovered from the charnel and four from the churchyard. The results were consistent with an origin in Britain (raw data available in Evans *et al.* (2012) and in Montgomery *et al.* (2014): supplementary material). The study included only a single soil leachate from Repton, which was cautiously considered representative of the local BASr with a $^{87}Sr/^{86}Sr$ value of 0.7115. Soil leachates have proven to be less reliable in terms of biosphere representation than other types of samples and more emphasis is put on plant sampling to investigate local BASr (Evans *et al.* 2009; Evans *et al.* 2010; Maurer *et al.* 2012; Snoeck *et al.* 2016; Ryan *et al.* 2018; Britton *et al.* 2020). Additional $^{87}Sr/^{86}Sr$ results from the Repton cemetery and charnel were recently measured (Jarman *et al.* 2019). The $^{87}Sr/^{86}Sr$ in the dentition of 43 individuals from the post-873 AD burials ranged from 0.7092 to 0.7143. Variation was thus significant and led the authors to conclude that some of the individuals with $^{87}Sr/^{86}Sr$ values at the higher end of the spectrum were likely part of the Viking Great Army and/or the subsequent settlement phase, with possible origins in Scandinavia. Jarman *et al.* (2019) proposed that the BASr for Repton ranged between $^{87}Sr/^{86}Sr$ 0.7112-0.7120, based on three dentine samples, one previously published soil leachate, and one faunal sample (cow). Still, the suggestion that the enclosure at St. Wystan, Repton, was the sole base for the winter camp of the Viking Great Army is unlikely. The D-shaped earthwork at Repton encloses an area of 0.4ha, compared to the 55ha camp at Torksey, and 31ha at the camp at Aldwark, in North Yorkshire (Williams 2020). Recent metal-detected finds, including characteristic lead gaming pieces and Islamic coins, as well as weights, now suggest that the area known as Foremark, situated between the village of Repton and the cremation cemetery of Heath Wood, was also part of the landscape that made up the camp at Repton (Jarman 2021).

6.1.1 HUMAN AND ANIMAL REMAINS

Only a limited amount of cremated bone was available for analysis. In Mound 56, McKinley identified an adult between 18 and 40 years, and in Mound 50, she identified the remains of an adult (possible female) between the ages of 18 and 45, as well as those of a non-adult (Richards *et al.* 2004). Samples for the $^{87}Sr/^{86}Sr$ analysis consisted of cross sections of femoral shaft cortical bone for both adult individuals. For the adult in Mound 50 a rib fragment was added, and for the adult in Mound 56 a cranial fragment. Additionally, we analysed a cranial fragment from amongst the remains in Mound 50, which was determined to belong to the non-adult individual. Three of the animals found intermingled with the cremated human remains in Mound 50 were also included for $^{87}Sr/^{86}Sr$ analyses. The remains belonged to a horse, a dog, and a possible pig. The evidence from the excavation suggests that the horse, and most likely the pig (one half present), were cremated in full (Richards *et al.* 2004). However, the same could not be confirmed for the dog because the pyre was raked and remains were partially removed post-cremation (Richards *et al.* 2004).

A sample of cortical bone from the fused radius/ulna fragment of the horse was used and based on the fusion stage, it was determined to have been older than three years (Richards *et al.* 2004). The identification of the horse was re-confirmed by Bond for this study (*personal communication)*. For the dog, a fragment of cortical bone from the radius was used. The dog was older than 11 months at the time of death based on the stage of fusion of the distal radius (Richards *et al.* 2004). A fragment of astragalus was analysed for the possible pig. For a full description of the method see chapter 3, Materials and Methods (3.3.1).

6.2 RESULTS

6.2.1 PLANT SAMPLES

The most extensive bedrock geology in the 25km catchment is the Triassic Mercia Mudstone Group (Sample 2), which ranges between 0.7095 and 0.7109 based solely on our

plant samples, and between 0.7095 and 0.7124 when including samples from Evans *et al.* (2010) and Johnson (2018). Due to its proximity to Repton and Heath Wood, the results from sample location 3 are also highly relevant. These plant samples, based on the Triassic Sherwood Sandstone Group, range from 0.7106 to 0.7111 and fall between the other plant $^{87}Sr/^{86}Sr$ available on the same bedrock within the 25km catchment (Table 22; Evans *et al.* 2010). The plant samples collected from location 6 on the Pennine Lower Coal Measures are higher in comparison to the plant $^{87}Sr/^{86}Sr$ based on the same geological bedrock, albeit c. 50km north of the site (Evans *et al.* 2010), with a difference of approximately +0.0030. A further 12 plant samples based on the Precambrian Charnian Supergroup and the Charnwood Diorites southeast of Heath Wood range between 0.7104 and 0.7112, whilst a singular plant at 0.7110 is found on the Ordovician Mountsorrel Igneous Complex (Table 22) (Johnson 2018. Available from: http://etheses.dur.ac.uk/12637/).

TABLE 22 - $^{87}SR/^{86}SR$ FOR THE PLANTS FROM THE SIX PLANT SAMPLING LOCATIONS. FOR LOCATIONS SEE MAP IN FIG. 22. PLANT SAMPLES FROM EVANS ET AL (2010) LOCATED WITHIN THE 25KM CATCHMENT AREA ARE INCLUDED FOR COMPARISON WITH THE NEW DATA. (*) DENOTES SAMPLES LOCATED C. 50KM NORTH OF HEATH WOOD FROM EVANS ET AL. 2010. ALL SAMPLE LOCATION 7 SAMPLES FROM JOHNSON 2018.

Plant sample location	Coordinates		Bedrock	$^{87}Sr/^{86}Sr$ from plant samples (Evans et al 2010, 2018; Johnson, 2018)	$^{87}Sr/^{86}Sr$ from samples from this study and 2 σ		
	Eastings	Northings			Grass	Shrub	Tree
1	430680.256	347419.61	Carboniferous - Bowland High Group and Craven Group	0.70905	0.710537 0.000008	0.710479 0.000008	0.711881 0.000011
2	413998.945	323228.121	Triassic mud-, silt-, and sandstone - Mercia Mudstone Group	0.71142 0.71170 0.71209 0.71219 0.71239	0.710899 0.000010	0.709836 0.000013	0.709473 0.000009
3	434564.455	325725.42	Triassic sandstone and conglomerate, interbedded – Sherwood Sandstone Group	0.70992 0.71283	0.710593 0.000008	0.710787 0.000010	0.711061 0.000011
4	436886.361	325522.939	Carboniferous mud-, silt-, sandstone - Millstone Grit Group	None	0.711341 0.000008	0.711178 0.000011	0.711608 0.000009
5	437295.523	321256.869	Pennine Lower Coal Measures Formation And South Wales Lower Coal Measures Formation	None	0.712890 0.000009	0.713071 0.000009	0.712137 0.000010
6	443217.02	345471.426	Pennine Middle Coal Measures Formation And South Wales Middle Coal Measures Formation	0.7110* 0.7114*	0.715073 0.000009	0.714498 0.000009	0.714916 0.000008
7		various	Precambrian Charnian Supergroup, Charnwood Diorites, and Ordovician Mountsorrel Igneous Complex (Johnson 2018)	0.71098 0.71079 0.71064 0.71060 0.71110 0.71058 0.71040 0.71063 0.71039 0.71118 0.71060 0.71050 0.71047	--	--	--

6.2.2 CALCINED HUMAN AND ANIMAL BONE

The $^{87}Sr/^{86}Sr$ results measured on animal and human remains for Mounds 50 and 56 range from 0.7103 to 0.7161 (Table 23). The results for the adult individual in Mound 56 are lowest, with a $^{87}Sr/^{86}Sr$ of 0.7103-0.7104. The highest ratios are derived from the bone samples of the possible pig (0.7161), the horse (0.7158), and the dog (0.7150). The femoral ratios from the adult in Mound 50 are slightly higher than that of the rib sample from the same individual (Table 23). The cranial fragments from both mounds are similar in terms of their $^{87}Sr/^{86}Sr$ ratios (0.7107 and 0.7104 for Mounds 50 and 56 respectively). The Sr concentrations further separate the individuals.

TABLE 23 - SUMMARY RESULTS FOR THE CREMATED HUMAN AND ANIMAL BONE SAMPLES INCLUDING AGE, LOCATION, BONE ELEMENT, 87SR/86SR AND [SR] DATA. *[SR] NORMALISED TO 40% CA.

Sample ID	**Age**	**Mound**	**Bone element**			**[Sr]**
				$^{87}Sr/^{86}Sr$	**2σ**	**ppm***
HW00_242	Adult (18-40)	56	Femur	0.710314	0.000008	107.7
HW00 508 SF220			Cranium	0.710419	0.000009	156.0
HW99 411_1	Adult (18-45)	50	Rib	0.713655	0.000011	297.1
HW99411_2			Femur	0.714268	0.000010	260.0
HW99 411.2	?non-adult	50	Occipital	0.710695	0.000009	115.0
HW99 411_2_P	-	50	Pig astragalus	0.716065	0.000008	272.0
HW99 411_2_H	> 3 y	50	Horse radius/ulna shaft left	0.715815	0.000010	287.2
HW99 308_D	> 11 m	50	Dog radius	0.715024	0.000007	256.0

6.3 DISCUSSION

6.3.1 PLANTS

6.3.1.1 ISSUES WITH SAMPLE LOCATION 6

The plant samples taken at location 6 returned unexpectedly high $^{87}Sr/^{86}Sr$ ranging from 0.7145 to 0.7151. These contrast with the two plant samples collected by Evans *et al.* (2010; 2018), and also contrast with data collected by Johnson (2018. Available from:

http://etheses.dur.ac.uk/12637/) from the Pennine Coal Measures around Nuneaton, at 0.7103 and 0.7106, immediately south of the 25km catchment border. According to Evans et al (2018), carboniferous sandstones in central and north England produce $^{87}Sr/^{86}Sr$ ratios in plants which fall in-between 0.7095 (minimum value measured) and 0.7117 (maximum value measured; n=11). The carboniferous sandstones of southwest England and Wales produce a range of 0.7103 to 0.7126 (n=7), and those of Scotland fall in-between 0.7091 and 0.7124 (n=17). Therefore, there exists significant doubt that the values measured at plant sample location 6 are a genuine representation of the underlying rock unit and by extension, the BASr.

All the Sample 6 plants were collected in what today is the Shipley Country Park in Derbyshire. This is a communal park area with parking, a small expanse of grass lined with trees, and shrubs. Beyond a narrow strip of trees to the north-northeast lies a modern housing development. In the late 1800s, this was farmland around Thorpehill farm (Fig. 87). By the late 1880s, Great Northern Railways had constructed the Heanor railway branch (Fig. 86), which was not only used to transport passengers, but also coal and other materials between 1890 and 1925 (Fig. 85), after which it was only used sporadically and then fell into disrepair. Figures 84 to 87 below illustrate the main sampling area and the changes that were taking place there in the last two centuries.

FIGURE 84 - AREA OF SHIPLEY COUNTRY PARK, DERBYSHIRE, ON OS MASTERMAP® TOPOGRAPHY LAYER 1:2500 YELLOW CIRCLES: SHRUB SAMPLES; RED TRIANGLES: TREE SAMPLES; BLUE DOTS: GRASS SAMPLES. CONTAINS OS DATA © CROWN COPYRIGHT AND DATABASE RIGHT (2022).

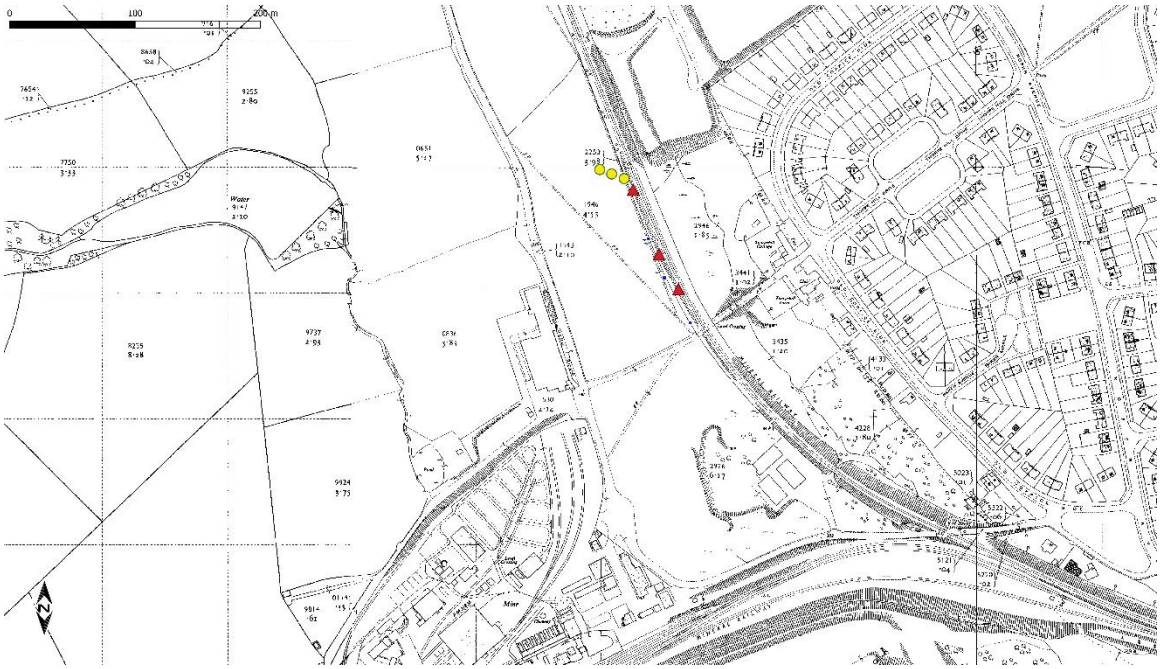

FIGURE 85 - AREA OF SHIPLEY COUNTRY PARK, DERBYSHIRE, ON NATIONAL GRID MAP 1:2500 1ST EDITION YELLOW CIRCLES: SHRUB SAMPLES; RED TRIANGLES: TREE SAMPLES; BLUE DOTS: GRASS SAMPLES. © CROWN COPYRIGHT AND LANDMARK INFORMATION GROUP LIMITED (2022). ALL RIGHTS RESERVED. (1943-1995).

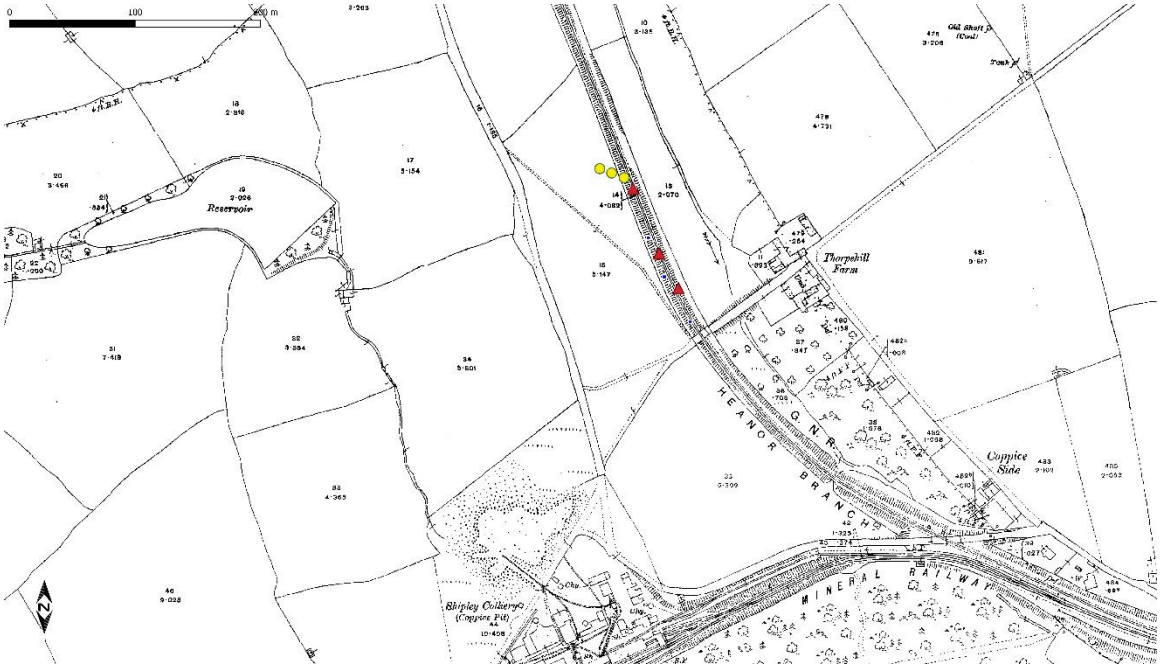

FIGURE 86 - AREA OF SHIPLEY COUNTRY PARK, DERBYSHIRE, ON NATIONAL GRID MAP 1:2500 2ND REVISION YELLOW CIRCLES: SHRUB SAMPLES; RED TRIANGLES: TREE SAMPLES; BLUE DOTS: GRASS SAMPLES. © CROWN COPYRIGHT AND LANDMARK INFORMATION GROUP LIMITED (2022). ALL RIGHTS RESERVED. (1924-1951).

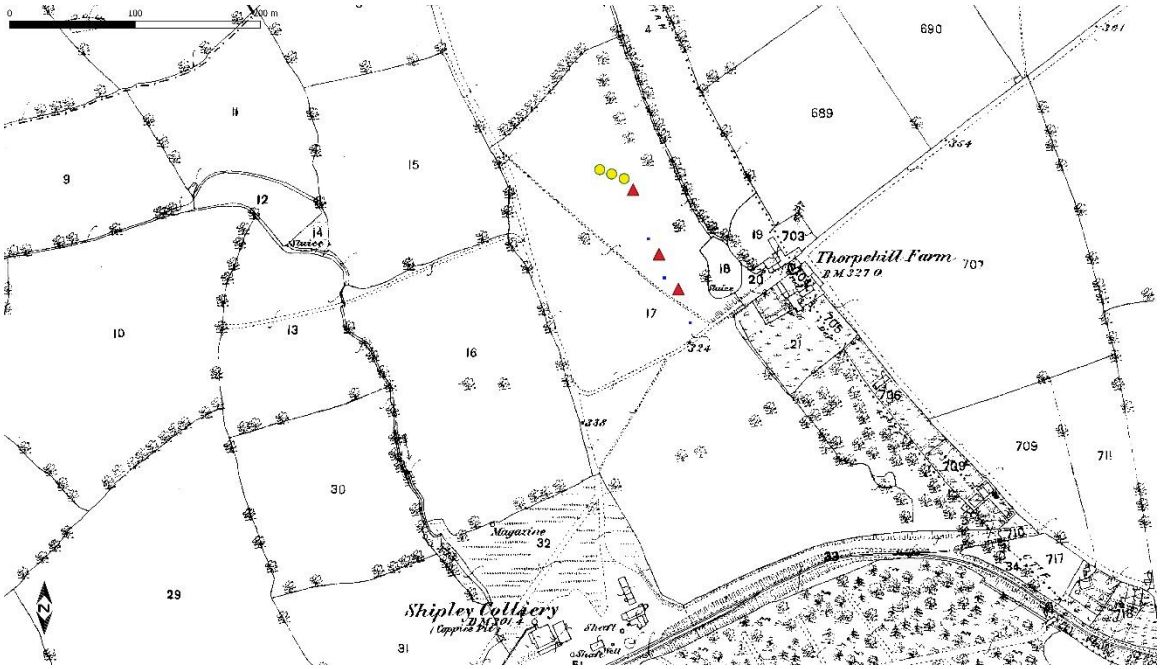

FIGURE 87 - AREA OF SHIPLEY COUNTRY PARK, DERBYSHIRE, ON COUNTRY SERIES MAP 1:2500 1ST EDITION YELLOW CIRCLES: SHRUB SAMPLES; RED TRIANGLES: TREE SAMPLES; BLUE DOTS: GRASS SAMPLES. © CROWN COPYRIGHT AND LANDMARK INFORMATION GROUP LIMITED (2022). ALL RIGHTS RESERVED. (1853-1904).

When the tree, shrub and grass sample locations are superimposed onto historic maps, it becomes clear that the samples were taken from the exact run of the historic track of the Great Northern Railway (Heanor branch; Derbyshire HER: MDR4963; Monument record available at https://her.derbyshire.gov.uk/Monument/MDR4963). Interestingly, the lowest $^{87}Sr/^{86}Sr$ derived from the shrubs, which were located furthest from the railway track.

One attempt at an explanation related to the railway track directly concerns the construction materials used. Railway tracks are not placed directly on the ground, but rather upon a bank of built-up earth, and material which is known as 'ballast'. Historically, different types of ballast were used, and primary importance was given to the size rather than the material. The different types of ballast included stone, broken brick, slag, ashes, cinder, ashes, sand, or clay, and sometimes a two-layered system was employed which meant that finer material was laid out atop the coarser material to stabilise the sleepers and facilitate load distribution (Claisse & Calla 2006). There is a possibility that granite from northern quarries was used, although the transportation requirements make this an unlikely explanation. It is also possible that the material used to backfill the rail track after decommissioning in the 1960s is responsible for the high $^{87}Sr/^{86}Sr$ values. In conclusion, the location for our plant sample 6 is clearly heavily impacted on by anthropogenic processes and is in close proximity to longstanding industrial activity. As such, it was decided to exclude these samples from the dataset.

The box-plot below visualizes the variation of the plant samples from the various geological formations (Fig. 88). The data includes not only the samples measured for this study, but also a small number from Evans *et al.* (2010; 2018), and from the PhD thesis of Lucie Johnson (2018. Available from: http://etheses.dur.ac.uk/12637/ ; Johnson *et al.* 2022). As can be determined from the plot, there is a relatively broad range of $^{87}Sr/^{86}Sr$ present in the plants around Heath Wood, from 0.7091 to 0.7131. Both the mud-, silt-, and sandstones from the Bowland High Group (sample location 1) and those of the Triassic Mercia

Mudstone Group (sample location 2) have the broadest variation. The highest $^{87}Sr/^{86}Sr$ values were measured in plants from the Pennine Lower Coal Measures (sample location 5), although one outlier from the Triassic sandstone (0.7128; sample location 3) clearly falls into the higher spectrum of the catchment. In fact, this value is the highest measured from Evans *et al.* (2010; 2018) for this type of geology. The range determined by Evans *et al.* (2010; 2018) for the most extensive geology in the Heath Wood catchment is 0.7098 to 0.7128, and this range approximately corresponds to the one measured for this study (0.7094 to 0.7124).

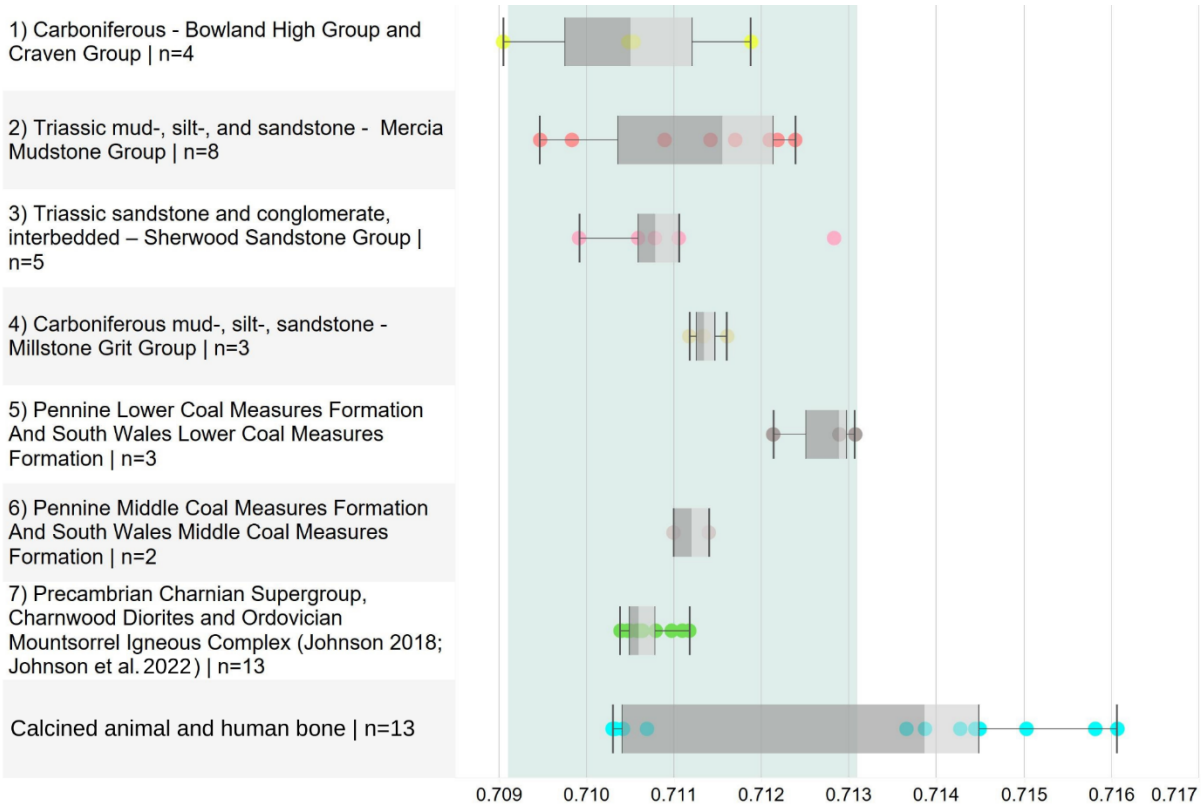

FIGURE 88 - BOXPLOT OF PLANT SAMPLE RESULTS: $^{87}SR/^{86}SR$ BY LITHOLOGY INCLUDING BGS DATA WITHIN OR ADJACENT TO THE CATCHMENT AREA WHERE AVAILABLE (EVANS ET AL. 2010; 2018). LOCATION 6 SAMPLES FROM THIS STUDY NOT INCLUDED. CHARNWOOD SAMPLES FROM JOHNSON (2018). BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES. SINGLE POINTS ARE EXTREME OUTLIERS.

6.3.1.2 BASR AT HEATH WOOD

The variation seen in the plants from all locations measured in this study, including those measured by Evans *et al.* (2010) and Johnson (2018), ranges from 0.7091 to 0.7131 (see

Table 22; Fig. 22). We are here using this as a conservative $^{87}Sr/^{86}Sr$ range that would encapsulate any individuals who lived on food sources from within a 25km catchment from Heath Wood. As such, any individual with $^{87}Sr/^{86}Sr$ higher than 0.7131 we are deeming to not have spent a lot of time in the area around Heath Wood.

6.3.2 Calcined Human and animal remains

The adult and the animals in Mound 50 have $^{87}Sr/^{86}Sr$ ranging from 0.7137 to 0.7161 and are conclusively not from the area around Heath Wood. The nearest areas to Heath Wood that consistently produced BASr values >0.7130 include the Precambrian bedrock of the Malvern Hills (England), the Silurian Ludlow bedrock in Wales (Chenery *et al.* 2010; Evans *et al.* 2018; Johnson 2018. Available from: http://etheses.dur.ac.uk/12637/), the Carboniferous granitic intrusions of Dartmoor (Müldner & Frémondeau 2021) or further afield towards Scotland (Evans *et al.* 2018; Johnson 2018. Available from: http://etheses.dur.ac.uk/12637/) and some small areas in Ireland (Snoeck *et al.* 2020). However, when viewed in consideration of their archaeological context, and for reasons pertaining to how $^{87}Sr/^{86}Sr$ are generated in tissues from the environment, it is likely that these ratios were not produced in the British Isles. Instead, the $^{87}Sr/^{86}Sr$ observed most likely reflect a life on the Palaeozoic and Precambrian gneissic or granitic lithologies of Scandinavia – an area with convincing parallels to Heath Wood in terms of burial rites and grave goods. These lithologies are common within the Baltic Shield (Palaeozoic and Precambrian lithologies), which underlies most of Norway and large areas of central and northern Sweden, and indeed Finland. BASr values from Scandinavia regularly produce values from 0.7140 to >0.7200 (Åberg & Wickman 1987; Åberg *et al.* 1989; Åberg *et al.* 1998; Poszwa *et al.* 2004; Price *et al.* 2017; Price *et al.* 2018; Ryan *et al.* 2018; Price *et al.* 2019). It is thus a strong possibility, with reference to the archaeological and historical context, that the adult human and the animals buried at Heath Wood in Mound 50 came to Britain from this part of the world. In fact, the horse has a $^{87}Sr/^{86}Sr$ of 0.7158 and this may be explained by a diet exclusively ingested by grazing on meadows on granitic or gneissic

soils/lithologies. Similarly, the $^{87}Sr/^{86}Sr$ of the possible pig suggests a diet deriving from a high $^{87}Sr/^{86}Sr$ lithology. In early medieval rural locations, pigs have been noted to feed on acorns in forests, as well as on roots of ferns and dandelions (Kelly 1997), which can explain these values considering the observation that ancient woodland areas often produce elevated $^{87}Sr/^{86}Sr$ (Johnson 2018. Available from: http://etheses.dur.ac.uk/12637/ Ch 6; Johnson *et al.* 2022). The third animal, the dog, has a $^{87}Sr/^{86}Sr$ of 0.7150, slightly lower than that of the horse and pig but more elevated than the adult human, and this may be due the fact that dogs, like humans, are omnivores and feed off scraps from human food sources, especially if they are companion animals.

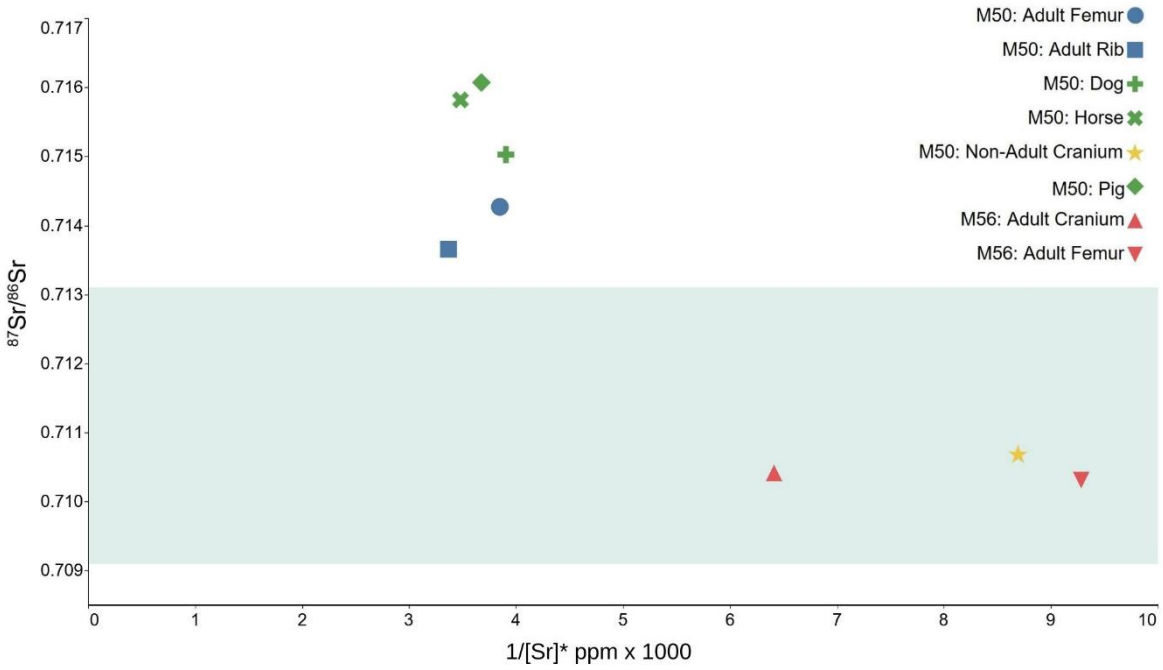

FIGURE 89 - $^{87}SR/^{86}SR$ VS [SR] (EXPRESSED AS 1/[SR] X 1000) FOR THE HUMANS AND ANIMALS OF HEATH WOOD. TRANSPARENT GREEN BAND INDICATES SR BIOSPHERE WITHIN A 25KM CATCHMENT OF HEATH WOOD. M50 – MOUND 50; M56: MOUND 56. ERROR LIES WITHIN THE SYMBOLS. *[SR] NORMALISED TO 40% CA.

An alternative explanation pertaining to these values is that the animals could have died soon after arrival in Britain, without extensive bone remodelling taking place in the new environment. This would have made it impossible for their tissues to reflect the lower $^{87}Sr/^{86}Sr$ ratios of the local area. In contrast, through the process of bone turnover, $^{87}Sr/^{86}Sr$ from the catchment of Heath Wood could have contributed to produce the lower $^{87}Sr/^{86}Sr$

ratios seen in the adult. Bone remodelling is a relatively slow process, however, and therefore it is most likely that the difference in $^{87}Sr/^{86}Sr$ ratios was produced by a dissimilar diet, for example through a more substantial consumption of marine resources such as seaweed or salt with a $^{87}Sr/^{86}Sr$ of 0.7092 (Allègre *et al.* 2010; Montgomery 2010). There is also a slight decrease in $^{87}Sr/^{86}Sr$ from 0.7143 (femur) to 0.7137 (rib). It may be that this reflects mobility and/or a change in diet. If the $^{87}Sr/^{86}Sr$ are considered as a process and not as a 'snapshot', an explanation may be proposed: In the rib – reflecting the Sr intake of the last 5 or so years of life - a shift in diet, to crops with lower $^{87}Sr/^{86}Sr$, can be recognised. The contribution of Sr from the new biosphere, or indeed from the diet during extensive travel, may have pulled the average of the $^{87}Sr/^{86}Sr$ towards a lower value, while the thick femoral cortex of the femur is subject to much slower turnover and therefore reflects more substantially the elevated $^{87}Sr/^{86}Sr$ of the previous environment.

The $^{87}Sr/^{86}Sr$ of the adult (56) and the non-adult (50) fall within the BASr range of the 25km catchment around Heath Wood, and more generally, are consistent with values seen across Britain (Evans *et al.* 2010; Evans *et al.* 2018). It is conceivable that these individuals grew up in the area, in southern or eastern England - or even large parts of Europe. For Scandinavia, Denmark or southwestern Sweden would also be a possible place of origin as they share similar lithology and have a BASr range of 0.7081 – 0.7111 (Frei & Frei 2011; Frei & Price 2012). For the cremation rite observed at Heath Wood, parallels have been identified at the contemporaneous cemeteries of Northern Jutland, in Denmark, such as Jelling and Vennebjerg (Shetelig 1954; Richards *et al.* 2004; Breuning-Madsen *et al.* 2016), although mound burials are also known from central Sweden (i.e. Gamla Uppsala; Birka) and Norway (such as Bøkeskogen, Larvik; Borre, Vestfold). Crucially, this is a single-proxy study and unfortunately, it is impossible to be more precise about the origin of these two individuals. In terms of both $^{87}Sr/^{86}Sr$ and [Sr], the non-adult from Mound 50 is far removed from the adult and the animals found in the same mound that have much higher $^{87}Sr/^{86}Sr$ (0.7137-0.7161). The $^{87}Sr/^{86}Sr$ in fact deny direct immigration from Denmark for the adult individual

and animals in Mound 50, based on existing Sr biosphere data (Frei & Frei 2011; Frei & Price 2012). This is a strong indication that the two people in Mound 50 spent most of their lives in different places. The [Sr], which is tied to diet and soil/lithological composition strengthens this point.

Fundamentally, the Sr data presented here suggests that there are people and animals with different mobility histories buried at Heath Wood, and that - should they have belonged to the Viking Great Army - this war band was composed of people from different parts of Scandinavia and/or the British Isles. Recent work by Jarman *et al.* (2018; 2019) has highlighted the same differential composition of the Scandinavian presence at nearby Repton. In contemporary Scandinavia and the Baltic, similarly varied mortuary populations have been detected at Birka (Price *et al.* 2018), Sigtuna (Krzewinska *et al.* 2018), at the early medieval trading port at Ridanäs, Gotland (Peschel *et al.* 2017), at the Trelleborg fortress in Denmark (Price *et al.* 2011), and in Salme in Estonia (Price *et al.* 2016; Price *et al.* 2020), amongst many others. In the British Isles there have been similar observations for this period at Weymouth (Chenery *et al.* 2014), in Dublin (Montgomery *et al.* 2014; although see Knudson *et al.* 2012), Orkney, and the Hebrides (Montgomery *et al.* 2003). Therefore, it is unsurprising to find people of different provenances across Europe during the Viking age. However, this research presents the very first direct evidence that not only people made their way across the North Sea in the 9th century, but also animals. This is of particular interest given the specific association between Heath Wood and the Viking Great Army of AD 865-78, and by extension the information contained in the Anglo-Saxon Chronicle.

6.3.3 The Viking Great Army

As noted above, the Viking Great Army was a highly mobile force, travelling by a combination of land and water, and camping at strategic crossing points on arterial rivers, where mounted warriors could be resupplied from the slower moving fleet (Baker & Brookes 2013; Hadley & Richards 2016). The Anglo-Saxon Chronicle records that the force that first

landed in East Anglia in AD 865 ‘took up winter quarters’ and ‘there they were supplied with horses’ (Whitelock *et al.* 1961). Indeed, given the difficulty of transporting horses across the North Sea in open boats one might assume that the army generally seized its horses in England. However, it is not impossible that its leaders brought their personal mounts with them. A few decades later, in the entry for the year AD 892, the Anglo-Saxon Chronicle reports that a part of the army moved from France to Kent on ships ‘in a single journey, horses and all’ (Swanton 2000). Almost two centuries later, in vessels which still closely resembled Viking plank-built ships, the Norse descendent William of Normandy reportedly transported some 10,000 men and 2000 to 3000 horses across the English Channel, as famously depicted on the Bayeux tapestry (Bachrach 1985). In 1967, a horse was successfully disembarked from a replica of the Ladby ship (Sawyer 1971), although it is unlikely that vessels with such a low freeboard could be used to transport horses in anything but the smoothest of conditions. The best-preserved examples of Viking ships with a hold and deep enough draught to transport livestock are the vessels known as Hedeby 3 (constructed c. 1025), Skuldelev 1 and 3 (both built c. 1040), Roskilde 3 (built after 1060) and Roskilde 4 (built 1108). However, the Norwegian migrants who settled Iceland from the 870s onwards took their cattle with them, and it is probable that the large fleets, which landed in England in the same period, included cargo ships as well as the seek and slender long ships. Indeed, archaeological evidence from excavated early Scandinavian ships indicates that amongst the 9th and early 10th century models, it was the Norwegian and Swedish examples, which appear to have had more significant loading capacity through more stabilising proportions (Graham-Campbell *et al.* 1994; Williams 2014; Roesdahl 2016). Given that, it is less surprising that a Viking leader would also bring their prized hunting dog, another key status symbol. A similar instance was reported at Salme in Estonia by Price *et al.* (Price *et al.* 2016; Price *et al.* 2020). Despite the less secure identification of the pig, it is possible to surmise that the Army would bring food supplies with it, rather than depending entirely upon what it could pillage or trade for. The discovery

of a hoard of three plough shares at the camp at Torksey, and a fourth at Foremark, might also indicate a level of intentionality to settle (Hadley & Richards 2016, 2021), and the pig might have been intended as initial livestock. However, this may be too large an assumption to make, especially because the pig could have been transported in part as preserved meat for food. Feasting was likely an integral part of the funerary rite; and based on the few identifiable remains of the pig, a third possibility holds that the pig bones arrived in Britain as already de-fleshed, disassembled parts as amulets or similar.

6.3.4 IDENTITY, IMAGISTIC RITUAL, AND MEMORY

The Viking Great Army appears to have been a composite of individuals from different Scandinavian origins. The isotopic evidence cited in section 6.3.2 confirms that during the Viking period, Scandinavian armies were generally constructed in this way, and research based on other sources supports this (Raffield *et al.* 2016: 36). Therefore, questions can be raised about the cohesion and group identity at work in this context. An important consideration is the nature of warfare in the context of source-acquisition at play during the movements of the Viking Great Army in the British Isles in the 9th century. Individuals of varied origins organised in smaller units called *lið* were confronted with violence, the very real threat of death, and pain through injury. Whitehouse and Lanman (2014: 677) have highlighted what is termed '*identity fusion*' after impactful experiences which are stored in episodic memory due to their traumatic circumstances, and warfare clearly falls into this category. The theory purports that when individuals perceive that others in the group shared the same traumatic and dysphoric experiences as them, there may arise a sense of *psychological kinship* (ibid; see also: Raffield *et al.* 2016: 37). Traumatic events such as these are powerful generators for identity construction, and for the Viking Great Army, they almost certainly occurred repeatedly during conquest. There is little doubt that during its long progress through Britain, the various members of the Army developed a form of group identity based at least partially on these experiences. Where animals such as horses or dogs were part of these experiences, the inclusion into the *psychological kinship* group

might have extended to them, especially when Viking Age ontological boundaries are considered. This cognitive process would have served to blur these boundaries more effectively through the recall of dysphoric events (episodic memory). Essentially, funerary rites which involved all senses and operated on a large scale, such as the cremations and mound constructions at Heath Wood, are products of a highly imagistic religiosity and likely commemorate not solely the dead humans.

6.3.5 Fundamental implications of the animal presence

At Heath Wood, we observe a rite strongly symbolic in character. A selection process is implicit in the sacrifice of the animals in the mounds and, short of dying on the battlefield, their deaths do not make economic sense. This is the case especially in a scenario where the Viking Great Army – a group of people intent on settling in a new environment – lands in Britain with what was presumably a limited stock of animals in tow. By extension, a prior selective process is apparent which is based on the fact that a ship would only be able to carry a very limited number of these animals across the North Sea. Through the burial rite, and the inclusion of 'companions' from Scandinavia, the mounds at Heath Wood provide a direct link, a proxy, to the 'homelands' of those buried here (Gräslund 2004; Jennbert 2011; Sykes 2015). This becomes especially momentous in the context of the inhumation burials of several individuals of Scandinavian origin – likely also members of the Army – at Repton (Jarman *et al.* 2018; Jarman 2021). If contemporaneous and created in the span of one or a few years, the decision was made at Heath Wood to cremate rather than inhume, to create mounds instead of the use of stone slabs, and to do so in an adjacent location, not in close proximity to the commemoration place of the Mercian royal line and St. Wystan. The use of outright Scandinavian burial practices and artefacts may indicate a looking backwards, or a reference to the old homelands (Ó Ríagáin 2016). The formation of what Ó Ríagáin terms 'emotive foci' in a contested landscape (Ó Ríagáin 2016), through the deposition of the dead, creates a connection of people to a particular space.

6.3.6 AGENCY AND RELATIONSHIPS AT HEATH WOOD

Perhaps a good place to continue this discussion is to look towards primary source material, such as the *Eddas, Icelandic Sagas,* law codes, and what these convey about the way that people perceived and engaged with their environment. Although these post-date the first landing and the movements of the Viking Great Army by two/three centuries, they can be used – with consideration of their historical context – to access themes or ideas which existed earlier (Hedeager 2011: 22; Brunning 2015: 54). One of the highlighted themes conveys that, in Norse mythology, there is a central place for animals. The sources tell of horses such as Sleipnir, Odin's eight-legged horse, which can travel between the realms of the living and the dead (Sikora 2003/2004). The horses Arvak and Alsvinn pull the sun (Simek 1993; Sturluson 1995), and Skinfaxi and Hrimfaxi are the bringers of day and night (Simek 1993; Sturluson 1995). Similarly, dogs are prominent and powerful actors and allies, such as Garmr, Loki's offspring and the guardian of Hel's gate to the afterlife (Simek 1993; Sturluson 1995), and Freke and Gere (wolves) who accompany Odin and feast on fallen soldiers (Simek 1993; Sturluson 1995; Gräslund 2004). Fenrir, although also technically a wolf, is well known as Odin's killer during Ragnarok, at the end of all things (Sturluson 1995). Dogs – and wolves – clearly embody liminality and enforce transition, often in the context of death and dying (Lurker 1969). Special value is also placed on boars in Norse myth, for example attested by the presence of Gullinbursti in the 12th century *Prose Edda*, where the boar is ridden by Freyr to Baldr's funeral (Sturluson 1995), or in Valhalla, where the boar Sæhrímnir is hunted and feasted on every day only to live again the next day (Simek 1993; Sturluson 1995). The boar is 'an endless source of food… [that] never dies' (Catts & Zurr 2013). Apart from being companion animals, Norse mythology and cosmology lends them an identity and agency which extends beyond mere co-existence with humans (Lurker 1969; Gräslund 2004; Jennbert 2011).

Ontological borders are transgressed in those stories which feature the *Æsir* (Norse gods of the principal pantheon, as opposed to the *Vanir* of the second pantheon) or ordinary people

shifting shape into an *other*. Most often, this is an animal or another gender, sometimes both. Odin possesses the magical power called *seiðand* is able to shape-shift because of this - and it is precisely this quality that makes him one of the most powerful beings in Norse mythology (Hedeager 2011: 82, 84). He is the only one of the *Æsir* who can do so. Value is clearly attributed to this transgression of ontological and taxonomic boundaries in the Norse world, and, at the same time, the boundaries are blurred. A vivid example are the narratives of people who take on specific qualities of animals, for example in war. Four animals are particularly important in this context – the bird of prey, the wild boar, the wolf, and the bear, and these represent different ways of fighting, based on the respective animal's qualities (Hedeager 2011: 85-95). The arenas of action for animals and humans are therefore not separate, and certain qualities can create relationships and connections; these connections are also established between objects and beings (although we may consider qualities objects (Abram 2019: 174)). For example, Brunning has shown that swords were linked with snakes in the medieval Scandinavian mind (Brunning 2015). The recurrence in various primary sources of similar linkages, such as the one between swords and snakes, suggests that these were well known associations. How far this understanding went is not completely clear, but there is an argument to be made that for some of the audience, the belief that one thing had the ability to change into the other was a physical reality. A warrior, donned with a certain linked symbol on a helmet, shield or sword, could *become* a bear (*berserk*) or a wolf (*ulfheðnar*) (Hedeager 2011: 95-96; Raffield *et al.* 2016: 43). Certainly, the identification with particular animals such as the bear or wolf by a group would have served to foster in-group cohesion as well (see section 6.3.4)(ibid).

This did not work solely through the content of mythology, but was also reflected in poetry, and through Old Norse poetic techniques. In particular, *kennings* are 'complex linguistic constructions' (Brunning 2015: 56) which 'operate *like* … metaphor[s]' (Abram 2019: 171). Some of these stem from the 10th, and even the late 9th centuries — the period in question here. *Kennings* are used to replace nouns in poetry, and many examples have been

recorded online in the *Skaldic Poetry of the Scandinavian Middle Ages* database (accessible at: https://skaldic.abdn.ac.uk/db.php?if=default&table=kenning&view=), or the *Kenning Lexicon* (https://lexiconpoeticum.org/m.php?p=kenninglexicon). A cat becomes *inn kámleita véli viðbjarnar aldinna veggja* — 'the dark betrayer of the wood-bear of old walls', where the 'wood-bear of old walls' is the *kenning* for 'mouse' (Clunies Ross 2017: 505). This example qualifies as a *double kenning* as it includes two substitutions (Sturluson 1995: 167-68). Similarly, the breast becomes *hlátrelliða* - 'of the laughter-ship', or *ógnstǫðvar* - 'of the terror-place'. The latter are simple combinations of a ***base-word*** (ship, place), and a ***determinant*** (laughter, terror). Like the link between swords and snakes, a prescient example relevant to this study is the relationship between buildings, the body, fire, and death (see Table 24 below). Frequently used *kennings* for fire or flames refer to the destruction of halls or houses. Indeed, this can be taken literally, seeing as any large structures like houses were constructed of wood during the Viking period, and therefore fire must have been a real danger. If we consider body-related *kennings*, however, the argument can be made that the reference to 'halls' or 'houses' function just as well in the context of pyre cremation. In this case, the house or hall refers to the body, which is destroyed by fire. Although specifically found in Old English poetry and therefore not directly transferable to a Scandinavian context, the *kenning* used for body in 'Beowulf' is *bān-hūs* – 'bone-house' (Heaney 2001: lines 2508, 3147). A similar connection is made in the Old Norse *kenning* for 'bone', which is *sal mergjar* – 'the hall of marrow' (Bjbp *Jóms* 31[I], in Lethbridge 2012: 986).

TABLE 24 – KENNINGS FOR ‘BONE’ AND ‘FIRE’, AND THEIR INTERCONNECTEDNESS. SOURCE: THE SKALDIC PROJECT. (ACCESSIBLE AT: HTTPS://SKALDIC.ORG/SKALDIC/M.PHP?P=KENNINGS)

Referent	Old Norse	English	Reference	in
Bone				
	sal mergjar	the hall of marrow	Bjbp *Jóms* 31[I]	Emily Lethbridge (ed.) 2012, ‘Bjarni byskup Kolbeinsson, *Jómsvíkingadrápa* 31’ in Diana Whaley (ed.), *Poetry from the Kings’ Sagas 1: From Mythical Times to c. 1035*. Skaldic Poetry of the Scandinavian Middle Ages 1. Turnhout: Brepols, p. 986.
Fire				
	allfrekr bani hallar	the most ravenous slayer of the hall	Arn *Magndr* 8[II]	Diana Whaley (ed.) 2009, ‘Arnórr jarlaskáld Þórðarson, *Magnússdrápa* 8’ in Kari Ellen Gade (ed.), *Poetry from the Kings’ Sagas 2: From c. 1035 to c. 1300*. Skaldic Poetry of the Scandinavian Middle Ages 2. Turnhout: Brepols, p. 217.
	heiptir húss	the destroyer of the house	Ótt *Knútdr* 4[I]	Matthew Townend (ed.) 2012, ‘Óttarr svarti, *Knútsdrápa* 4’ in Diana Whaley (ed.), P*oetry from the Kings’ Sagas 1: From Mythical Times to c. 1035*. Skaldic Poetry of the Scandinavian Middle Ages 1. Turnhout: Brepols, p. 772.
	lífgalli hallar	the life-harm of the hall	Sturl *Hrafn* 11[II]	Kari Ellen Gade (ed.) 2009, ‘Sturla Þórðarson, *Hrafnsmál* 11’ in Kari Ellen Gade (ed.), *Poetry from the Kings’ Sagas 2: From c. 1035 to c. 1300*. Skaldic Poetry of the Scandinavian Middle Ages 2. Turnhout: Brepols, p. 736.
	húsþjófr	the house-thief	Þjóð *Yt* 20[I]	Edith Marold (ed.) 2012, ‘Þjóðólfr ór Hvini, *Ynglingatal* 20’ in Diana Whaley (ed.), *Poetry from the Kings’ Sagas 1: From Mythical Times to c. 1035*. Skaldic Poetry of the Scandinavian Middle Ages 1. Turnhout: Brepols, p. 44.

In this way, *kennings* function to blurr ontological and taxonomic boundaries between people, animals, and things. It is conceivable that in order to exist, these poetic devices must have been accessible to the audience they were composed for. The productive nature of *kennings* is underlined by Abram (2019, 170), who explains how the *base-word* and *determinant* of the composite create the *referent*, which, in turn, becomes another (a *new*) object. One could argue, based on the productive relationality of agency and personhood (see Chapter 2, section 2.1), that this is a much more subtle cognitive level on which agency is operational. As discussed by Harman,

> 'When two objects enter into genuine relation, even if they do not permanently fuse together, they generate a reality that has all of the features that we require of an object. Through their mere relation they create something that has not existed before, and which is truly *one*.' (Harman 2005: 85; also cited in Abram 2019: 171)

If we take the object-oriented view of how *kennings* work, we recognize that 'the human [, animal, or object] is only one thing among many, that the person is made up of many objects (a hand, a head, generosity, a particular social status) and interacts with countless others' (Abram 2019: 174; square brackets by this author). Indeed, *kennings* appear to emphasise the idea that ontological borders are blurred, or at the least transgress-able. In other words, the world and all the relationships in it are much less hierarchical and anthropocentric (Kreager 2021) in the Viking mind, and this is expressed through literary devices.

Turning back to the archaeological evidence present at Heath Wood, it is possible to observe a similar transgression of ontological borders in the way that the physical remains are assembled. Through the process of cremation, the bodies of humans, animals, and objects – some of these purposefully damaged – become intermingled, and essentially part of the same thing. In this way, destruction is a formative process where the end result is

unlike anything that came before. Cremated bone from animals and people are virtually unrecognisable, and it is almost certain that the members of the community partaking in the cremation ritual would not be able to identify which bone belonged to whom once the pyre was extinguished. Even today, this is sometimes difficult to do for zooarchaeologists and osteoarchaeologists who specialise in this area of study. This is not to say that the presence of individuals amongst the remains post-cremation was disregarded. Rather, the intermingling of people with animals and jewellery or weapons was accepted, or even desirable. The removal of a portion of the cremated material from the pyre site of Mound 50, as well as the deposition of intermingled cremated bone under Mound 56, is perhaps an indication that the people cremating their dead at Heath Wood were thinking in terms of dividual personhood (discussed in section 2.1), where the relationships between the community/group and those on the pyre were to some extent preserved in their post-cremation form.

6.4 Conclusion

The cremation cemetery at Heath Wood presents a unique and robust fragment of evidence of the Scandinavian presence in early medieval Britain. In stark contrast with the omnipresent contemporary inhumation rite in Britain, the cremated bone inside the mounds indicates a strong Scandinavian influence. The $^{87}Sr/^{86}Sr$ analysis of the small amount of cremated bone which remains has shown that the adult from Mound 56, and a non-adult from Mound 50 had $^{87}Sr/^{86}Sr$ consistent with the local Sr biosphere and thus conceivably grew up and lived locally (although similar values are seen in Denmark and southwestern Sweden). However, in the context of the archaeology, the $^{87}Sr/^{86}Sr$ values of the other adult, the horse, the dog, and the possible pig in Mound 50 indicate migration from the Baltic shield regions of Scandinavia -- that is Norway, or central and northern Sweden. This assessment is strongly supported by the contextual information of the site, such as the striking parallels of the funerary ritual of cremation in conjunction with mound construction, as well as the presence of Scandinavian style grave/pyre goods and historical

documentation in the Anglo-Saxon Chronicle. Consideration of continuous bone remodelling throughout life suggests that these incoming individuals died soon after arrival. Further, although the sample size is small, there is an indication that the individuals cremated here grew up in at least two geologically different areas. This confirms finds from other archaeological sites in a military context and suggests that these groups were often heterogeneous albeit connected through identity fusion based on shared dysphoric events – and this fusion may also have included animals. The cremation rite observed at Heath Wood in the context of theories of agency, personhood, and identity strongly suggests that ontological borders were blurred not only in Scandinavian primary sources, but that they became a physical reality during the cremation process. The theory of partible dividuality (discussed in section 2.1) may be a valuable asset in considering how the Scandinavian mind thought about the cremated remains, and why remains were partially removed from /deposited under the mounds. Finally, these results provide unique evidence for the migration in the late 9th century of both people and their animals – including horses and dogs – across the North Sea, from Scandinavia to the heart of England.

7 SYNTHESIS, DISCUSSION, AND CONCLUSION

The primary aim of this thesis was to harness recent techniques and test these on a number of British early medieval cremation cemeteries to demonstrate how new information could be gleaned from cremation deposits that might help further contextualise and advance our knowledge of early medieval society. Several research questions were outlined in the Introduction to guide the inquiry throughout this thesis and these are laid out in Table 25 below with references to appropriate sections for direct access. The aims and questions varied by site, dictated by the level of survival, the specific date and context of the cemetery and the amount of contextual information available on the excavated sites.

This chapter reviews the results and presents a contextual discussion of the findings and their value to knowledge. This is followed by a review of the interdisciplinary methods used and its potential for future studies of this kind, and a discourse on prospective work that could follow.

TABLE 25 – REFERENCE TABLE FOR SECTIONS ADDRESSING SPECIFIC RESEARCH QUESTIONS IN THE THESIS.

Dimension	Research Questions	Addressed in section
Spatial	• What evidence is there for mobility and heterogeneity of the cremated individuals? • How is this reflected in the burial context?	4.3.3 for Ingleby Barwick; 5.3.2 for Cleatham; 6.3.2 for Heath Wood; 7.2 for all
Temporal	• Is there evidence for the retention of cremation customs in local populations, or does the evidence suggest that there was a gradual influx of people who were cremated? • How do these findings alter our	5.3.6 for Cleatham; 6.3.3 and 6.3.4 for Heath Wood; 7.2.2 general

	understanding of the nature and extent of the movement of people from the continent and other areas of Britain in the post-Roman and later centuries?	
Theoretical	• What does this mean in the broader context of the sites and early medieval migrations, and what can it tell us about the sense of identity, the individual agency of people and social memory in early medieval England? • Do the concepts used in archaeological research of mobility and migration provide a sound theoretical framework for this type of study?	4.3.5 for Ingleby Barwick; 5.3.6 and 5.3.7 for Cleatham; 6.3.4 – 6.3.6 for Heath Wood; 7.3 general
Practical	• What are observable pitfalls/limitations of the methods applied, and how can these be avoided? • Is it possible to systematically sample cremated bone from individuals in order to create a life-mobility-history approach, with several phases of an individual's life covered?	7.3 general 2.3.8; 2.4; 5.3; 7.1.1

7.1 Site-specific Reviews and Conclusions

7.1.1 Ingleby Barwick

This PhD presents new osteological and palaeopathological information on the cemetery population at the mixed-rite cemetery at Ingleby-Barwick, Stockton-on-Tees. This was important to collect before Sr analysis was conducted to elevate the interpretation potential. My investigation into the level of mobility apparent at Ingleby Barwick showed that $^{87}Sr/^{86}Sr$ and [Sr] analyses of the cremated remains are a useful tool for examining even small cemeteries. Since otic capsule sampling was not possible at this site, the interpretation is somewhat limited to the later life of the individuals – early life mobility for adults cannot be determined here. The diaphyseal and rib sampling indicates that most of the humans were consistent with the local environment in terms of $^{87}Sr/^{86}Sr$ at least during the later part of their lives. Sr isotopes also show that two animals were grazing on lithologies producing higher $^{87}Sr/^{86}Sr$ ratios relative to the people (in two cases – horse and sheep/goat). One other sheep/goat was managed differently and appears to have derived its food from a similar place as the people at Ingleby Barwick. Here also, the cremation rite appears to have altered the relationships between humans and animals, subjecting both to the transformative power of the same funerary pyre.

In future, the archaeological assemblage at Ingleby Barwick would benefit greatly from the creation of a comprehensive post-excavation publication featuring the data presented in this study, a zooarchaeological assessment by a specialist, and following this – additional Sr isotope analyses. C and O isotopes have been measured already and will be presented elsewhere. Similarly to Cleatham, radiocarbon dating would improve our knowledge of the chronology of the site greatly. The parallels observed between Ingleby Barwick and the large inhumation cemetery at Norton only a few kilometres away would make an isotopic comparison between the sites ideal, and especially the three cremation burials should be included in this investigation to further our limited understanding of the region.

7.1.2 CLEATHAM

Cleatham was a large-scale cemetery which Leahy (2007) has argued served several communities within the region. This has now been confirmed by Sr analysis, and further temporal aspects could be examined: The large sample size at Cleatham allowed me to show that mobility from further afield was more prominent during the earlier phase of use of the cemetery (in the 5th and early 6th centuries), and that most of the incomers were sexed female. This observation of the change through time was contingent especially on the sampling of otic capsules, which reflect Sr isotopes incorporated during infancy. This may support the notion of an originally patrilocal community, where women arrived from long-distant locales for marriage, whether this was strategic or not (Harrington 2020: 101). That we find fewer such women in the later phase of cemetery use suggests that this has changed, perhaps reflecting changes in wider social practice and/or social organisation. In any case, Leggett *et al.* (2022: 2 in preprint version of article) have shown with large-scale isotopic data from early medieval Britain that 'movements were gendered, regionally variable and not restricted to male elites. We cannot treat England, or Britain, as a unified space with one straightforward, linear, mobility history'. In this context, we assert that our data is suggestive of gendered mobility with temporal variation at Cleatham.

At Cleatham, an interesting pattern crystallised when life-mobility-histories of individuals were observed: A possible specific connection to a location on lithologies producing $^{87}Sr/^{86}Sr$ ratios around 0.7128, which is one of the highest $^{87}Sr/^{86}Sr$ ratios measured for an individual from c. AD 410-750 in England to date. On an individual level I was able to show that the dead who had been provided with unique items such as coral beads and ivory rings derived from mixed origins, but that there is not necessarily an indication that they have to have come from elsewhere. We are limited in our interpretation by the small sample of individuals, however. In the future, it is recommended to conduct a multi-proxy analysis of Sr, O, S, and perhaps C and N isotopes on the 63 inhumated individuals. It would be highly desirable to investigate whether some of these individuals reflect similarly diverse

origins, and perhaps even support the link with a location producing $^{87}Sr/^{86}Sr$ ratios of 0.7128. Further radiocarbon samples would also improve our knowledge about the site, especially in relation to the issues with Leahy's (2007) phasing that were raised by Perry (2013). I can only emphasise the importance of a comprehensive zooarchaeological study for the associated cremated animal remains and further isotopic analyses. In this way, future research questions on animal-human relationships as well as mobility and land-use might be answered with reference to the catchment geology.

7.1.3 HEATH WOOD

In Chapter 6, the isotopic results for the few individuals recovered from this cemetery were presented and they suggest not only human, but also animal mobility. Taking into account the archaeological and historical context and information, I argue that at least one individual made their way from central Sweden or large parts of Norway across the North Sea alongside a horse, a dog, and a ?pig. The small sample size is suboptimal, and I can therefore not draw broader conclusions about the other individuals buried in the mounds at Heath Wood, but I am certain that this is neither necessary nor desirable. If one aspect of early medieval – and especially Scandinavian – burial practice is clear, it is its diverse execution (Price 2010). I argue that exploring individual life-mobility-histories pays tribute to this fact. For the contextualisation of Heath Wood, I looked to historical documents such as the *Eddas*, and specifically the poetic tool of the *kenning*, to emphasise that ontological boundaries (as we perceive them) were drawn differently, blurry, and transgress-able. I found this assessment supported on a physical level by the cremation ritual featuring intermingling of burnt remains of objects, animals, and people – indicating intimate and changeable/transitional relationships at work. The isotopic data reenforced this view.

Following this, the exact nature of the relationship between Repton, the Viking Great Army, and Heath Wood requires further work, but this must encompass further excavation. Recent research by Jarman at Foremark is promising to illuminate the Scandinavian presence in the area (Jarman *et al.* 2018; Jarman *et al.* 2019; Jarman 2021), but further excavation at Heath Wood would ensure the better understanding of the temporal aspect of the cemetery. With additional radiocarbon analyses it might be possible to narrow down or expand the period of use. Carbon and Oxygen isotopes have been measured for the samples contained in this study in order to look at cremation practices, but they exceeded the scope of this thesis and will be published elsewhere in the future. A necessary step in the future is to re-sample plants at and around Sample location 6 near Shipley, where the

existence of a mine and associated railway may have impacted on the $^{87}Sr/^{86}Sr$ bioavailability in the area.

7.2 Synthesis and Discussion

7.2.1 Cross-site comparisons in Sr

Due to the fact that this project has generated new Sr data for three early medieval sites in England, a first point of analysis should be a direct comparison between sites. In Fig. 90 below, the Sr results are presented in one plot. Although variation in terms of $^{87}Sr/^{86}Sr$ and [Sr] is considerable at each of the sites, there exists relatively clear site-specific clustering. At Heath Wood the data is more spread out than at Ingleby Barwick and Cleatham. Still, clustering is also prominent when sample type is considered, with animal bone consistently plotting with higher [Sr] than the associated human population.

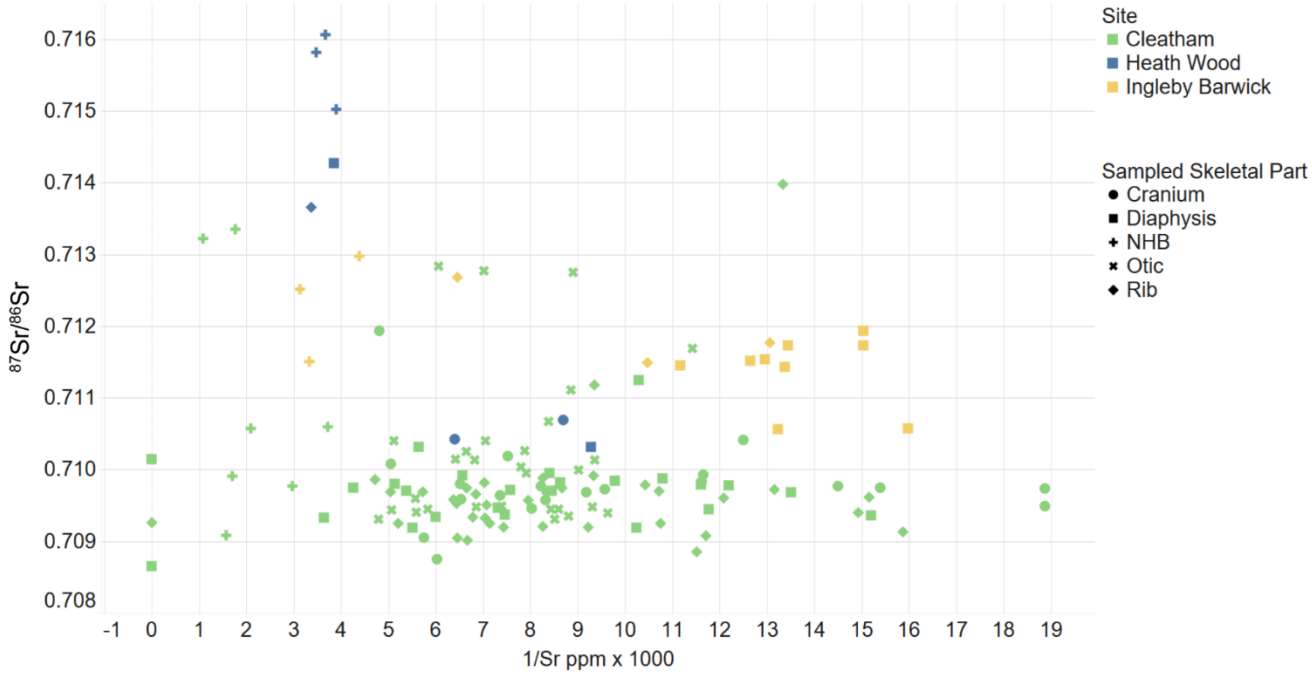

FIGURE 90 - $^{87}SR/^{86}SR$ VS [SR] PLOTTED BY SITE (COLOUR) AND SAMPLE TYPE (SHAPE) FOR ALL THREE EARLY MEDIEVAL SAMPLING SITES.

The data above clearly shows the potential for exploration of more extensive sites, but the same is the case for smaller sites with few individuals. I would like to emphasise that the

multi-skeletal sampling method is inherently focussed on the individual which means that we dismiss interesting life-mobility-histories if we dismiss smaller sites. A second point to emphasise here is the potential of this method to look closely at animal-human relationships, and by extension ontologies and perceptions. Different communities have different ways of thinking about the world (Morris 1998: 167; Sykes 2015: 8) and the way that animals feature in this are valuable hinges in examining these. I would add to this last point that this needs to also allow for diversity across sites and communities: the early medieval period is clearly characterised by great variation.

Recent review work by Snoeck *et al.* (2022) has drawn together all published Sr isotope data from cremated remains, but only one of these sites has been dated to the early part of the early medieval period and is therefore comparable with Cleatham and Ingleby Barwick. This site is located in the Netherlands in the area around Echt and the data was published by Veselka *et al.* in 2021. Similar in scope to the analysis of Cleatham presented in this thesis, the data from Echt includes diaphysis, rib, and otic capsule sampling. In Fig 91, the Echt results have been added to the cross-comparison plot (see Fig. 90) and it can be noted immediately that the pattern of animal-human [Sr] difference apparent at the English does not hold up as reliably. It should be noted that the sampled animal bone at Echt was exclusively identified as pig, and because pigs are omnivores and can feed off scraps from human food, these blurred lines are not surprising. Indeed, this way of comparing site-specific data may highlight interesting differences in animal feeding practices and landscape management. With only one other possible pig represented at Heath Wood, this remains to be done in a future study at a larger scale.

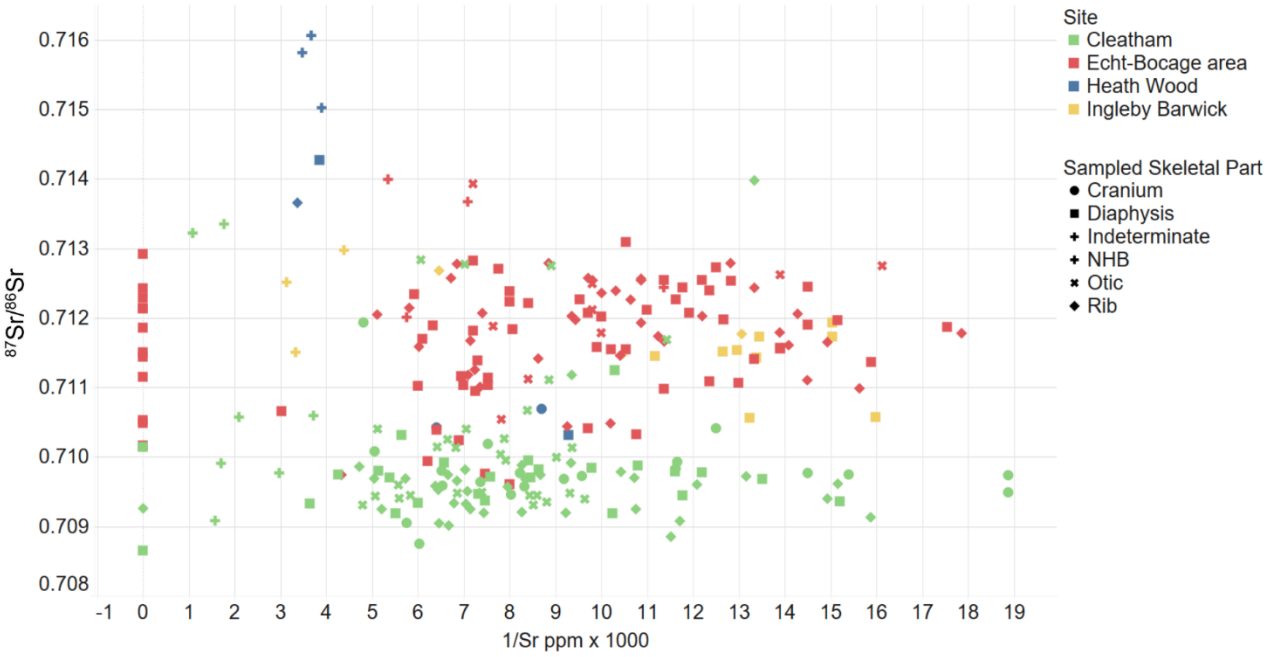

FIGURE 91 - $^{87}SR/^{86}SR$ VS [SR] PLOTTED BY SITE (COLOUR) AND SAMPLE TYPE (SHAPE) FOR ALL THREE EARLY MEDIEVAL SAMPLING SITES AND THE EARLY MEDIEVAL SITE AT ECHT IN THE NETHERLANDS FOR COMPARISON (DATA FROM VESELKA ET AL. 2021 AND SNOECK ET AL. 2021).

A recent study by Dalle et al. (2022) on Belgian cremated bone from the metal ages and the Roman period demonstrated the impact of seasalt on the variation in [Sr] and $^{87}Sr/^{86}Sr$. The use of salt for preservation of food products during the Roman period clearly shows a narrowing of $^{87}Sr/^{86}Sr$ variation and a pull towards the seawater $^{87}Sr/^{86}Sr$ ratio at 0.7092, alongside an increase in [Sr] in the individuals. The data from the Belgian sites is plotted here (Fig. 92) against comparable data from early medieval England (data from this thesis) and the Netherlands (data from Veselka et al. 2021). The red boxes add information about the bioavailable $^{87}Sr/^{86}Sr$ range at the site, with a wider regional catchment indicated by the purple boxes.

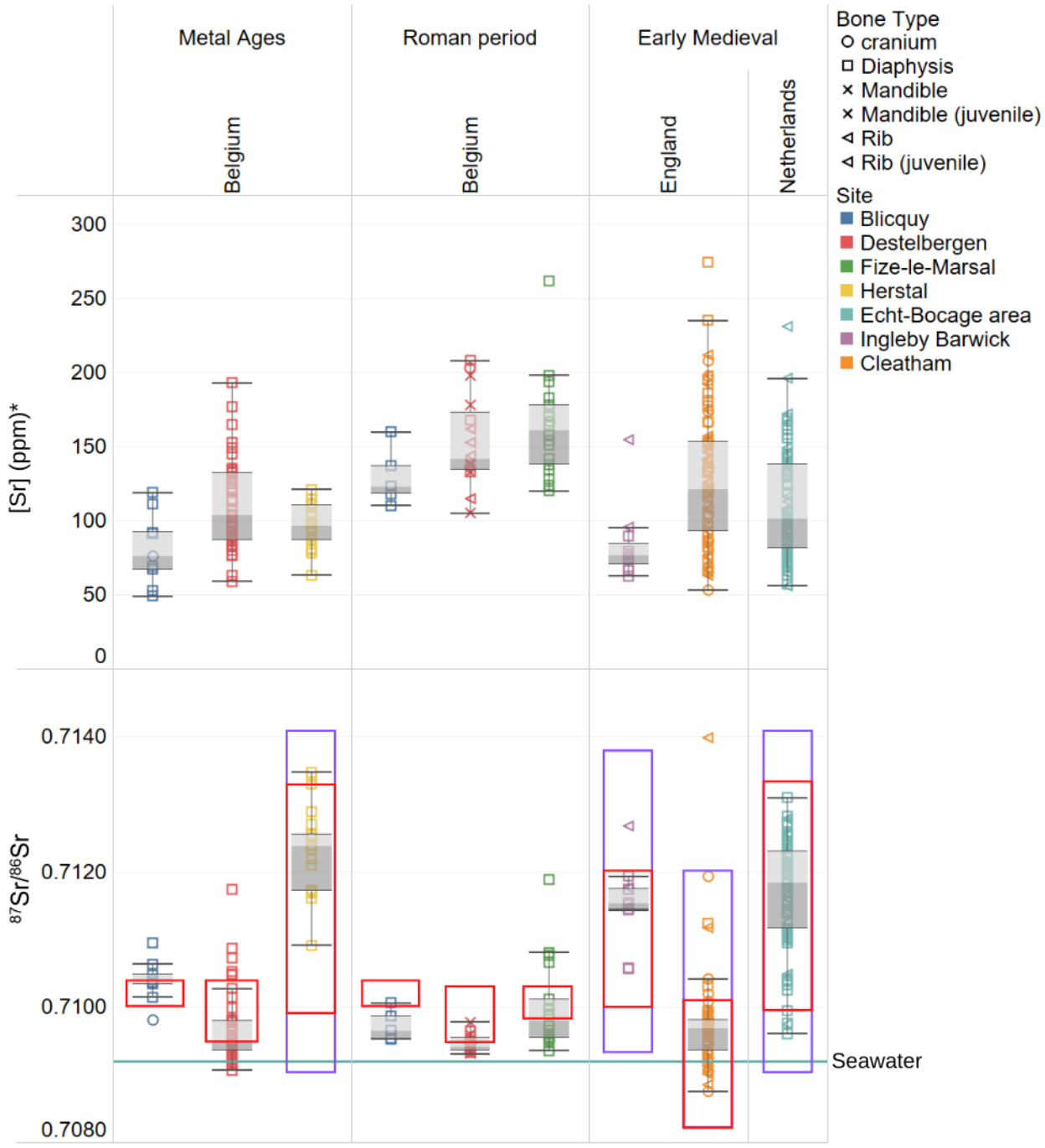

FIGURE 92 – [SR] (PPM) AND $^{87}SR/^{86}SR$ BOXPLOT HIGHLIGHTING VARIATION OF DATA FROM CREMATED HUMAN BONE FROM DIFFERENT COUNTRIES (BELGIUM, NETHERLANDS, ENGLAND) AND SUBSEQUENT PERIODS. METAL AGE DATA INCLUDES BRONZE AGE AND IRON AGE DATA. RED BOX FRAMES INDICATE BIOSPHERE $^{87}SR/^{86}SR$ RANGE FOR EACH SITE, PURPLE BOX EXTENSIONS INDICATE THE WIDER CATCHMENT. [SR] PPM HAS BEEN NORMALISED TO 40 %WT CA. ERROR OF $^{87}SR/^{86}SR$ LIES WITHIN THE SYMBOLS. DATA FOR ALL BELGIAN SITES FROM DALLE ET AL. (2022); DATA FROM ECHT FROM VESELKA ET AL. (2021) AND SNOECK ET AL. (2022). FOR COMPARATIVE PURPOSES, OTIC CAPSULE (PETROUS PART) MEASUREMENTS HAVE BEEN EXCLUDED FROM THIS PLOT. BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES. SINGLE POINTS ARE EXTREME OUTLIERS.

The difference already highlighted by Dalle *et al*. (2022) between the Belgian sites through time is apparent: wider variation in $^{87}Sr/^{86}Sr$ is coupled with generally lower and more diverse [Sr] during the metal ages. In the Roman period, this has changed and $^{87}Sr/^{86}Sr$ ratios more closely reflect the seawater $^{87}Sr/^{86}Sr$ in conjunction with elevated [Sr]. The marine Sr input has clearly become an endmember pulling $^{87}Sr/^{86}Sr$ towards 0.7092 (Montgomery *et al.* 2007; Montgomery 2010). When this data is compared to the early medieval sites in England and the Netherlands, we note that there is very little pull of $^{87}Sr/^{86}Sr$ ratios towards the seawater line at Ingleby Barwick, and [Sr] mirrors pre-Roman [Sr] data from Belgium much closer than the contemporaneous ones (Cleatham and Echt). The indication here is that marine Sr – in whichever form: seasalt, seaweed, or other – did not appear to have much of an impact on the $^{87}Sr/^{86}Sr$ at this site. This contrasts with Cleatham, where $^{87}Sr/^{86}Sr$ ratios range around the seawater value, and [Sr] includes higher values as well as lower ones. The lithologies underlying both catchments are very similar, but Ingleby Barwick is slightly closer to the coastline (c.18km straight line) and is closer to a waterway leading to the sea (River Tees, c.2km straight line from cemetery). We might expect to see more influence of preservatives like seasalt or marine-Sr bolstering plants here, but this appears not to be the case. Therefore, Ingleby Barwick and the settlements around Cleatham likely had different strategies for food procurement/preservation.

In essence, the fact that Cleatham was a major cemetery for different communities in the region is reflected: some of these communities are bound to have settled closer to the sea (effect of seaspray), or even preserved food with salt. The variation of $^{87}Sr/^{86}Sr$ recorded for Echt in the Netherlands is similar to that at metal age Herstal in Belgium, but the associated [Sr] is more varied and includes some slightly higher values. The contemporaneous cemetery at Echt operated in a similar way to Cleatham and served several communities in its catchment – and here, too, food procurement and/or preservation strategies likely differed and must have included more or less influence of marine derived Sr (Veselka *et al.* 2021). That both large early medieval cremation cemeteries on different sides of the

channel (Echt and Cleatham) exhibit what appear to be parallels is very encouraging for future research. I would like to emphasise here that the production of data from other early medieval cremation cemeteries such as Spong Hill, Sancton, Elsham, and Newark must be the next step in the endeavour to look at these possible patterns more clearly, but this should not happen to the detriment of smaller cemeteries. The most intriguing revelations about the early medieval period may arise from the relationships between large and small cemeteries within any given region.

7.2.2 COMPARATIVE DATA

As noted already, one of the caveats undertaking work employing methods which have been relatively recently developed means that comparative data is sparse. Because the Sr isotope analyses of cremated remains have been shown to hold great potential on a micro- (individual) and macro- (population) scale, there is little doubt that this situation will improve in the near future. Crucially, until more comparative data is available, a way to mediate this lack could be to compare only the otic capsule (formation 16-18 weeks *in utero* to two years of age) $^{87}Sr/^{86}Sr$ of the cremated remains to tooth enamel $^{87}Sr/^{86}Sr$ from inhumed individuals in order to facilitate more direct comparison (albeit enamel and bone are not identical materials) between sites. Enamel reflects the average incorporated $^{87}Sr/^{86}Sr$ during the formation of the crown in childhood, the duration of which depends on the type of tooth sampled. Most accurately would be to exclude all data besides the permanent first molar and/or deciduous dentition which forms within approximately the same timeframe as the inner part of the petrous portion (Moorrees *et al.* 1963; Ubelaker 1979; both also cited in: Schaefer *et al.* 2009: 80-85, 94-95). To illustrate this approach, data from several publications has been drawn together. Fig. 93 below highlights $^{87}Sr/^{86}Sr$ data from early medieval cemeteries which in all cases, except at Cleatham and Echt (marked with *), derive from teeth of inhumed remains. $^{87}Sr/^{86}Sr$ results from first molars that date to an earlier (Roman) or later (c. AD 750 onwards) phase have been excluded. Since no otic

samples were measured for the individuals buried at Ingleby Barwick, this site is not represented.

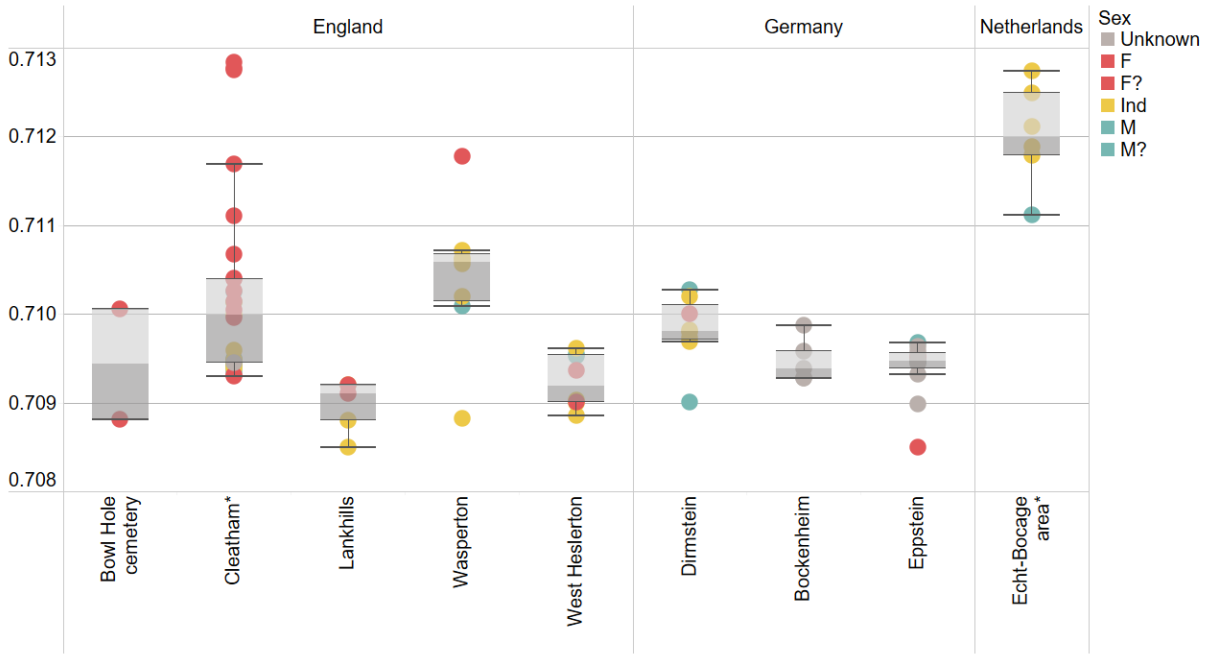

FIGURE 93 - $^{87}SR/^{86}SR$ RESULTS FROM EARLY MEDIEVAL CEMETERIES CONTEMPORARY WITH CLEATHAM AND INGLEBY BARWICK. (*) DENOTES OTIC CAPSULE DATA, ALL OTHER DATA DERIVES FROM PERMANENT FIRST MOLARS AND DECIDUOUS DENTITION FORMING DURING APPROXIMATELY THE SAME TIMEFRAME AS THE OTIC CAPSULE. ESTIMATED SEX INDICATED BY COLOUR. BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES. SINGLE POINTS ARE EXTREME OUTLIERS. DATA FROM *(MONTGOMERY ET AL. 2005; EVANS ET AL. 2006; EVANS ET AL. 2012; GROVES ET AL. 2013; CHENERY ET AL. 2014; SCHUH & MAKAREWICZ 2016; WINTER-SCHUH & MAKAREWICZ 2019; LEGGETT 2020; LEGGETT ET AL. 2021; VESELKA ET AL. 2021; SNOECK ET AL. 2022)*.

Both Cleatham and Echt contain individuals with relatively high infant $^{87}Sr/^{86}Sr$ ratios which, at Cleatham, are considered outliers (at 0.7128) and date to the early period of activity. The individuals at Echt are considered locals because their $^{87}Sr/^{86}Sr$ ratios are consistent with the geological variation within the catchment (Veselka *et al.* 2021: 97). The German sites besides Eppstein (three outliers present; Upper Rhine Valley) are all much narrower in their variation and much lower in $^{87}Sr/^{86}Sr$ than the Dutch samples. This may be related to their location within inland Germany relatively far from the North Sea (although they are close to the rivers Rhine and Main) or to a less complex and variable geology as that observed around Echt. Within England, Cleatham appears most like Wasperton in terms of variation

of $^{87}Sr/^{86}Sr$, but only if the outliers are included in the consideration. Keeping in mind that these are $^{87}Sr/^{86}Sr$ ratios reflecting infancy intake, what we observe in this box-plot is the level of mobility to each of these sites at some point during the lifetime of the individuals.

When later-forming teeth are included in the table, data density is of course increased (Fig. 94). In this case – because we have little comparative material otherwise – I argue that including $^{87}Sr/^{86}Sr$ ratios of later-forming teeth provides a much more informative reflection of mobility for each site. Cleatham clearly mirrors variation observed at other cemeteries of the early medieval period in England and further afield. It must be emphasised, however, that the highest $^{87}Sr/^{86}Sr$ ratios from Cleatham are the highest overall measured for England dating to the period between approximately AD 410-700. These relatively high $^{87}Sr/^{86}Sr$ ratios appear to occur more frequently at contemporary sites on the continent in Germany, France, or the Netherlands (where they are often also interpreted as non-locals to the sites). This box-plot indicates at the most basic level that mobility during the period in question was omnipresent which is also confirmed by larger-scale studies (see especially Leggett 2020, 2021; Leggett *et al.* 2022) and aDNA studies (Gretzinger *et al.* 2022).

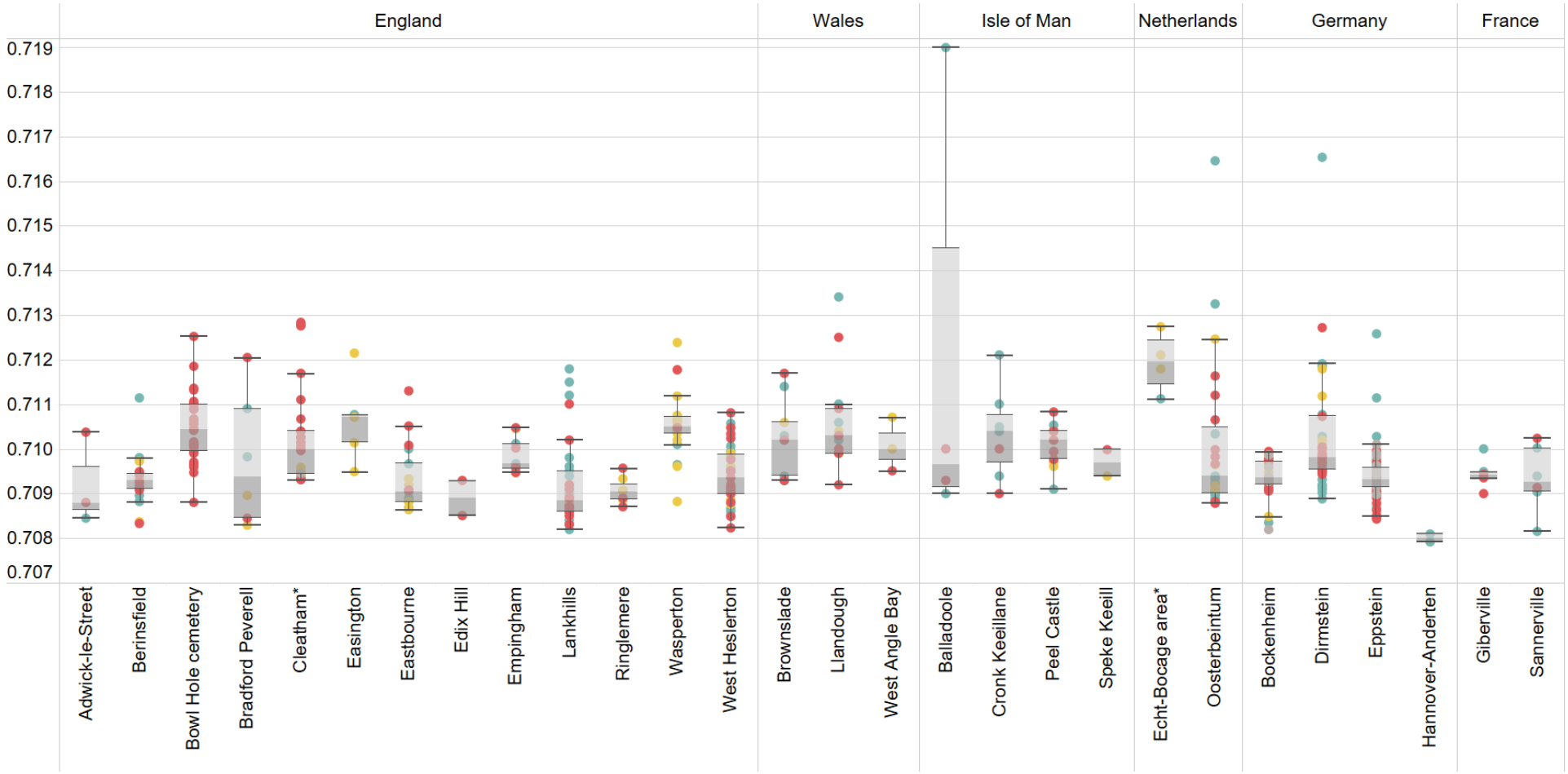

FIGURE 94 - 87SR/86SR RESULTS FROM EARLY MEDIEVAL CEMETERIES CONTEMPORARY WITH CLEATHAM AND INGLEBY BARWICK. (*) DENOTES OTIC CAPSULE DATA, ALL OTHER DATA DERIVES FROM PERMANENT AND DECIDUOUS DENTITION FORMING AT DIFFERENT TIMES DURING CHILDHOOD. ESTIMATED SEX INDICATED BY COLOUR. BOX DENOTES INTERQUARTILE RANGE AND WHISKERS SHOW MIN AND MAX VALUES. SINGLE POINTS ARE EXTREME OUTLIERS.DATA FROM (MONTGOMERY *ET AL.* 2005; EVANS *ET AL.* 2006; EVANS *ET AL.* 2012; GROVES *ET AL.* 2013; CHENERY *ET AL.* 2014; SCHUH & MAKAREWICZ 2016; WINTER-SCHUH & MAKAREWICZ 2019; LEGGETT 2020; LEGGETT *ET AL.* 2021; VESELKA *ET AL.* 2021; SNOECK *ET AL.* 2022).

7.2.3 ARCHAEOLOGICAL IMPLICATIONS OF MOBILITY

In the background chapter (section 2.2.3.7), I highlighted the forms that mobility may have taken in the early medieval period that do not necessarily represent long-distance migration. I would like to discuss whether the approach I have taken in this study can be helpful in exploring these mobilities, and if yes, what we can see now that we could not before this study.

First, one of the major drivers for mobility that is consistently brought up in archaeological research is the movement of women in the course of marriage. We know of long-distance, high-status relationships which are formed in this way, for example in the case of AEthelbert of Kent and Bertha of Francia in the 6th century (Yorke 1990: 36; Harrington 2020). These instances are often recorded in annals and chronicles and were mostly written down by Christian chroniclers. After having analysed the Sr isotopes from Cleatham, we can with similar determination state that young women (addressed through multi-skeletal sampling) were moving – probably regionally – in other parts of the country and even earlier in time (late 5th, early 6th century). It was also possible to illuminate changes of this through time, with cremating communities appearing to remain more regionally homogeneous in the later 6th century. It is very possible that women were still moving locale for marriage, but this is hidden from our view because it occurred short distance, amongst neighbouring communities. If we consider exotic items such as coral beads and ivory rings to signal high status, we could argue that the longer-distance mobility that we see at Cleatham is mirroring what happens in 6th century Kent, with princesses moving across the country to marry regional rulers. This is not supported in all instances, however.

Taking the presence of such exotic items such as coral beads and ivory rings as evidence for trade, one might suggest that the mobility we observe associated with such items is correlated – the items moved, and so did the people. However, it is more than likely that regional trade networks were woven into longer distance ones, and that we can explain

what we see as people moving shorter, regional distances and acquiring these precious items from closer to home. One factor to support this is the mobility that animals exhibit – at Cleatham, we see horses coming from further afield, similarly to some of the people. The suggestion is that there is a connection at Cleatham to a locale further away. If we consider possible geographical locations for the $^{87}Sr/^{86}Sr$ values that we see, the closest possibilities include Herefordshire and the Yorkshire Dales – certainly a movement of women from the west and northwest of England towards the east. Perhaps we are looking at the formation of kinship ties across the country in the 5th century. Certainly, the presence of the animals with such $^{87}Sr/^{86}Sr$ ratios would indicate that travel occurred over land, rather than from beyond the Channel (although see Heath Wood).

Third, as was noted by Fontaine (2017), where we observe trade, we can also expect slave-trade. While it is unlikely that people subjugated to an inferior position in life would have been buried with jewellery (coral beads), accessories (ivory ring), or animals, on the flip side the mere presence of these items implies that slavery could have been a driving force for some of the mobility observed at Cleatham. As we only analysed a small sample of burials from this cemetery, larger patterns might be hidden. At Ingleby Barwick, the truncation of many of the burials likely led to the removal of grave goods which could have been more informative on this front. Regional trade may be inferred by the presence of the amber and glass beads in some of the inhumation burials dating to the late 5th to early 6th centuries, so slavery could factor as an explanation for the slight difference in the isotopes of two of the individuals cremated here. However, it could equally show regional mobility for marriage, given that one of the individuals was sexed possibly female.

Lastly, warfare, local or regional conflicts might account for some of the mobility observed at Cleatham and Ingleby Barwick. Although the fact that mostly women were travelling would suggest that they did this within a patrilocal marriage system, we cannot exclude that their relocation was a preservation mechanism to avoid aggression or danger

elsewhere. At Heath Wood, because of its association with the Viking Great Army, any observed mobility is clearly linked to warfare. The purpose of this long-distance travel was the taking of land and – as is argued – the intention to settle in a new place (Hadley & Richards 2021). The presence here of animals who share the same or similar Sr isotope ratios is suggestive of animal transport across the North Sea, as early as the late 9th century.

7.3 Review of approach and Limitations

Generally, the methods employed in this thesis were useful for addressing the research questions. Some of the protocols were/are still in transition as sampling took place for this thesis. This project benefitted from communication with other researchers working on the same material type, as was especially the case for the otic capsule: Here I followed Veselka *et al.* (2021), but this protocol has now been slightly amended to prevent sample loss. The petrous portion (cut in half) requires ultrasonication in full before sampling to avoid inclusion of soil material into the powdered sample through drill vibration. This also helps to clean otic surfaces which then require less intensive superficial abrasion before sampling. I found that there is often less Sr contained in the otic capsule, which means that more than the ten mg of powdered sample – ideally exceeding 15 mg – should be used for Sr isotope analyses to make sure that a reliable result is measured. The pre-treatments and methods used for all other sample types (skeletal, plants) had been well established at the time of use and went smoothly (these were based on the protocols published in: Snoeck *et al.* 2015; Ryan *et al.* 2018; Snoeck *et al.* 2020). It was possible to closer characterise the spatial variation of bioavailable $^{87}Sr/^{86}Sr$ for a 25km catchment around each site by increasing the existing plant-sample density in Evans *et al.* (2018). Because the sampling for this study encompassed plants only, the new data complements that of the BGS isoscape accessible online and can be used by researchers investigating $^{87}Sr/^{86}Sr$ isotopes in the wider areas in the future.

The interpretation of the isotopic data is highly contingent on a multitude of variables. One of the most difficult hurdles, because of its imprecision, is the rate of bone turnover and by extension the allocated represented timespan per skeletal element sampled. Clinical research has not yet provided clear parameters to answer this question and there are no practical or consistent ways for an osteoarchaeologist to measure turnover, especially for Sr in bioapatite. Our knowledge about turnover rates of bone collagen is much more advanced, with the study by Hedges *et al.* (2007) frequently cited in isotopic studies on C

and N (for example see also: Beaumont *et al.* 2018; Matsubayashi & Tayasu 2019). But this cannot be used to determine the turnover of bioapatite generally, and that of Sr in particular. This would be like comparing apples and oranges. In a future study a relative method for the assessment of turnover may be created, based on histological analyses of a thin slice taken from the sample fragment, whereby the number of primary vs secondary osteons (and occurrence of other types of osteons) for a specific area is established (see for example Marie & Glorieux 1981; Streeter *et al.* 2010; Jo & Kim 2011; Fahy *et al.* 2017; Cooke *et al.* 2021). However, this would require a large data-set, an experimental approach involving animals, and/or a modern skeletal collection with known parameters.

Infrared (FTIR) analyses have been conducted for the bone samples from the sites of Ingleby Barwick and Heath Wood, but these analyses followed an outdated protocol from 2017/2018. Since then, the BB-Lab at Vrije Universiteit Brussel has overhauled this protocol (described in Materials and Methods Chapter in this thesis) for the CRUMBEL project and adapted it to the instrument at the laboratory (see Stamataki *et al.* 2021). This new protocol is significantly more time-intensive and has therefore not yet been used for all the samples presented here, although preparation to do so is well underway. The results will be presented alongside the C and O isotope analyses in separate publications.

I have used an interdisciplinary approach when looking at and interpreting the isotopic data. This allowed me to include osteological and palaeopathological information, and elements of agency and personhood theory to humanise the data and search for meaning beyond the numbers. I found the best access for this enquiry in considering especially the relationship constellations presented through the funerary rite. Cremation lends itself to this approach because of the decision-making process evident in the level of intermixing between peoples' remains, or remains of animals and people (Williams 2001, 2004, 2008). Combined with the isotopic analysis, I found the results extend our knowledge of the kind of relationship presented beyond the funerary ritual and hint at how this was experienced in

life. In some cases, it was possible to tie this back to the idea of a worldview which may have involved less strongly defined and experienced ontological boundaries between people, animals, and objects (Brunning 2015; Sykes 2015; Klevnäs 2016).

The lack of comparative data from early medieval cremation cemeteries in Britain is blatantly apparent. I hope that I have been able to show with this body of work that there lies enormous potential in studies like these, even if they are single-proxy studies for the time being. I have only presented the Sr isotope data here, but I will also be able to share C and O and FTIR data soon to comment on cremation practices and their potential. The inclusion of ^{88}Sr may also be able to help illuminate how people and animals used and related to the land. Therefore, I again emphasise the knowledge that we stand to gain from a systematic isotope analysis of the large British early medieval cremation cemeteries, especially in conjunction with the work that is currently being undertaken at the AMGC laboratories (BB-Lab) at the Vrije Universiteit Brussel, and the Université Libre de Bruxelles, which will provide a large dataset for comparison and contextualisation across the Channel. We are already in possession of a large amount of contextual knowledge for several of the large cremation cemeteries thanks to the dedicated and detailed work of many archaeologists through the production of site reports, for example for Spong Hill (Hills 1977; Hills & Penn 1981; Hills *et al.* 1984, 1987, 1994; McKinley 1994; Bond 1996; Penn *et al.* 2007; Hills & Lucy 2013, 2015), Sancton (Timby *et al.* 1993; Bond 1996), and many others. Many of these already include specialist reports on the animal remains and therefore provide access to questions about animal-human relationships, alongside osteoarchaeological analyses of the human remains. This existing information can be used to select samples based on defined research questions where the budget is constrained. Smaller cremation cemeteries benefit from a more comprehensive isotope investigation because sampling bias may be misleading otherwise.

Finally, the data generated for this study proved to be immensely useful for interpretation when tied back to the types of mobilities that we expect for the early medieval period. While it is often impossible to narrow down exactly what form of mobility we are looking at in any specific case, the consideration of the options helps us to imagine what kind of personal experience may have been tied to the move.

7.4 Final conclusions

The aim of this thesis was to test whether strontium isotope analysis on cremated remains can be used to draw out new information from early medieval cemeteries to investigate aspects such as mobility, animal-human relationships, and the social practice of cremating communities and their rites. By extension, it was hoped that the results would help to expand and deepen the insight that we have into the level and nature of mobility during the early medieval period. Based on this, the ensuing questioning has encompassed an interdisciplinary spectrum of information: Isotopic data was extracted from archaeological human remains and was used to investigate the level of mobility of the individuals. In some cases, it was possible to tie this back to the idea of a contemporary worldview which may have involved less strongly defined and experienced ontological boundaries between people, animals, and objects. The theoretical engagement with agency and personhood has made it possible to highlight the importance of relationships, and it has been shown that relationships are closely connected to mobility. With a variation of research questions (outlined above), it was possible to investigate three different case-studies – Ingleby Barwick, Cleatham, and Heath Wood. Consequently, our level of knowledge about each one of these sites has been advanced. This includes the observation that at such sites as Cleatham, mobility from outside the site catchment was larger in the early period of use. Women were more likely to travel to the area over longer distances, at least from as far west as Herefordshire or Wales, or northwest from the area of the Yorkshire Dales, and this may suggest a patrilocal system at play during the early phase of cemetery use because most of these individuals appear to have travelled to the area in their youth. At Ingleby

Barwick, we likely observe short-distance mobility within the catchment of the cemetery, perhaps also in the context of a patrilocal marriage system, although most young individuals appear to have spent their childhood here. This thesis has furthermore shown that isotopic analyses involving a multi-skeletal sampling approach from early medieval cremation cemeteries of all sizes in Britain has enormous potential for the investigation of mobility regionally and further afield. Comparisons of data from contemporaneous sites show up crucial dissimilarities in the level of mobility to the areas under investigation, whether the cemetery was used by several communities, and where marine-derived Sr likely played a larger part in the diet. Studies of this kind provide us with a more nuanced understanding not only of human-human relationships, but also of animal-human relationships in the past and I argue that this is one of the most useful avenues to approach past ontologies and perceptions of the world.

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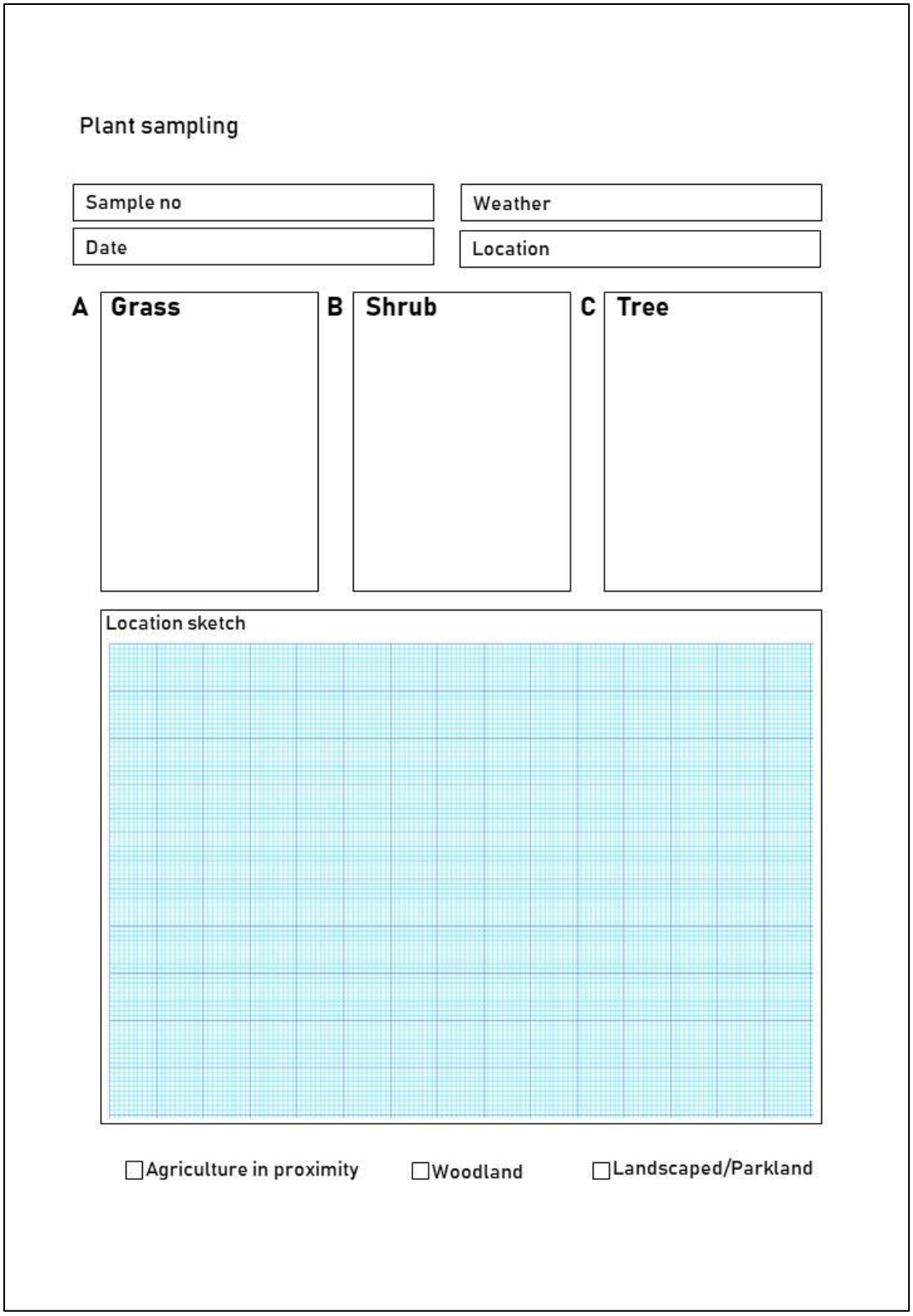
A. APPENDIX

A.1 PLANT SAMPLING PRO-FORMA



A.2 PLANT SAMPLE DETAIL – INGLEBY BARWICK, STOCKTON-ON-TEES

Sample ID	Sample info			Coord			Coord system	Environment	Notes
	Type	Species ID	Detail	Easting	Northing	Elevation (6-7m accuracy)			
1-a	Grass	n/a	*n/a*	433042.274	517877.126	48.714	OSGB36 - OSTN02	Farmland. Ploughed agricultural fields all around sampling area. Grasses were taken from around the hawthorn hedge running along main road, next to a pasture. At small intervals within a stretch of 10m along side of road.	Area quite flat, land intensively farmed - pastures but predominantly agriculture.
1-b	Tree	Crack willow	*Salix fragilis*					Three different trees of same species sampled. These were aligned in a small copse separating the main road from a ploughed field. All trees were at border of field, next to a large ditch holding no water (may be drain for field separating field and road). Tree 1 - 5m away from road at gate to field, L of gate; Tree 2 - 5m away from road at gate to field, R of gate; Tree 3 - further away from road along field border, c.30 away from 1 and 2.	

1-c	Shrub	Hawthorne hedge	*Crataegus monogyna*					3 samples derive from hawthorn hedge running alongside main road next to pasture field. Opposite side of road from small copse separating field and road where trees were sampled. Samples were taken from same hedge at intervals of ca. 15m.	
2-a	Grass	n/a	*n/a*	455968.863	506821.056	92.259	OSGB36 - OSTN02	Grass taken from side of road as far into copse as possible. Ca 5m into copse away from roadside within a space of 5m.	This area is mainly characterised by farming (pasture and agriculture). Not as flat as IBL, but has slight hills and interspersed small, wooded areas.
2-b	Tree	Sycamore	*Acer pseudoplatanus*					Samples were taken from 3 trees near at the border to a copse along the main road. Across from farmhouse. The trees were spaced at approximately 10-20m from each other. Close proximity to the slope of a small beck/ditch. Leaves of sycamore have Rhytisma acerinum spots.	

2-c	Shrub	Holly	*Aquifoliaceae*					3 Holly shrubs sampled within copse ca 5 - 10m away from road. Small stream nearby, but not right next to it. 3 different plants within radius of 5m of each other.	
3-a	Grass	n/a	*n/a*	445124.692	512608.588	29.813	OSGB36 - OSTN02	Grasses were taken from within small copse of trees right next to playground area. Main road running along edge of playground area divided by copse of trees. Grasses taken within a radius of 5m.	This is the location of the Anglo-Saxon cemetery. Now there is a playground area publicly accessible with a small copse separating this play area from the busy main road. Generally, the area is visibly flat and only a few hills are observable in the distance.
3-b	Tree	Ash	*Fraxinus excelsior*					Samples taken from 3 Ash trees at border to playground area. The trees were separated by ca 10m from each other. Tree 1- relatively large (15m); Tree 2 - smaller than Tree 1, ca. 3.5m in height; Tree 3 - large tree, ca. 15m	
3-c	Shrub	Hawthorne hedge	*Crataegus monogyna*					The 3 samples were taken from three separated Hawthorn shrubs at the border of playground and copse. The tree plants were spaced approximately 5-10m and well within the 50m catchment of the recorded sample area (GPS). All were below 3m in height.	
4-a	Grass	n/a	*n/a*	440311.717	524270.653	48.88	OSGB36 - OSTN02	Grasses were sampled from area immediately behind parking area entry at border to small copse with trees.	This sample derived from the vicinity of the parking area for

								No farming in immediate area, mud splash unlikely due to distance away from road, grass all around.	the Wynyard Country Park. Slightly rolling hills in this area with agriculture interspersed with small woodland areas such as this.
4-b	Tree	Ash	*Fraxinus excelsior*					Tree samples were taken from 3 Ash trees within parking area of Wynyard Country Park. All within 40m of each other (radius 40m). Effort was made to sample healthy looking ones which were still green. Landscaped area.	
4-c	Shrub	Hawthorne hedge	*Crataegus monogyna*					Shrub samples were taken from 3 Hawthorne plants from alongside the main road opposite the parking area for the Wynyard Country Park. This was due to the fact that there were hardly any suitable shrubs present in the Country Park area. The samples derived from the hedge and were taken at intervals of approximately 10-15m.	
5-a	Grass	n/a	*n/a*	466333.593	510517.209	170.275	OSGB36 - OSTN02	Grasses were taken from edge of village green. Some tougher grasses derived from edge of small drain running alongside green space.	The samples at this site derived mainly from the village green area (Commondale). The village is located on a medium slope down the hills in the area of the North Yorkshire Moors. This
5-b	Tree	Large-leaved Lime	*Tilia platyphyllos*					The 3 tree samples derived from three large-leaved lime trees situates in the centre of the village green. Tree 1 and 2 were spaced ca 8m apart from each other, the	

								third one was located ca 25m away from both. The road was running past the green approximately 10m away from the trees.	place was chosen for sampling as trees were present as well as shrubs and grasses - as opposed to more open and higher areas of moors.
5-c	Shrub	Gorse	*Ulex europaeus*					The 3 shrub samples derived from three separate gorse shrubs of ca 1.5m height. Two were located immediately adjacent to a small drainage canal alongside the green with a downwards slope. Behind shrubs was a dry-stone wall behind which a house was located. No water was visible inside drain/ditch. Samples 1 and 2 were within 8m of each other on same drain. Sample 3 located 25m up the hill away from the house/drain. Next to this plant was a small wilderness area with fern and large boulders of granitic rock (not bedrock outcrops).	
6-a	Grass	n/a	*n/a*	440789.174	533157.623	107.646	OSGB36 - OSTN02	Grasses derived from below the oak tress within the area of the copse, ca 6m off bridleway. No water sources in vicinity, mud splash very unlikely.	Most samples came from area on side of public bridleway where a small copse was located. Generally, the area appeared mostly flat and fertile, with a much farming and agriculture.
6-b	Tree	Durmast/Sessile Oak	*Quercus petraea*					3 oak trees were sampled from within a copse ca 6m off public bridleway. These three trees were ca 5m apart from each other and were relatively young. The grasses	

								were taken from same area around the trees.	Pastures and ploughed fields.
6-c	Shrub	Hawthorne hedge	*Crataegus monogyna*					For the shrub samples, 3 hawthorn bushes were sampled from a hedge running alongside the bridleway. Spaced at approximately 5-10m intervals. Small ditch in front of hedge, but this was dry at the day of sampling.	

A.3 PLANT SAMPLE DETAIL – CLEATHAM, LINCOLNSHIRE

Sample ID	Sample info			Coord			Coord system	Environment	Notes
	Type	Species ID	Detail	Easting	Northing	Elevation (6-7m accuracy)			
1-a	Grass	n/a	*n/a*	467515.691	400298.213	5.841	OSGB36 - OSTN02	From below hawthorn shrubs and trees along the fence line at the edge of the field. All three samples taken from here but spaced out at least 15m from each other.	Small village called Blaxley. At edge of village, off the main road along a public footpath through a small copse (copse parallel to main road, separating road from field). Elusive bull on large field behind copse.
1-b	Shrub	Hawthorne	*Crataegus monogyna*					Samples taken from shrubs along the field side/copse border. The plants were behind fencing. Leaves were bright green and young. The 3 plants were spaced out by at least 15m from each other and covered a similar stretch than grasses sampled.	
1-c	Tree	Pine	*Pinus nigra*					These pines were quite tall and definitely mature. Just some of the dark green needles were sampled. The 3 trees were spaced at least 15m apart and situated along the field side of the copse, not the roadside.	
2-a	Grass	n/a	*n/a*	479959.282	398904.959	5.471	OSGB36 - OSTN02	Sample 1 was taken from under the treeline between the fields (next to small	Agricultural farmland and dyke holding

								road); sample 2 was taken from beneath shrub sample 2 (on the dyke); and sample 3 derived from roadside on the other side of the bridge next to a hawthorn hedge.	stagnant water. Samples derived from treeline between two fields (agricultural) and from area around the dyke itself, which was somewhat removed from dyke.
2-b	Shrub	Hawthorne	*Crataegus monogyna*					Samples 1 and 2 were taken from the dyke itself (in-between the two parallel running ditches holding water), spaced approximately 15m apart; sample 3 was located on other side of bridge along the roadside, at least 25m away from other samples.	
2-c	Tree	Birch	*Betulaceae*					These were some very young leaves from three trees in a small treeline along a small road (probably farm access) separating two fields. These were also spaced at least 5m from each other.	
3-a	Grass	n/a	*n/a*	492327.484	404256.11	19.533	OSGB36 - OSTN02	From three locations spaced out at least 25m. 1 and 2 derived from small copse underneath birch trees where tree sample 3 derived from. This area was away from road and is unlikely to have been affected by mud splash. Sample 3 from main road side along pheasant	These samples derive from a catchment of approximately 100m. They were taken from several areas around a main road making an S-curve. Along

								pen, at least 30m away from other samples.	one side of road was a small fenced-off hill forming the basis for a pheasant area. On the other ran a small copse with relatively recent trees (pines and birch trees). Beyond this area was a designated wildlife areas which may have been an ex-quarry.
3-b	Shrub	Hawthorne	*Crataegus monogyna*					Hedges sampled were all away from road on the side of the nature reserve, spaced ca 10m apart from each other.	
3-c	Tree	Birch	*Betulaceae*					The trees sampled were quite young, but all were over 3m in height. Tree sample 2 in bend of road was much taller and more mature. They had limited foliage to sample. Trees 1 and 3 were from small new copse separating the road from the nature reserve; these were at least 15m away from road.	
4A-a	Grass	n/a	*n/a*	493937.914	401233.867	74.417	OSGB36 - OSTN02	The three grass samples derive from the area along the main road side at the north-eastern edge of the field (3) and from the parking area for the dog parkour (1 and 2).	This area was just north of the Anglo-Saxon cemetery (possibly a few hundred meters). Most of the samples derive from a copse across from a dog parkour with parking area. This borders on
4A-b	Shrub	Hawthorne	*Crataegus monogyna*					All three samples are from within the copse, but they were spaced apart by ca 15m. Young leaves were sampled.	

4A-c	Tree	Field Maple	*Acer campestre*					These were leaves from field maples dispersed inside the copse. The trees were relatively young but all were over 3m at the very least. Foliage was small and fresh and new.	the field holding the cremations (the cemetery is located on the southern border).
4B-a	Grass	n/a	*n/a*	498005.502	406398.494	11.411	OSGB36 - OSTN02	Sample 1 derived from underneath large pine tree in avenue, closest to gatehouse, in the middle of the field. Sample 2 derived from underneath a second tree ca 25m away from sample 1. Sample 3 was located underneath a third tree in the avenue, ca 30m away from 2.	This site was parkland area belonging to a hall and accessible via public footpath. It showed signs of providing pasture for cattle in summer, but at time of sampling there was no cattle present (nor had it been recently, possibly last summer). Large field (parkland) was fenced off with tree copses on both sides, with the occasional hawthorn shrub. In the middle of the field was an avenue of large, very old trees. These consisted of pines and others. The catchment area
4B-b	Shrub	Hawthorne	*Crataegus monogyna*					These three samples come from three hawthorn shrubs alongside the field edge, spaced at least 20m away from each other. Sample 3 from hedge outside gatehouse.	
4B-c	Tree	Pine	*Pinus nigra*					These samples are all from large pine trees from the avenue of trees in the middle of the field. Trees set ca 40m apart from each other.	

									for this sample was ca 250m.
5-a	Grass	n/a	*n/a*	504294.693	397670.663	22.398	OSGB36 - OSTN02	The grass samples derive from the roadside, but they are spaced at least 25m apart from each other. Sample 1 derives from the side of an unpaved farm track dividing a field and a copse (copse-side sampled). Samples 2 and 3 from alongside main road.	This sample derived from agricultural farmland near a village. A small copse belonging to a farm was located next to the main road, with several small roads for farm access.
5-b	Shrub	Hawthorne	*Crataegus monogyna*					These samples derive from hedges framing a farm access road and the main road (sample 3). Samples are at least 25m spaced out.	
5-c	Tree	Horse Chestnut	*Aesculus hippocastanum*					The trees sampled come from the small copse alongside the road next to the farm access road (1 and 2). The third tree derives from a field next to the copse (single tree in field), at least 15m away from the others).	
6-a	Grass	n/a	*n/a*	513409.472	408774.949	44.343	OSGB36 - OSTN02	grass samples were taken from the parking area. Samples 1 and 2 were spaced apart ca 10m while sample 3 derived from the edge of the forest path near the parking area.	Private parkland with sloping hill (mausoleum on top). This area is mostly forested and thus grass was confined to parking area. Mixed trees in forested area,
6-b	Shrub	Holly	*Ilex*					These three holly samples were taken from three holly plants smaller than 3m and	

								at least 10m apart from each other. Near parking area.	which were all quite tall and mature. Catchment of samples was ca 150m.
6-c	Tree	Pine	*Pinus nigra*					The three pine trees sampled derived from within the forest area along the path and further inside the forested bit. Spaced ca 25m apart from each other.	

A.4 PLANT SAMPLE DETAIL – HEATH WOOD, DERBYSHIRE

Sample ID	Sample info			Coord			Coord system	Environment	Notes
	Type	Species ID	Detail	Easting	Northing	Elevation (6-7m accuracy)			
1-a	Grass	grasses, tips	*n/a*	430680.3	347419.6	97.436	OSGB36 - OSTN02	grass tips only; taken from parkland only; within 50m of GPS point.	Near Shottle Hall, Belper. Parkland, mostly; agriculture in proximity: across main road ; samples only from side of parkland.
1-b	Shrub	Hawthorn hedge	*Crataegus monogyna*					From hedge alongside main road to hall; sample 3 taken from side of hedge away from road.	
1-c	Tree	Oak	*Quercus*					Large grown oak trees along side of road; all on parkland side, away from agricultural field across road.	
2-a	Grass	grasses, tips	*n/a*	413998.9	323228.1	120.026	OSGB36 - OSTN02	From inside picknick area next to parking; only grass tips; within 15m of each other.	Forest parking and picknick area near Newchurch village. Woodland, so might spike.
2-b	Shrub	Fern/Bracken	*Polypodiopsida*					Ferns/bracken used because no other shrubs present; these were located in the forested area around the picknick.	

2-c	Tree	Oak	*Quercus*					Trees from next to main forest path (left) and at the outside of picknick area (3); 3 was smaller tree.	
3-a	Grass	grasses, tips	*n/a*	434564.5	325725.4	108.194	OSGB36 - OSTN02	3 samples taken from along roadside; 1- alongside public path away from site, 2- on side of pasture fields (ca 2.5m away from road); 3- from roadside along pasture field with cattle including path to Heath wood.	Heath Wood area, from along main road, cornfield across road, but care was taken to sample only from along pasture fields and private garden; all samples within 80m of GPS point.
3-b	Shrub	Hawthorn hedge	*Crataegus monogyna*					From small plant next to roadside at gate to path to HW; 2 and 3 taken from inside private garden and away from road, 3 from garden hedge but on roadside.	
3-c	Tree	Oak	*Quercus*					Leaves taken from oak trees lining path up to HW forest across pasture field; Large, old trees.	
4-a	Grass	grasses, tips	*n/a*	436886.4	325522.9	92.79	OSGB36 - OSTN02	grass tips only; taken from grassy areas in-between trees - wooded area. Ca 20m apart from each other.	St.Brides wooded area (dog walking); near parking area for Poppy Wood; samples from inside Poppy Wood - might spike.
4-b	Shrub	Hawthorn hedge	*Crataegus monogyna*					hedge alongside main road sampled, all from side away from road.	

4-c	Tree	Oak	*Quercus*					trees from wooded area, alongside side of path; trees relatively young but more than 3m height.	
5-a	Grass	grasses, tips	*n/a*	437295.5	321256.9	89.124	OSGB36 - OSTN02	samples taken from next to roadside (Allee with tree lining), ca 25m away from each other, ca 5m away from road and on side of apparent pasture field (no agriculture).	Access road to Staunton Craft Centre (NT); pasture? On one side, wheat on other - only pasture site sampled.
5-b	Shrub	Hawthorn hedge	*Crataegus monogyna*					samples from hedge running parallel to main road; ca 6m away from road; 3 taken from side of field; ca 20m apart from each other.	
5-c	Tree	Oak	*Quercus*					oaks sampled from side of pasture fields, trees ca 20m apart; large, old trees.	
6-a	Grass	grasses, tips	*n/a*	443217	345471.4	99.328	OSGB36 - OSTN02	Dark green, thick leaves sampled, interspersed with grass; fine hair on leaves - no longer grass available; samples from treeline in parkland area	Shipley country park; small park near town, no agriculture in proximity.
6-b	Shrub	Hawthorn hedge	*Crataegus monogyna*					small hedge sampled alongside parkland field. Samples ca 15m apart.	
6-c	Tree	Oak	*Quercus*					Trees ca 20m apart, alongside well-maintained grassy field, separating houses from ark area - within 100m of GPS point.	

A.5 OSTEOLOGICAL RECORDING FORM

Recording Form

DATE

__ __ / __ __ / __ __

BASIC DATA

Site:

Cremation:

Cremation Nr :

Sample ID:	Sample Type:	87Sr/86Sr	2 SE	[Sr]

OSTEO

Age:

Justification:

Sex:

Justification:

Cranial:

Dentition:

Axial:

Upper Limb:

Lower Limb:

Pathology:

Roman Vessel: ☐
Accessory Vessel: ☐
No PG/GG: ☐
Coral Beads: ☐
Ivory Ring: ☐
Glass Bead: ☐
Bone Bead: ☐
Crystal Bead: ☐
Bone Comb: ☐

Bone/Antler Obj: ☐
Bone/Antler Pendant: ☐
Spindle Whorl: ☐
Toilet Implements: ☐
Pb Plug: ☐
Horse Tack: ☐
Ae Obj/Material: ☐
Fe Obj/Material: ☐
Animal Bone: ☐

Animals?

PG:

Notes:

A.6 OSTEOLOGICAL CATALOGUE A – INGLEBY BARWICK, STOCKTON-ON-TEES

This catalogue presents the results of the osteological analysis of the remains from Ingleby Barwick. The results were recorded in more detail than those at Cleatham since no other recording of these has been published. Images of the sampled fragments are attached.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 8	Adult	*	Femur (Humerus?)	263-266; 19

Notes:

This cremation deposit contained hardly any evidence for ribs or vertebrae. No pathology was observed. This deposit is almost completely white in colour, with a few fragments of the arms and the skull with slight blueish-grey tinge on internal surfaces – less heat exposure/shorter duration? Cracks are present on cranium and on many long bone surfaces. Post-ex breaks frequent, suggesting that any interpretation based on the size of fragments may be misleading. Striae were visible on several appendicular long bone shaft fragments (external cortical shaft fragments), but on most these appear not to be pathological. This cannot be determined, however, as the true extent on the bone is not observable. Some cranial surfaces show evidence of slight porosity (ectocranially?). Little evidence for trabecular bone in general and epiphyses in particular. Hardly any axial fragments.

Dental:

Two fragments of roots. May be same root but cannot be joined. Larger fragment is middle part of root, permanent, likely complete. Second fragment is the distal part of permanent root with apex fully closed. – Adult. Root fragments are blue to black on inside, but completely white towards external surface. Greyish blue sheen on surface like sheeting.

FIGURE 1 – IBL04 8 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (FEMUR). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 9	Non-adult/OJ	N/A	Femur/Tib/Humerus	249+248+16

Notes:

Most fragments are completely white, but there are a small number of fragments not completely calcined, some sandwich discolouration. One small cranial suture fragment has a slightly blueish hue, as well as the possible otic capsule fragment. A couple of the larger long-bone fragments appear almost cream-coloured on the inside. This may be soil staining. Half of the smaller long bones likely belonging to the arms (radius/ulna shaft?) have a blueish tinge on the internal surface indicating lesser exposure to heat. Unclear if one side or both as bones not clearly identifiable. One larger rib fragment slightly blueish on the internal surface. Long bones of legs more completely white than those of arms. Cracking is present on most long-bone fragments. This ranges from slighter chaotic hairline cracks to completely splintered nail-shaped cracks. The distribution seems random, although one of the smaller long bones (poss arm) which also have a blueish tinge on the inside, have thick cracks running across bone surface, some of them have fractured the bone completely. Humerus/tibia shaft frags exhibit slighter, chaotic hairline cracks, but only one side/surface is visible. Warping is visible in the long bone shaft believed to be the humerus/tibia, as well as some other leg bones. Not as strong in arm bones; Less heat – blue hue inside? Warping present in cranial fragments.

Dental:

None.

FIGURE 2 - IBL04 9 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (LONG BONE). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 10	Non-adult/older	N/A	Tibia/Humerus	274-276

Notes:

Cranial frags indicate non-adult, no other evidence suggests adult. Long-bone frags could be older non-adult (quite thick cortical bone).

Dental:

None.

FIGURE 3 - IBL04 10 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (TIBIA/HUMERUS). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 11	Adult	F??	Femur; Rib	32

Notes:

This cremation burial consists of only one spit. The cremation is mostly white, but some bluish and light bluish grey imperfectly cremated fragments, especially in the smaller bones of the arm and a few areas of the cranium. The larger long bones such as the humerus, femur and tibia are well cremated and mostly white. This may be due to imperfect heating of the lower arms/lower legs? One fragment likely belonging to the arm exhibits slight periosteal reaction in the form of advanced lamellar striae. This is possibly pathological although only a small extent is observable. The medial aspect of the frontal bone is present and appears very straight – this may indicate a possible female (also: fully fused and obliterated metopic suture). The individual was an adult as can be determined from the fully developed tooth roots (in the >5mm and 2-4mm sized spits) and the size of the bones.

Dental:

This size includes 5 fragments of tooth roots. One of these is the apical end of the root – this is mostly white in colour, apart from a dark bluish grey lining on the internal surface. The distal third of the root that is present appears very rounded so may be a maxillary incisor. Although damaged, it is possible to determine that the apex was fully closed. Due to slightly curved nature of distal third of root, this may also have been a maxillary third molar. The other, smaller fragments are covered in a patina of the same colour. No pathology is observable.

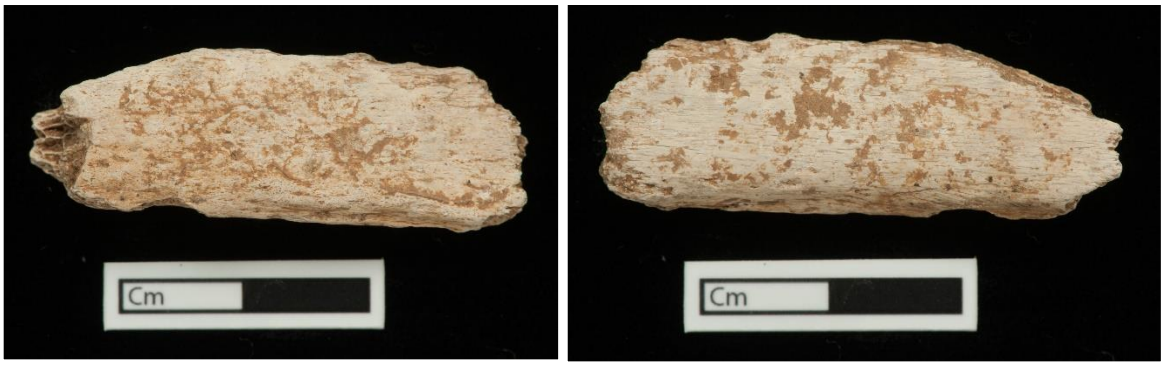


FIGURE 4 - IBL04 11 SAMPLING– CREMATED BONE FRAGMENT (RIB). LEFT IMAGE IS EXTERNAL SURFACE, RIGHT IS INTERNAL (VISCERAL) SURFACE.

FIGURE 5 - IBL04 11 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (FEMUR). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 268	Adult (18-40)	M??	Femur; Rib	256-261

Notes:

This cremation burial contains generally large fragments. Bones from hand, feet, spine, ribs, limbs and skull are all represented. It appears that especially the larger long-bones of the legs are less burnt (dark bluish grey). The individual was an adult as can be determined from the fully developed tooth roots (in the >5mm and 2-4mm sized areas) and the size of the bones. Most of the cranial fragments are white, approximately a third are ranging from bluish grey to dark bluish grey (GLEY2). Chaotic fissures and cracks present only in white frags, on external surface of temporal; many rib fragments, most completely white and c. 30% with light bluish grey discoloration on the cortical surface. Both fissures and cracks present on half of the frags. All of the frags are shaft fragments, some fit together and are likely from a left rib. The rest cannot be sided; one fragment has a small and slight hue of green indicating the presence of CuA at some point in the cremation; Fragments of vertebrae: 2 of these are the right lateral portion of a thoracic vertebra, including the superior articular facet and a small portion of the body (1 of them). The smallest fragment is a left pedicle, bridging the facet to the body (both not present). Both facets appear in good condition without pathology. No pathology can be ascertained from the fragmented remains of the body; Two others consist of an almost complete body and at least a partial pedicle. One is a left partial superior facet, pedicle, and small part of body. One is the dens of C2. One is a solitary thoracic superior facet (R) and one is the posterior half of the occipital condyle of the skull (?). Three bodies are cervical vertebrae. The vertebral elements are all white. The bodies are strongly curved towards the centre, but no pathology is observable. Where rims are present, these look fairly normal although sharp; Fissures and warping on all rib fragments, especially on external facing fragments. No pathology; Partial aspect of the inferior ischiopubic ramus. Not much remains; Cracks are present in some of the smaller, white long bones. Crescent shaped cracks are present in some of the thicker cortical bones, some of which are in smaller pieces, broken. Generally, it appears that some of the thicker white long bone have blotches of bluish grey discoloration across surfaces; the larger looking long-bone cortical fragments appear to be more discoloured with bluish grey (GLEY2 7/5PB – light bluish grey, GLEY2 4/10B – dark bluish grey). Ca 40% of long-bone fragments affected. Clear issues with burning. Cracks and chaotic fissures are mostly affecting the better cremated (white) areas; Several fragmented joint surfaces. a few are bluish grey (GLEY2 6/5B), rest white. No path observable, some too degraded. Non-specific; Sesamoid bone: This measures 8.55mm in diameter, with articular facet on one side. There is

a small lesion in the approximate centre of the surface. DD: this may be osteochondritis dissecans and presents the fractured bone part (‘mouse’).

Dental:

6 root fragments, 2 apex of double root, 2 single roots (1 mid-section, 1 apex). Both the double root and the mid-section are white, while the second single root, the apex is dark bluish grey.

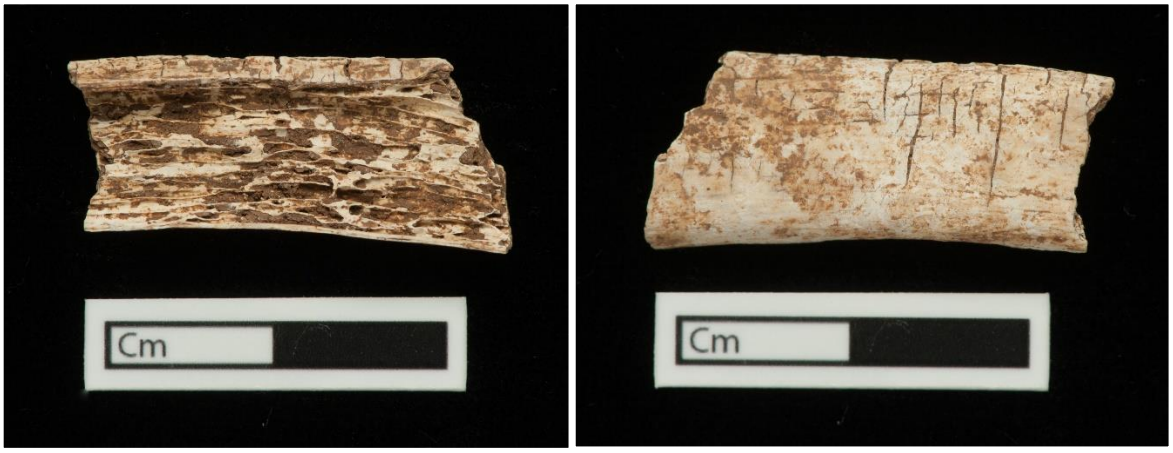


FIGURE 6 - IBL04 268 SAMPLING – CREMATED CORTICAL BONE FRAGMENT (RIB). LEFT IMAGE IS INNER (ENDOSTEAL) SURFACE, RIGHT IS EXTERNAL (PERIOSTEAL) SURFACE.

FIGURE 7 - IBL04 268 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (FEMUR). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 269	Non-Adult (<SF9, but not much)	N/A	Femur; Rib	267-273

Notes:

Deposit is mostly well calcined. All cranial fragments are white and 80% exhibit small fissures and cracks on cortical surfaces. No pathology apparent. The bone appears delicate, even under consideration of shrinkage during cremation. Consistent with juvenile. No-few fresh breaks apparent; There are at least 3 and a maximum of 7 fragments from the temporal bone present. 3 are parts of the inner ear petrous portion, including the bone around the concha, the otic capsule. The bone surface on the inside holding the canals is bluish grey (GLEY2 6/5B); 3 observable bone fragments with joint surfaces display billowing, suggesting that there is a non-adult present in this cremation burial. The rest are smooth surfaces which are consistent with adults, however – they could also belong to the non-adult of an advanced age as some joints fuse earlier. Also, only small fragments are present which means that the full extent is unclear – could be partially unfused epiphyses; 1 rib fragment from shaft – midshaft/vertebral end, fine lamellar bone on external facing surface. Periosteal reaction; 1 rib fragment, vertebral end of shaft (no head), white with cracks across surface. No pathology; Fine lamellar bone and woven bone patches present on at least 13 cortical long bone fragments; Crescent shaped and transverse cracks in surface of two fragments, chaotic and cross fissuring in the others. No fresh breaks, but clearly fragmented through heat; Consistency with juvenile age of individual – small size of rib fragments. Ilium, juvenile – auricular surface incompletely present and displays billowing; Mostly white, small fissures along bone cortex. Soil stained. Majority of long bone fragments are white, non-specific. Very fine lamellar striations visible on surface of several fragments. Could be pathological (periosteal reaction). One fragment is fully covered by fine lamellar bone which is likely a periosteal reaction – pathology. Few fresh breaks, some fragments feature slight transverse and cross fissures.

Dental:

2 crown fragments, unclear which crown. White on outside, but light to dark bluish grey hue. 17 dental root fragments. 2 frags can be joined, make up single root, not fully closed at apex. Consistent with juvenile age. One is a complete root, white on outside surface, but dark bluish grey on inside. Complete root exhibits black patches on external surface and its apex appears to not have closed completely yet.

FIGURE 8 - IBL04 269 SAMPLING – CREMATED CORTICAL BONE FRAGMENT (RIB). LEFT IMAGE IS INNER (ENDOSTEAL) SURFACE, RIGHT IS EXTERNAL (PERIOSTEAL) SURFACE.

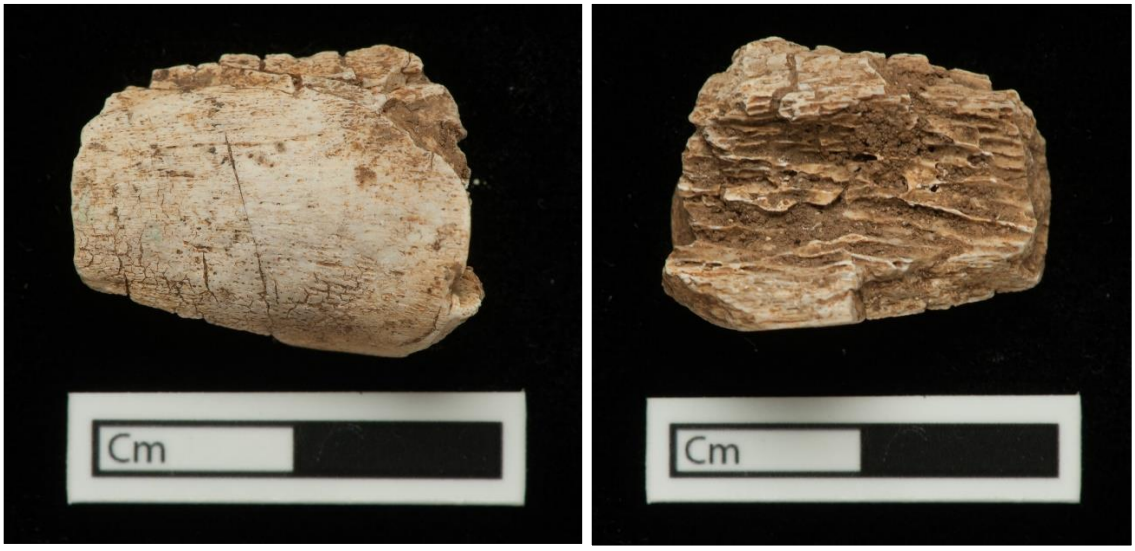


FIGURE 9 - IBL04 269 SAMPLING - IBL04 268 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (FEMUR). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 272	AO/Adult	N/A	Tibia/Humerus	247

Notes:

The bone belongs to an adult or older juvenile based on size. Pathology was not observed, apart from striations (lamellar) on the surface of one fragment – this was not necessarily judged to be pathological. This cremation deposit is completely white. The surfaces of the bones are in moderate condition; Cracking is present on the cortical surface of long bone fragments (crescent shapes and bishop hat-like). Fissures also present. It is likely, that this is an adult or young adult from the size of the bone fragments. Few fresh breaks.

Dental:

None.

FIGURE 10 - IBL04 272 SAMPLING– CREMATED CORTICAL BONE FRAGMENT (HUMERUS/TIBIA). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 273	Adult	*	Tibia/Humerus	250-251

Notes:

This cremated bone is mainly well calcined and completely white; One fragment is the internal surface of the mandibular spine which includes the mentum; Adult individual; Joint surfaces: most of these are non-specific, but one convex joint surface shows signs of eburnation indicating the presence of OA. Unfortunately, it cannot be determined whether this is from a human or animal. The rest of the joint surfaces appear non pathological but feature small fissures on the joint surfaces from heat exposure. At least 40% of these are not completely calcined (white). Blueish grey hue – 5/5B; Long bone fragments largely white, but some of these are not completely calcined – range from 6/5B – 2.5/5B (bluish grey – blueish black); Consistent with adult; Cracks frequently present (externally), fissures fewer (<10%). Good preservation mostly; One long bone fragment displays copper staining on the external surface. It is impossible to determine bone element (only small bit of cortical bone; are less well cremated and exhibit dark bluish grey (GLEY2 4/5B) hues. There is the distinct sense that these fragments may derive from different skulls, due to variation in colour, fire damage, and texture. There may be animal skull present, perhaps only. Warping is observable, and 4 fragments have cracks in the cortex, slight fissuring in 3 others; Some cranial fragments are less well cremated and exhibit dark bluish grey (GLEY2 4/5B) hues. There is the distinct sense that these fragments may derive from different skulls, due to variation in colour, fire damage, and texture - animal? Warping is observable, and several fragments have cracks in the cortex, slight fissuring in others.

Dental:

Two tooth roots (possibly molar?). One root is broken off at CEJ, external surface spottled dark bluish grey and white. Internally dark bluish grey.

FIGURE 11 - IBL04 273 SAMPLING – CREMATED CORTICAL BONE FRAGMENT (TIBIA). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

Sample ID	Age	Sex	Sampled element	Spits
IBL04 274	Adult	*	Femur/Humerus	

Notes:

Cranial fragments: One of these is part of the occipital bone featuring the raised surfaces of the interior crest. All fragments exhibit cracking on the internal surface and smaller fissures on the external cortex. No pathology is observable. Most fragments are white. No fresh breaks; 2 fragments likely belonging to the inner ear/ concha due to presence of canal impressions. The internal bit is bluish grey. From the consistent size of the cranial fragments in this deposit, it is likely that this individual was an adolescent or adult. – Complete roots suggest adult. Long bone fragments: These are all relatively small, without recognizable features, and thus not identifiable. Transverse cracks, crescent cracks. Some bluish grey discolouration (internally) – GLEY2 6/5B, Surface of some bone fragments in poor condition; Cracks are frequent, and some fragments have bluish grey (6/5B) discolouration. The overall surface condition is moderate. No pathology was observed.

Dental:

Nine root fragments, mostly broken. All are stained dark bluish grey (spottled).

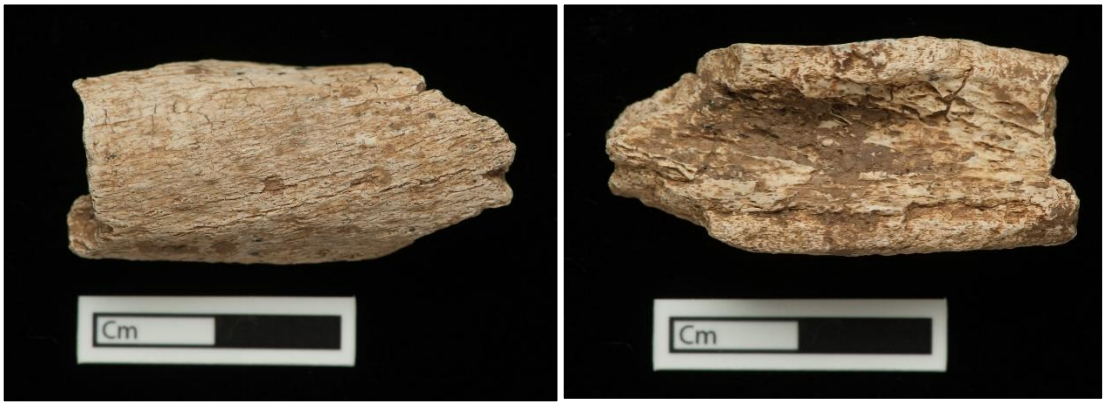


FIGURE 12 - IBL04 274 SAMPLING – CREMATED CORTICAL BONE FRAGMENT (FEMUR/HUMERUS). LEFT IMAGE IS EXTERNAL (PERIOSTEAL), RIGHT IS INTERNAL (ENDOSTEAL) SURFACE.

A.7 OSTEOLOGICAL CATALOGUE B – CLEATHAM, LINCOLNSHIRE

The following catalogue contains the osteological data from this author's analysis of the Cleatham sample. Also contained is a description of the sample types including Sample ID. The results of the analyses are plotted as 87Sr/86Sr vs 1/Sr (ppm) x 1000 (normalised to 40% Ca by weight to account for loss). At the end of each entry, an image of a choice of potential samples is presented, which include the sampled fragments.

Cremation Nr	Cremation	Sample ID			
20	**MT84AM**		**T026**	**T027**	**T028**
			Rib	Cranium	Tibia

Age (KS)	YA	Sex (KS)	M
Age (TL)	YA	Sex (TL)	M

Justification (age)	Dentition, joint surfaces, (sutures)	Justification (sex)	Supramastoid crest; blunt orbital margins

X	4.20
Y	34.30

Ctxt relationships

-

Cranial

Occipital frag (R hypoglossal canal atlas articulation); partial otic capsule in petrous fragment (L); Frontal: superior orbits L+R; L Temporal: sup.aspect of auditory meatus including supramastoid crest (M); L zygomatic process, sup.; c. 99 vault fragments

Dentition

Several tooth roots. Mand incisor worn with rest of enamel

Axial

rib fragments; frag of C1 (L)

Upper Limb

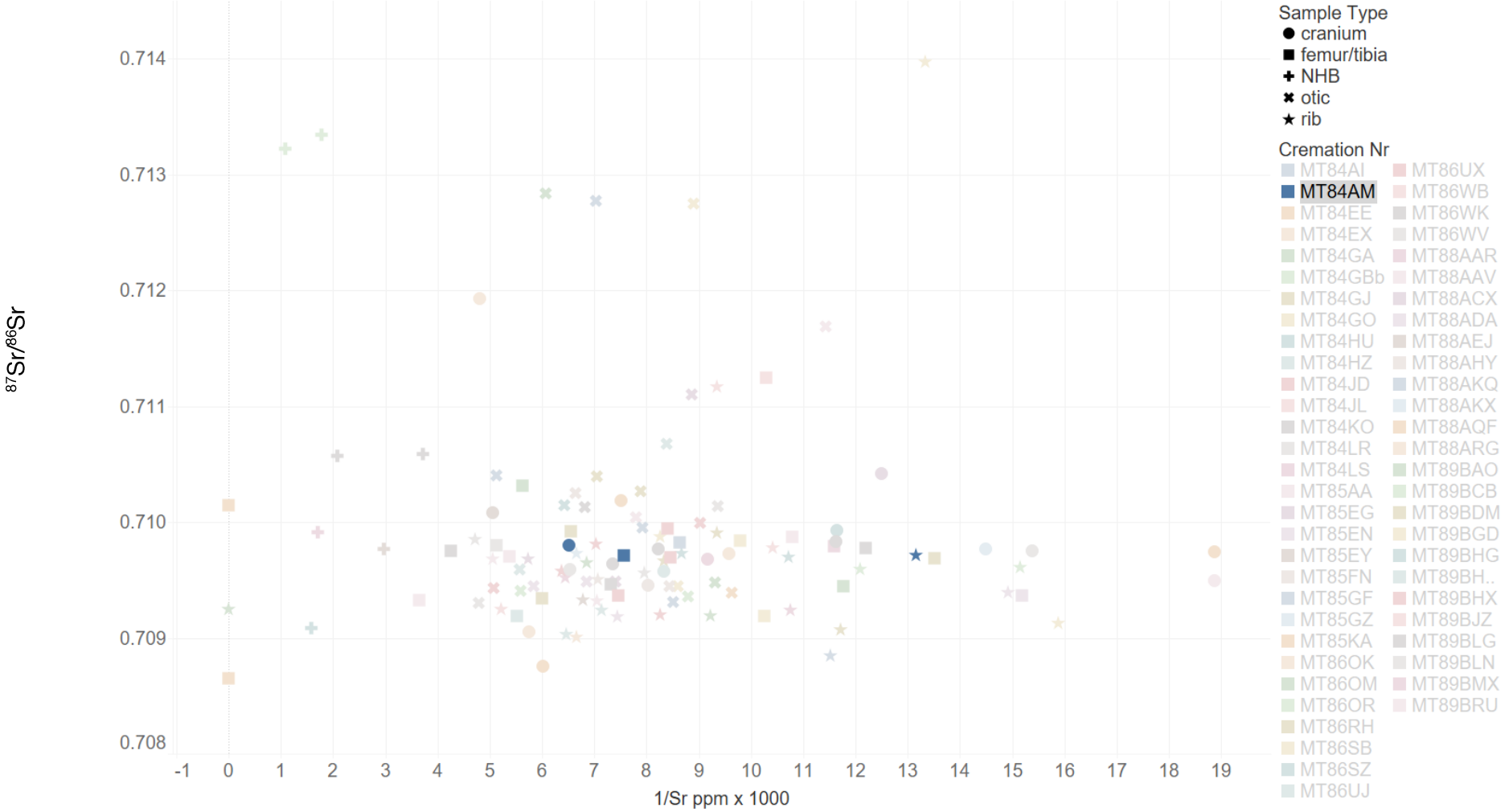
L trochanteric surface humerus; humerus diaphyseal cortical frags

Lower Limb

Tibia fragments ant. Crest; Femoral? Fragments - badly cracked (outside white, internal blackish blue

Pathology

Slight CO in L+R orbits (small foramina) - full extent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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
MT85EG
MT85EN
MT85EY
MT85FN
MT85GF
MT85GZ
MT85KA
MT86OK
MT86OM
MT86OR
MT86RH
MT86SB
MT86SZ
MT86UJ
MT86UX
MT86WB
MT86WK
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 13 – CLEATHAM 20 - RIB, CRANIUM, TIBIA

Cremation Nr	Cremation	Sample ID			
45	**MT84EE**			**T072**	**T075**
				Femur	Cranium

Age (KS)	YA	Sex (KS)	M
Age (TL)	YA	Sex (TL)	M

Justification (age)	Pubic symphysis; joint fusion and surface condition; cranial sutures (estimate); pubic symphysis ageing (I-2/II-1 = c. 18-24) (Suchey Brooks: 18-19 years); (Todd: II-III = 20-26); cranial sutures well defined, mostly unfused -- younger individual;	Justification (sex)	Pubic symphysis

X	29.50	Ctxt relationships	-
Y	88.70		

Cranial	Dentition
Vault fragments c. 48; mandible frags including socets; R mandibular condyle; L mandibular fragment including 3rd molar; R zygomatic bone	-

Axial

R scapula glenoid; L+R pubic symphises fragments; auricular surface fragments; vertebral fragments (arches; c.10 rib frags, unsided; C2 dens and facet

Upper Limb

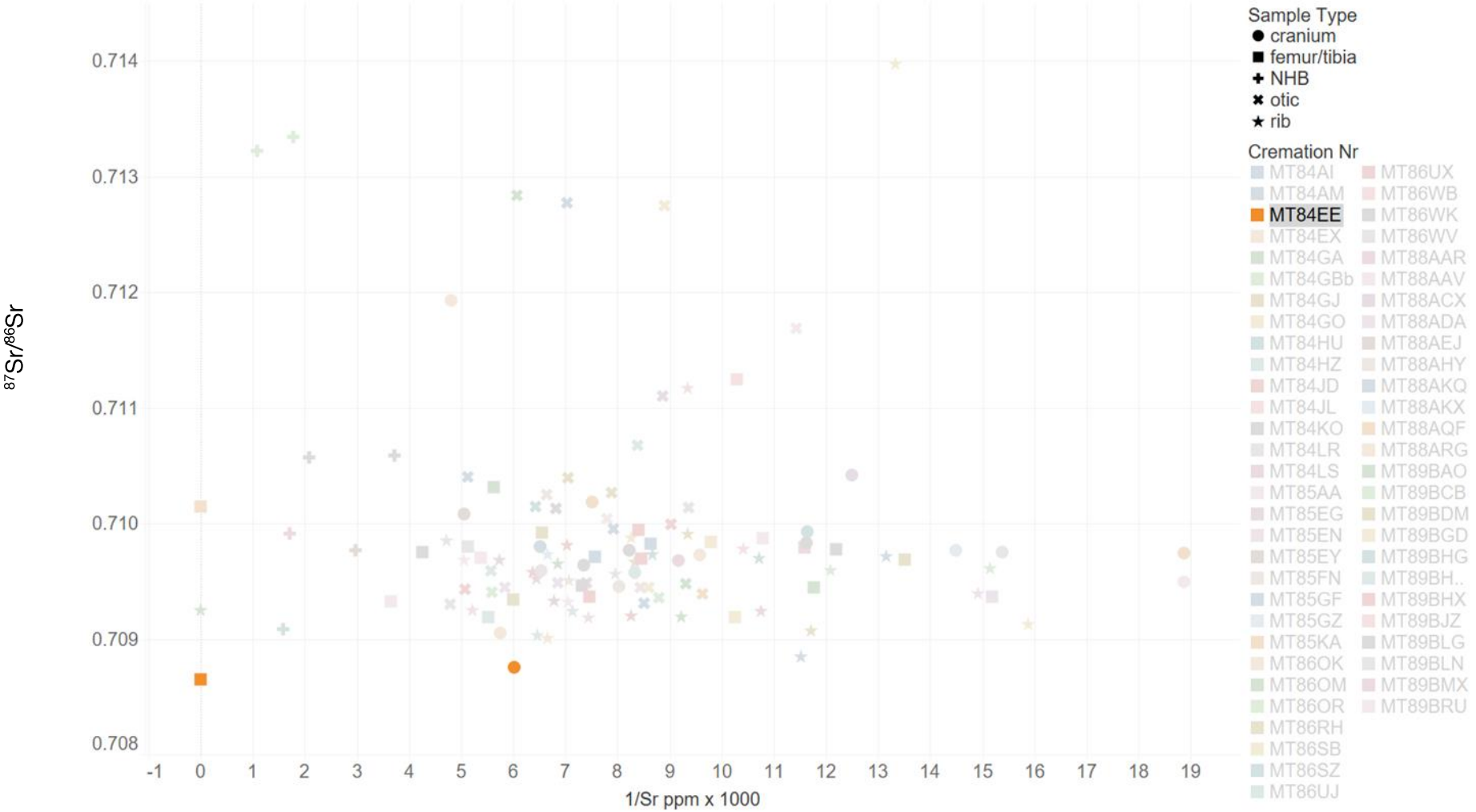
L humeral shaft x3, L+R distal ulnea; 2x radial shaft fragment; L distal humeral joint surface; proximal radius fragment (articulation); int/dist/prox phalanges

Lower Limb

Femur shaft x4 fragments (unsided); Femoral head+ distal posterior joint surface fragment; fibulea shaft frags x4 (unsided); 16 tibiae shaft fragments (2xL); int/dist/prox foot phalanges; R 1st MT (distal joint surface)

Pathology

Joint surfaces look good, no pathology; fine lamellar striations on long bone (transitional?) Diaphyseal fragment - non-active


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
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0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT85EN
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MT89BMX
MT89BRU

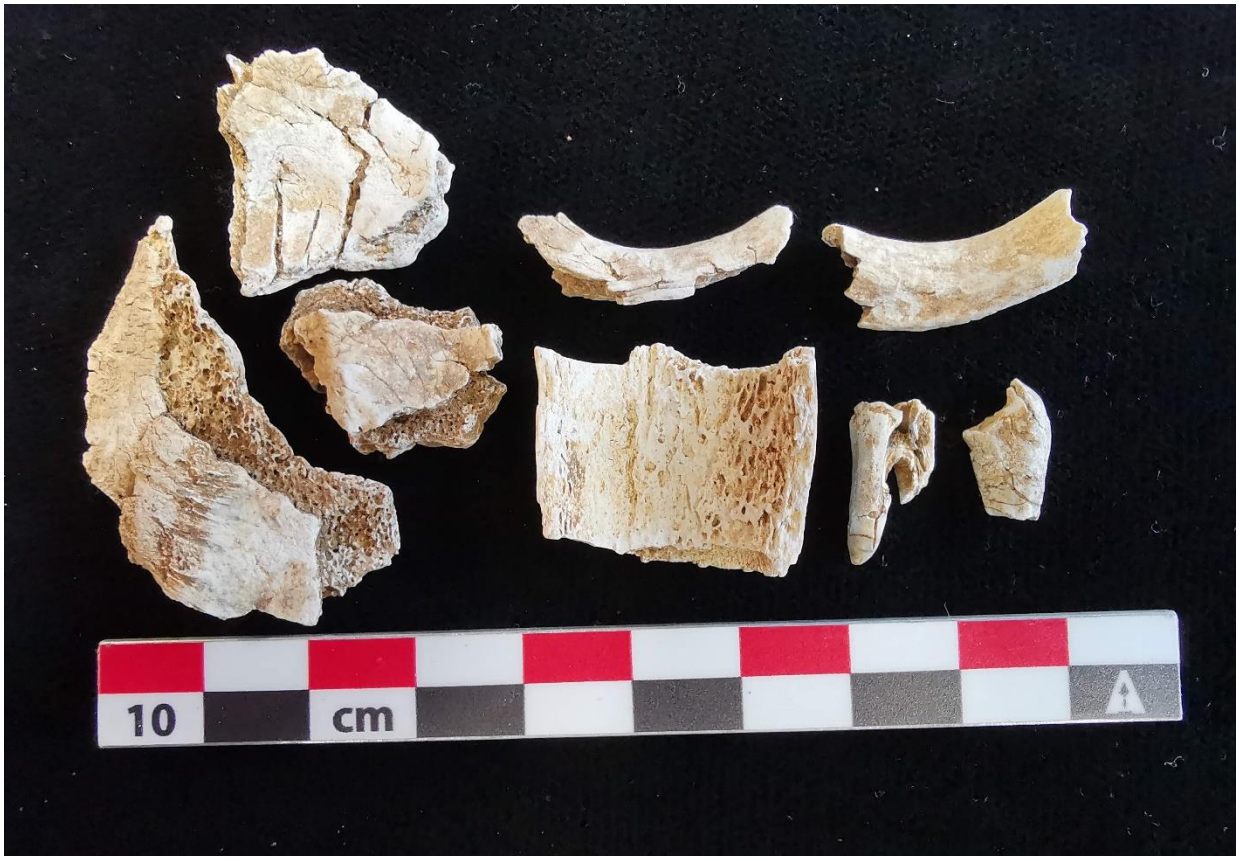


FIGURE 14 – CLEATHAM 45 – FEMUR, CRANIUM

Cremation Nr	Cremation	Sample ID			
63	**MT84HU**		**T069**	**T070**	**T071**
			Rib	Otic	Rib II

Age (KS)	OMA	Sex (KS)	F
Age (TL)	OMA	Sex (TL)	F

Justification (age)	Joint surfaces; auricular surface; cranial surfaces (estimate).	Justification (sex)	Sciatic notch; supraorbital margin; supraorbital ridge; overall size | L+R sup margins: sharp - F; L+R sup ridge: straight - F; sciatic notch: Wide/obtuse - F; 'gracile'

X	29.00
Y	97.10

Ctxt relationships

Urns 63 and 64 were next to each other, touching

Cranial

Vault fragments of occipital, parietal+ frontal c. 39 + smaller; central shenoid fragment with partial body; R zygoma fragment; mandible frag R; PP central frags x2; maxilla frags x2 with li1+li2+lc1+lp1+lp2 sockets

Dentition

Roots of mand. LM1, ?LP1, ?RP2, max. LI1

Axial

R clavicle frag distal half; min. 44 rib shaft fragments; 1st rib neck; lower 11t/12th neck; sciatic notch L; vertebral body fragments x5, Thoracic min x2; partial inferior pubic symphisis R; partial auricular surface; R lumbar superior facet; thoracic partial spinous process x4

Upper Limb

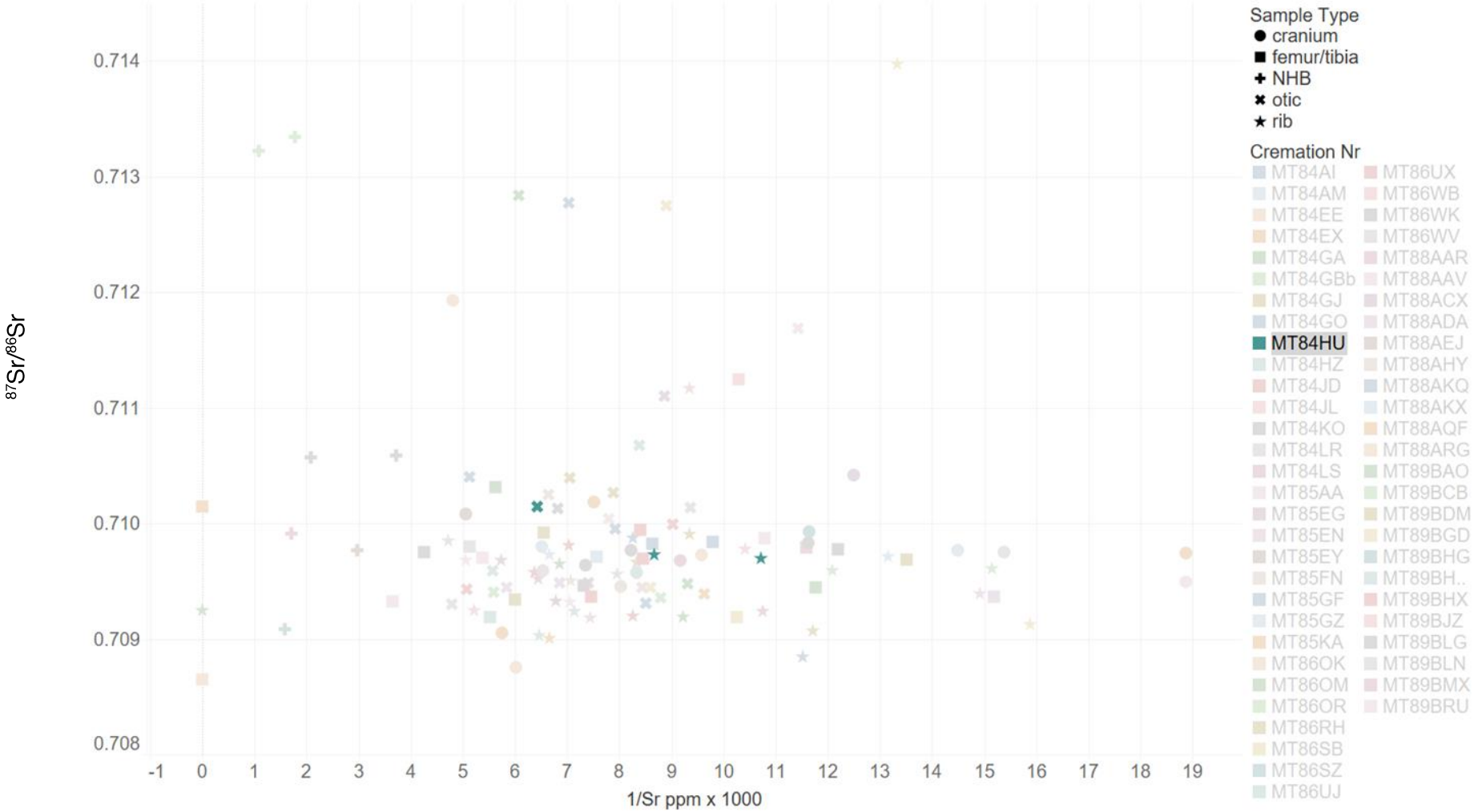
Humeral heads L+R; humeral shaft including deltoid tuberosity L; distal articulation of humerus fragment; L proximal ulna trochanter (surface of olecranon process); 5x distal end ends of interm/prox phalanges; 5x frags of distal phalanges; L+R proximal radii; R lunate and trapezium; R distal radius joint surface

Lower Limb

Partial head of RMT1; heads of 4 mts; tarsal fragments; probable femoral shaft fragments; fibular shaft fragments; probable tibia shaft frags; 5x prox ends of prox phalanges (foot or hand)

Pathology

CO in L orbit - vascular pin-sized holes/foramina - not clearly visible in R orbit; joint surfaces generally healthy looking, but vertebral bodies appear to belong to older adult; porosity in roof of palate.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0.713
0.712
0.711
0.710
0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 15 – CLEATHAM 63 - RIB, OTIC, RIB II

Cremation Nr	Cremation	Sample ID			
71	**MT84GA**			**T033**	**T035**
				Rib	Rib II

Age (KS)	YA	Sex (KS)	F?
Age (TL)	YA?	Sex (TL)	F?

Justification (age)	Open, well-defined cranial sutures; smooth and young-looking joint surfaces, no degenerative joint changes apparent.	Justification (sex)	Thin, smooth, and straight frontal bone; 'gracile'.

X	28.6
Y	85.20

Ctxt relationships

Placed directly on top of urn 242

Cranial

Vault fragments (generic) x49; mandibular fragments: anterior mentum + cortical bone featuring sockets (grey bluish black); PP (fragmented) unsided

Dentition

Maxillary L+R canine roots; several molar roots (incomplete); frag of double root apex = wide -- may be animal?

Axial

C.9 frags of rib shafts; C1 central arch with articular facet for dens; partial pelvis (incl lunate surface)

Upper Limb

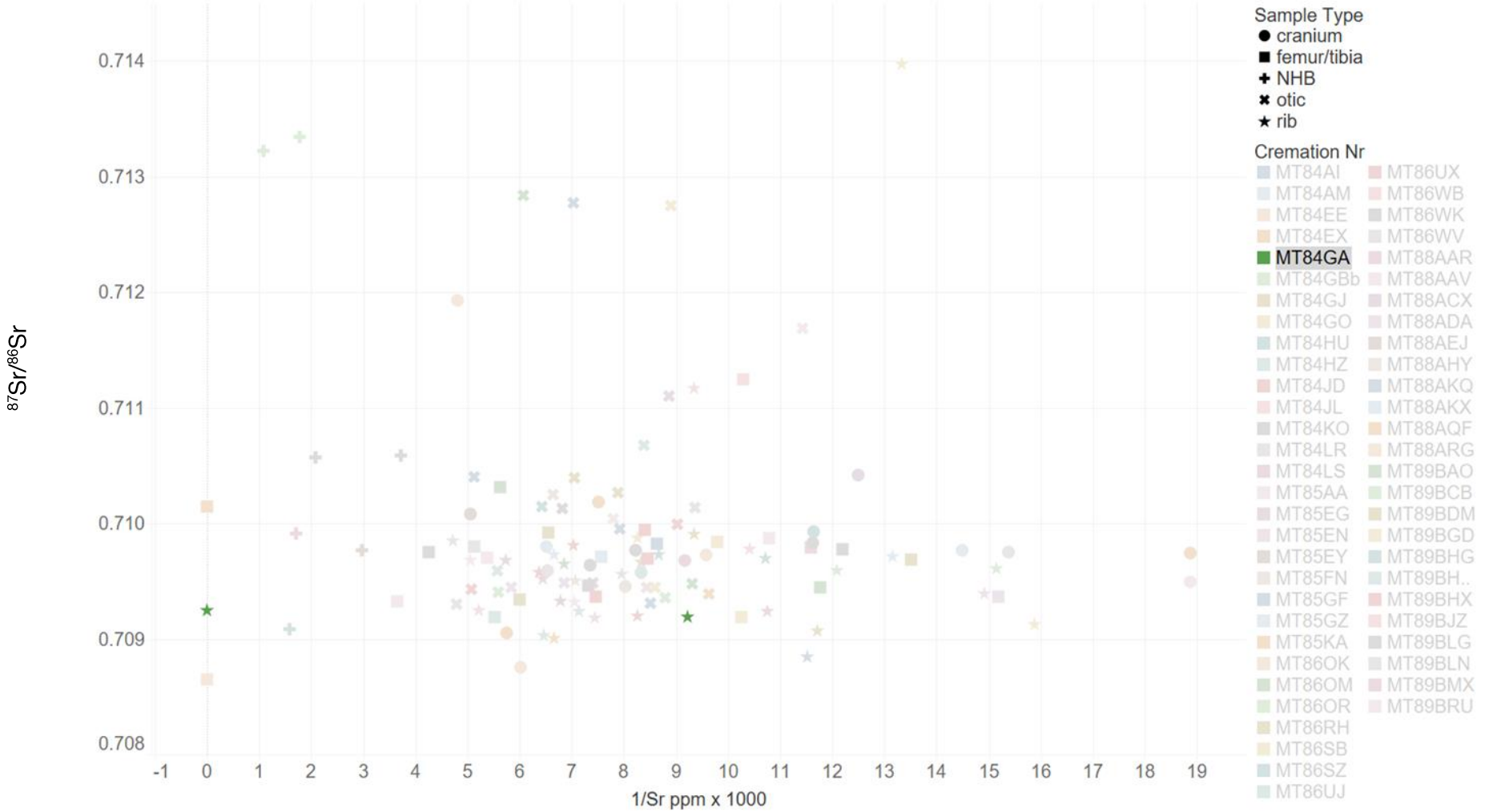
Ulna/fib shaft fragments; prox radius x2; int/prox half of 2 phalanges + 1 fragment of distal articulation; distal 1st/2nd phalanx; proximal ulna fragment

Lower Limb

C.4 tibia shaft fragments; unsided distal 1st MT

Pathology

Poss. Od in distal joint surface of 1st mt; lamellar new bone on internal surface of long bone (humerus?); lamellar structure looks smooth, but porous


$^{87}Sr/^{86}Sr$
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0.713
0.712
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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 16 – CLEATHAM 71 – RIB, RIB II

Cremation Nr	Cremation	Sample ID			
77	**MT84JD**		**T123**	**T124**	**T125**
			Rib	Femur	Otic

Age (KS)	ADO	Sex (KS)	Indeterminate
Age (TL)	ADO?	Sex (TL)	Ind

Justification (age)	Joints appear fused; small size.	Justification (sex)	L supraorbital rim: ?; L supraorbital ridge: F?

X	30.80
Y	83.50

Ctxt relationships

Ivory and CuA amongst remains, Comb fragments and terminal in top layer

Cranial

Vault fragments c.33; anterior mandible incl sockets; L anterior supraorbital rim; PP central fragment

Dentition

3 molar roots; 5x incisor roots including 2 mandibular incisors

Axial

Dens of C2 including joint surface; rib frags

Upper Limb

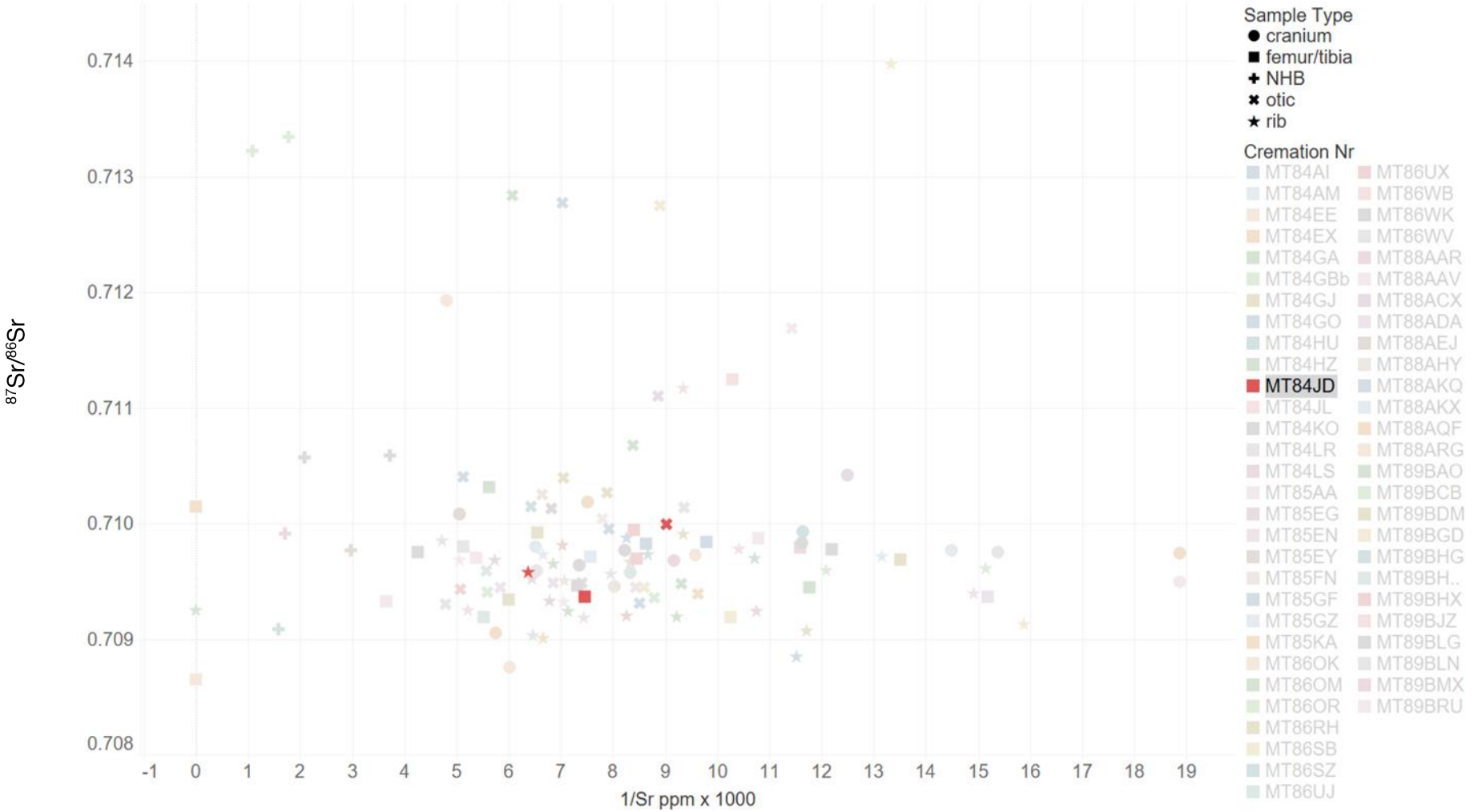
Radius/ulna shft fragments x4

Lower Limb

Tibia fragment with anterior crest; femoral shaft fragments min.6 frags joinable; distal phalanges x2

Pathology

Periosteal reaction on tibia shaft fragment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0.712
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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT89BGD
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MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 17 – CLEATHAM 77 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
84	**MT84GJ**			**T058**	**T059**
				Rib	Femur

Age (KS)	YMA	Sex (KS)	F
Age (TL)	OMA+	Sex (TL)	M?

Justification (age)	Joint surfaces: advanced age degenerative changes; tooth wear appears advanced (incisor including partial enamel worn off).	Justification (sex)	Supra-mastoid crest: M; anterior mandible: damage, ?; Robust individual.

X	29.20
Y	102.00

Ctxt relationships

-

Cranial

Vault fragments c.47; L temporal bone - posterior aspect with supramastoid crest and partial mastoid process; mandible L+R parts including AMTL; PP including otic capsule; L frontal none with supraorbital aspect; several maxilla fragments

Dentition

Several tooth roots. Mand incisor worn with rest of enamel

Axial

L superior articular surface of thoracic vertebra; cervical vertebra L1/3 of body with small superior body + L sup facet; cervical vertebra arch R with sup+ inferior facets +lamina; v samll fragments of ribs

Upper Limb

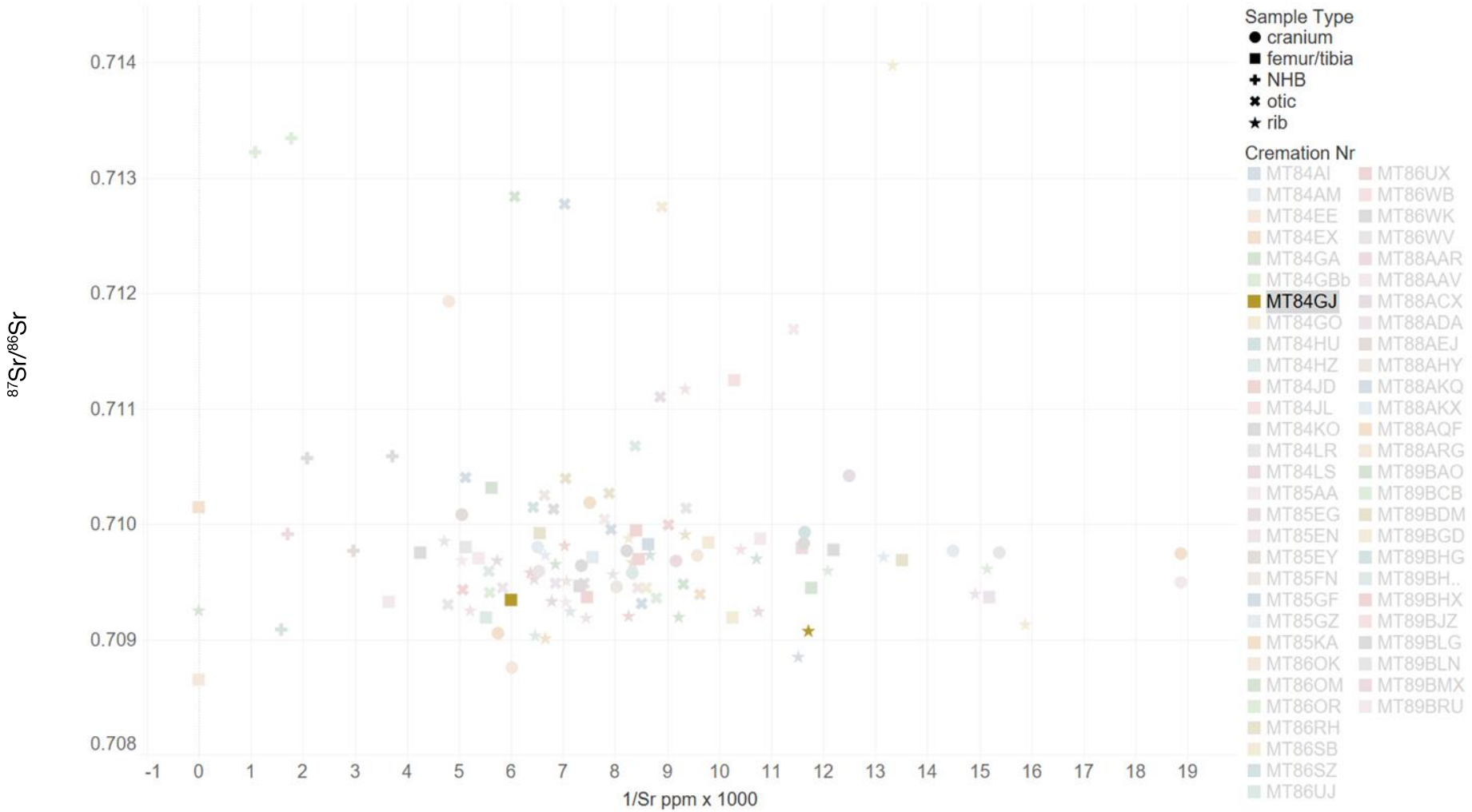
Head of radius; ulna shaft frags; int/prox phalanx shaft frag; radius shaft fragment

Lower Limb

Femoral shaft fragments including linea aspera c.10; tibia shaft frags x7 including anterior crest

Pathology

Entheaseal changes on linea aspera of posterior femur; arachnoid granulations on endocranial surface; L sup facet of thoracic vert: central osteophyte + slight porosity + MO; R cervical facet: MO + CO = porosity; AMTL in R mandible at RM2+3; Periapical abscess/lesion at apex of L mandible (molar area); Dental crowding in anterior mandible - anterior surface turned laterally: RI1+2; also laterally twisted: RC1


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
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0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT84LS
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MT86WB
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MT86WV
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 18 – CLEATHAM 84 – RIB, FEMUR

Cremation Nr	Cremation	Sample ID			
101	**MT84EX**			**T015**	**T016**
				Occipital bone	Rib

Age (KS) YA

Sex (KS) F

Age (TL) YA

Sex (TL) M

Justification (age) Joint condition very good (no degenerative changes); cranial sutures sharp and open; molar root complete (apex closed).

Justification (sex) Supraorbital ridges (M); supraorbital rims (M?); supra-mastoid crest (?).

X 31.90

Y 83.90

Ctxt relationships

-

Cranial

occipital bone frags x2; parietal + temporal squama; sup orbital ridges and rims L+R; L temporal supramastoid crest?; L mandibular condyle; L+R fragmentary PP; vault fragments x90

Dentition

double (fused) molar root (max/mand?); incisor? single root

Axial

vertebral frags including sup articular facet R (cervical); vertebral frag lamina (thoracic/L?); 1 rib fragment (shaft)

Upper Limb

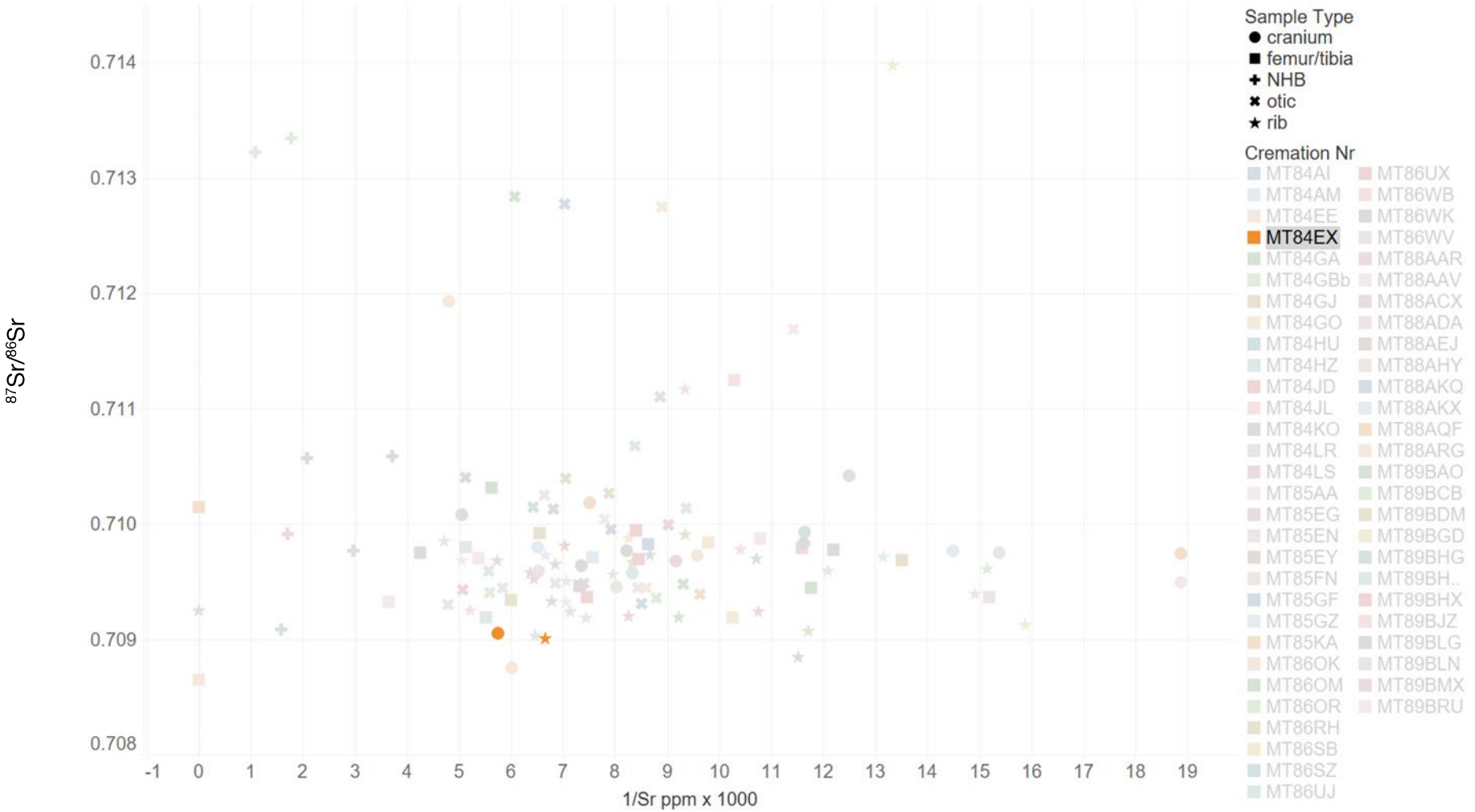
ulna/radius shaft fragments; phalanges x3 (interm or prox); distal phalanges x2; humeral shaft frags; distal radius articular surface; distal humerus articular surface fragments x2; MT x2 shafts (5th+ 2nd?3rd?)

Lower Limb

phalanx (int/prox); tibia frags (anterior crest); fibular frags shaft

Pathology

slight porosity on endocranial surface of internal occipital crest; (NMT) metopic suture retained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0.712
0.711
0.710
0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
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MT84EE
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MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT85EN
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MT88ARG
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 19 – CLEATHAM 101 – OCCIPITAL BONE, RIB

Cremation Nr	Cremation	Sample ID			
131	**MT84HZ**			**T098**	**T099**
				Rib	Otic

Age (KS)	YA	Sex (KS)	F
Age (TL)	YMA	Sex (TL)	F?

Justification (age)	Joints completely fused were present; cranial sutures closed.	Justification (sex)	External occipital protuberance (F); 'gracile' (F?).

X	32.20	Ctxt relationships	Found next to Urn 130
Y	84.10		

Cranial	Dentition
vault frags x25; occipital frag with external protruberance; zygoma L+R superior portion; PP central fragment	-

Axial

C1 atlas R facets (partial); rib shaft frag; dens of C2

Upper Limb

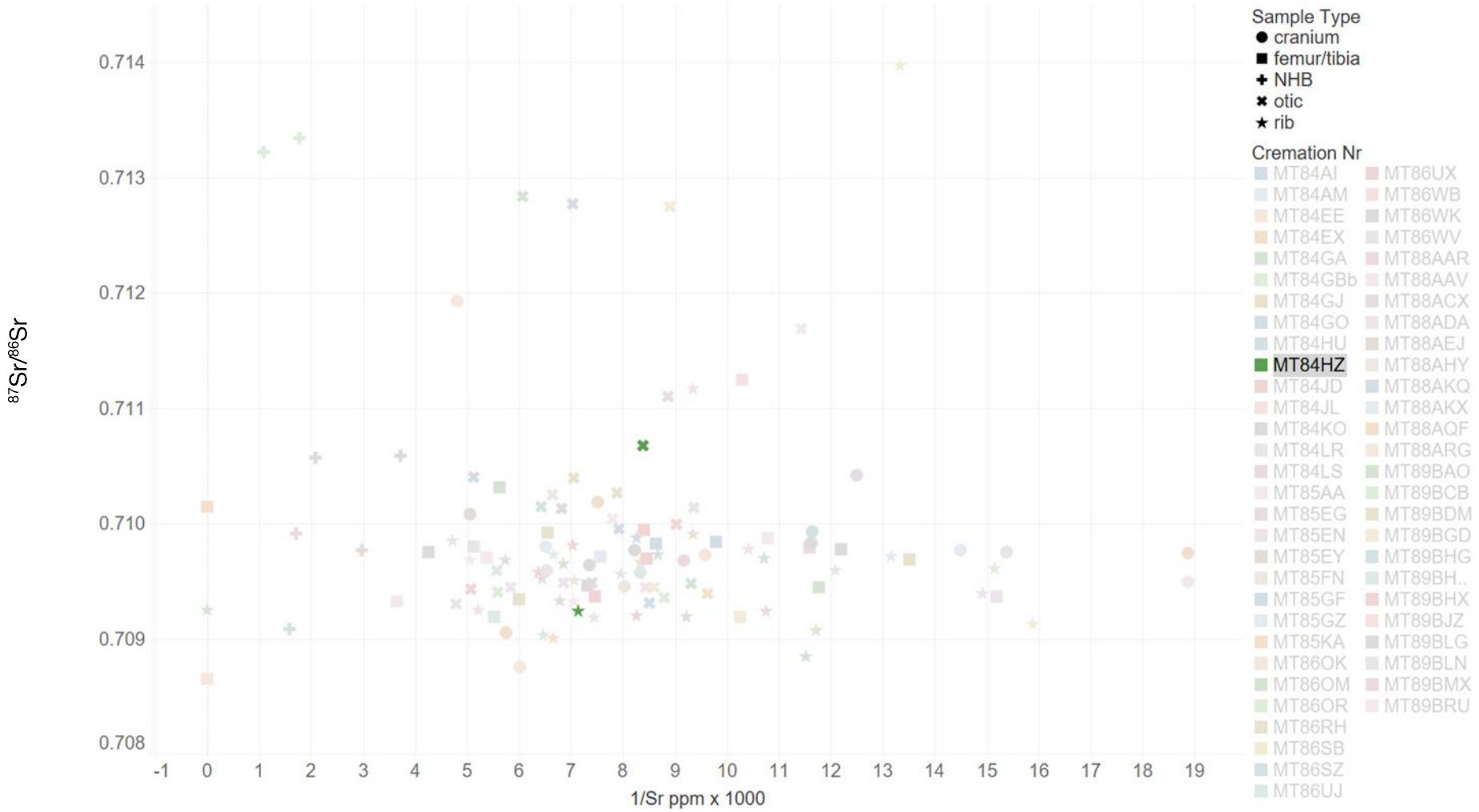
Humeral distal shaft fragment L;

Lower Limb

femoral shaft fragments - large cracks

Pathology

None observed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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT85EN
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 20 – CLEATHAM 131 – RIB, OTIC

Cremation Nr	Cremation	Sample Id			
158a	**MT84LR**				**T137**
					Lateral left frontal

Age (KS)	YA	Sex (KS)	M?
Age (TL)	YA	Sex (TL)	M?

Justification (age)	Cranial suture well defined and clear (sharp, open); epiphyseal fusion: adult; younger individual.	Justification (sex)	Zygomatic bone L is very wide (M); L supraorbital rim is sharp (F?);

X	25.60
Y	103.10

Ctxt relationships

-

Cranial

vault frags ca x20; lateral L frontal with sup orbit; L zygoma (superior aspect); internal mandibular cortex with sockets; PP central fragment

Dentition

-

Axial

-

Upper Limb

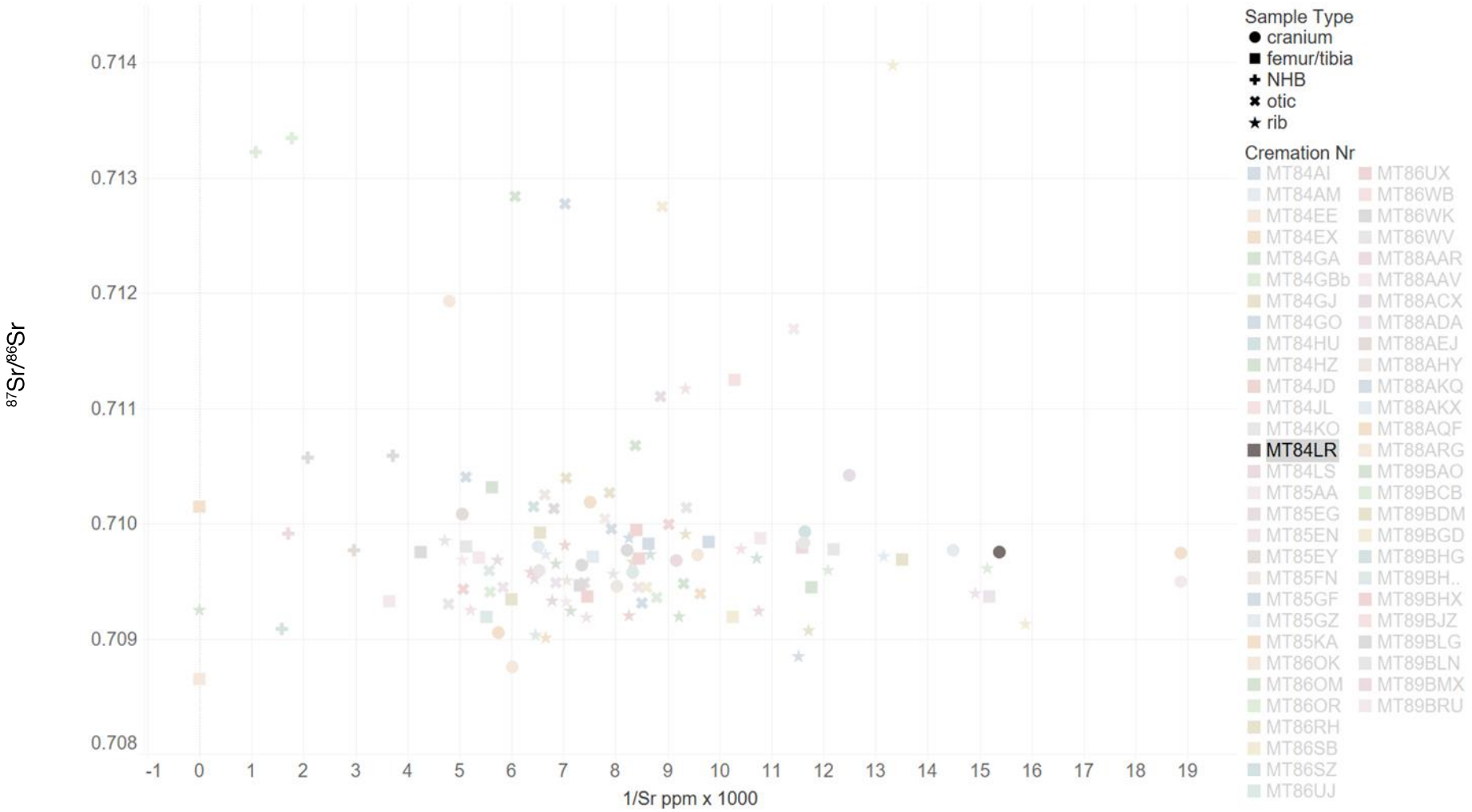
intermediate/proximal phalanx (distal); lunate? (DBG)

Lower Limb

intermediate cuneiform L foot

Pathology

None observed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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
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MT89BMX
MT89BRU

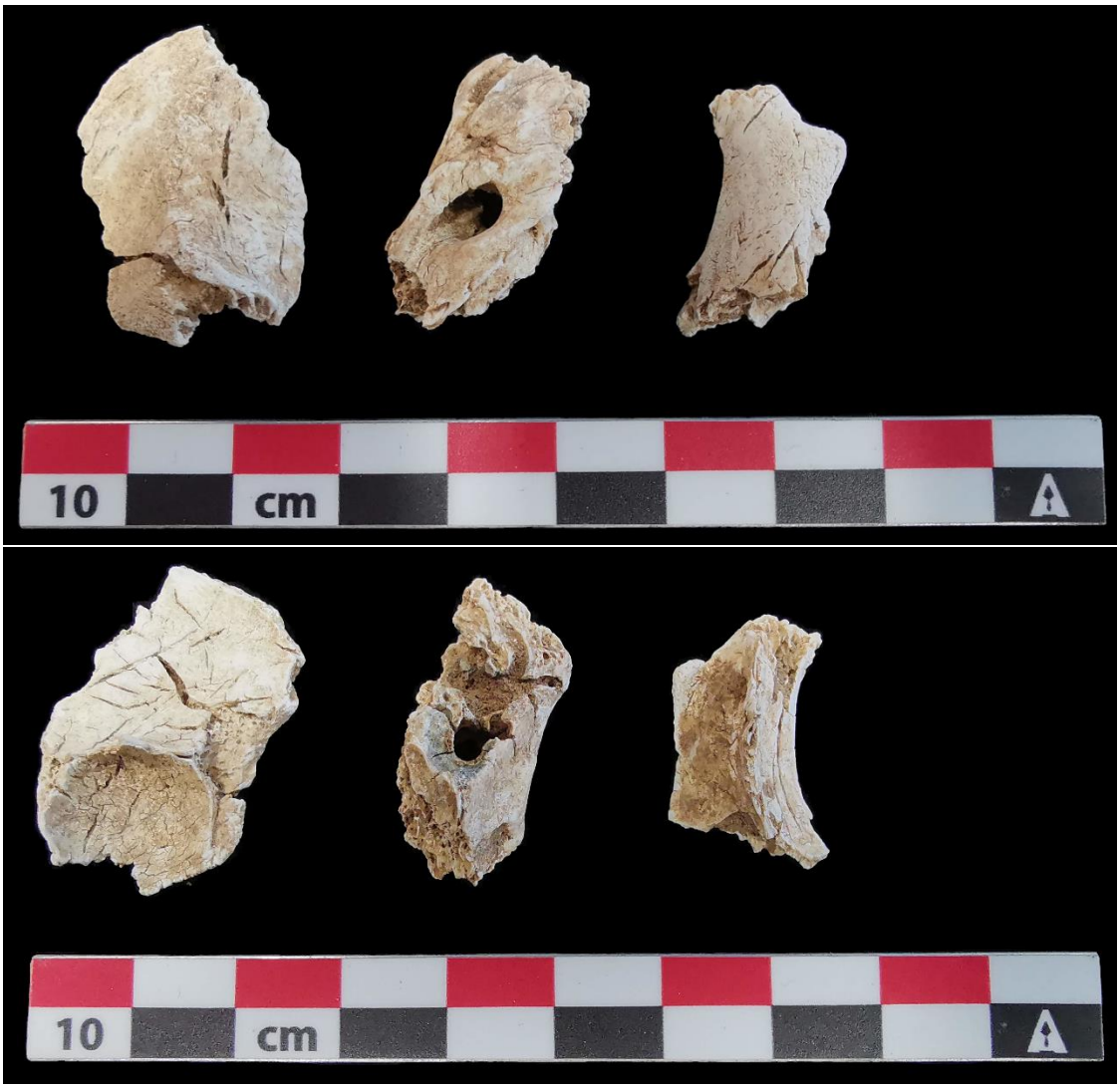


FIGURE 21 – CLEATHAM 158A – LATERAL LEFT FRANTAL BONE

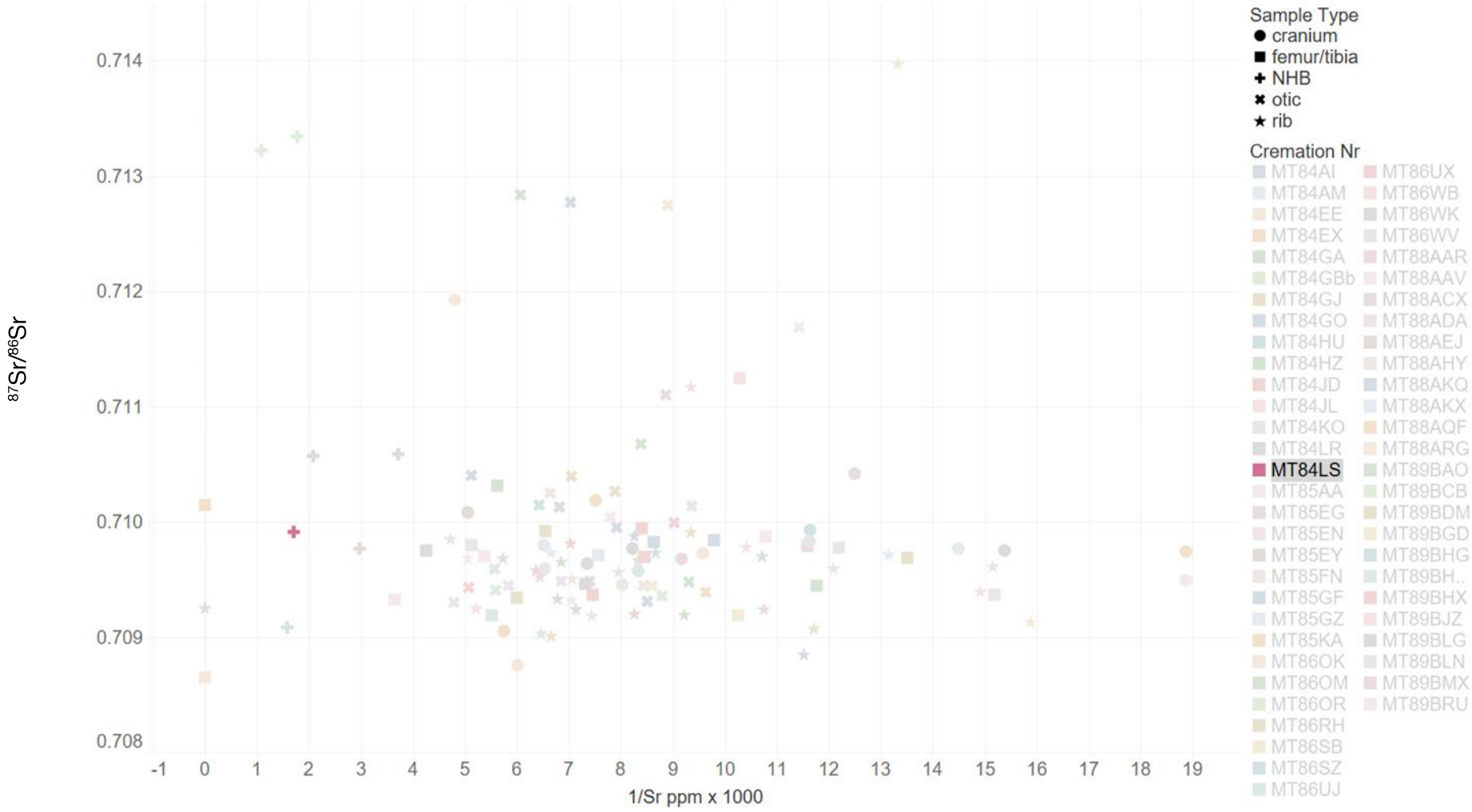
Cremation Nr	Cremation	Sample ID			
158b	**MT84LS**				**T147**
					Sesamoid HORSE

X 25.60

Y 103.10

Ctxt relationships

This urn was placed directly below 158 (MT84LR)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0.712
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
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MT89BDM
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MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 22 – CLEATHAM 158B – SESAMOID HORSE

Cremation Nr	Cremation	Sample ID			
168a+b	**MT84AI**			**T151**	**T152**
				Otic	Otic

Age (KS)	subadult	Sex (KS)	-
Age (TL)	Adult	Sex (TL)	F?

Justification (age)	Observable joints are all completely fused.	Justification (sex)	Sciatic notch (F?).

X	30.30	Ctxt relationships	1 of group of urns: 168, 170, 172, 173, 174 (likely contemporary)
Y	102.90		

Cranial	Dentition
vault frags x50; R zygoma; mastoid process; anterior mandible + internal surface; R mandibular condyle; PP x2 central parts (+ x2 extra); occipital bone	-

Axial

x5 rib shaft fragments; sciatic notch (L+R+ extra?); pubic symphisis R? older individual; R os coxa: sup lunate surface of scromion/ ischium +inferior lunate; C2 body + dens, no surface

Upper Limb

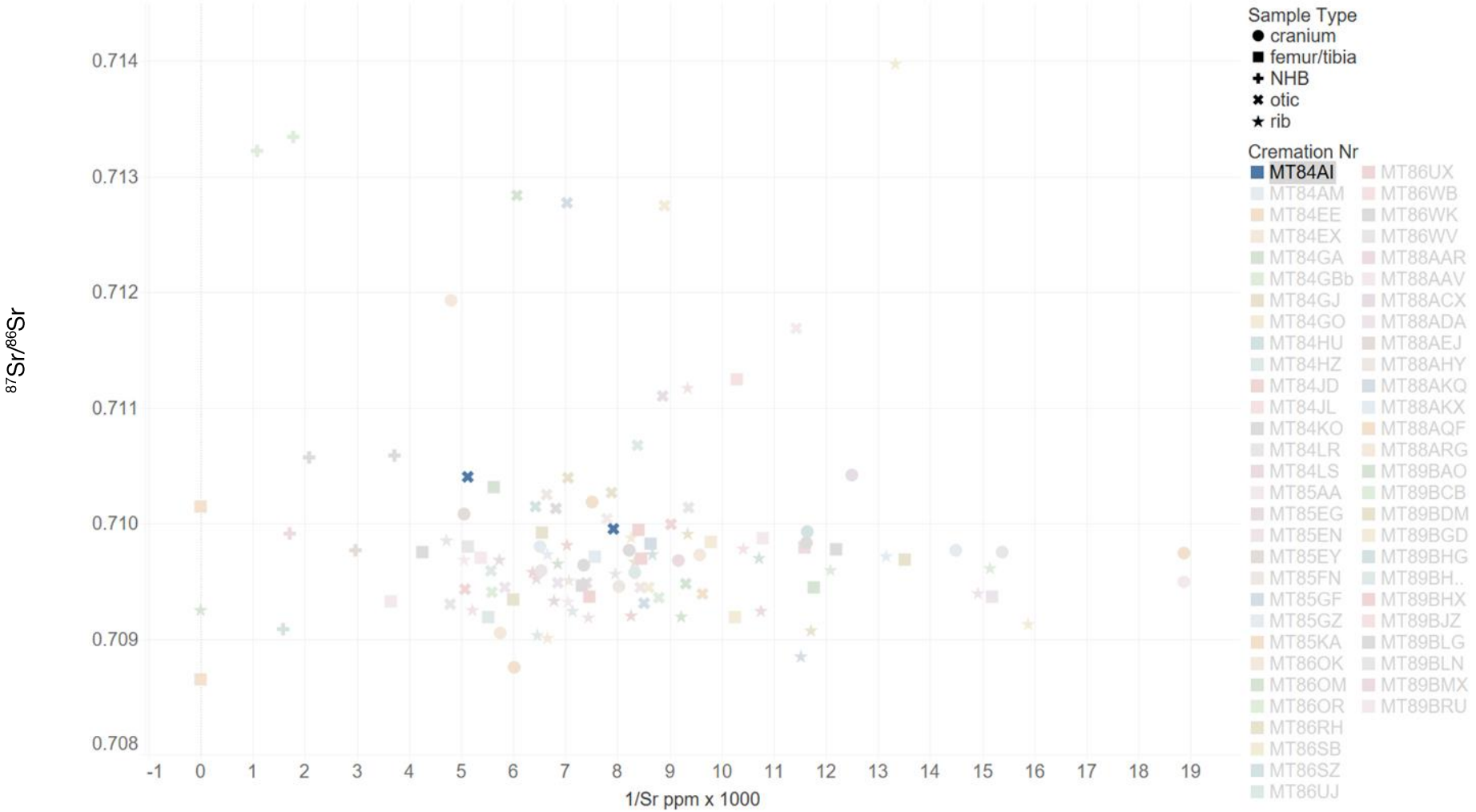
prox radial shaft +radial protubreance; ulna frags shaft; radial shaft frags; humeral shaft frags; x2 distal phalanges; x5 prox/interm phalanges

Lower Limb

Tali L+R; distal fibula R; distal tibia (joint w. malleolus joint surface; prox femur with neck L; distal joint femur 1/2; patella x2 (L+R? - looks like same person); femoral shaft frags; tibial shaft frags; prox. Phalanx (hand or foot)

Pathology

entheseal changes on both patellae; remodelled periosteal bone on femur +foot phalanx diaphysis - ulceration? / non-specific infection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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
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MT84EE
MT84EX
MT84GA
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MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT89BRU

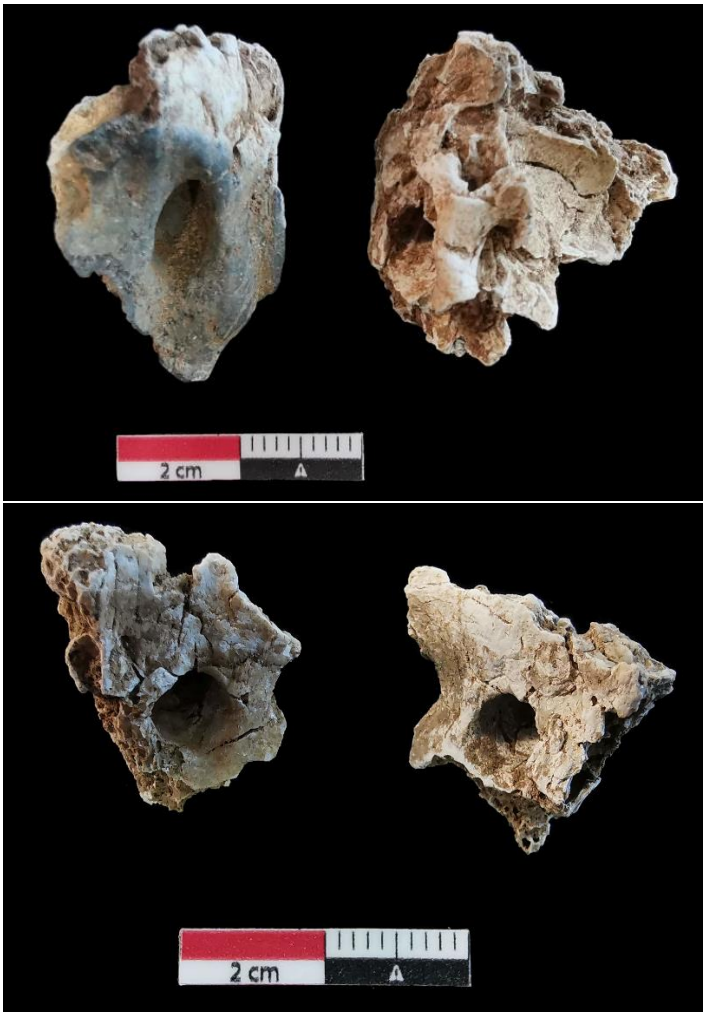


FIGURE 23 – CLEATHAM 168A+B – OTIC

Cremation Nr	Cremation	Sample ID			
176	**MT84GO**		**T050**	**T051**	**T052**
			Rib	Femur	Otic

Age (KS)	YMA	Sex (KS)	F?
Age (TL)	YMA	Sex (TL)	F?

Justification (age)	Joint surface condition very good; slight marginal osteophytes (MO) on dens of C2; no ante mortem tooth loss (AMTL) apparent.	Justification (sex)	Gonial flare (F); angle (F); narrow ramus; gracile mandible.

X	30.20
Y	93.70

Ctxt relationships

-

Cranial

L+R central PP incl. otic; cranial vault frags x41 at least; zygomatic frags including lateral orbit; L maxilla frag incl sockets for LI1+ LI2 + LC1; zygoma R; mandible R + anterior fragment

Dentition

9 single root frags; at least 5 molar root frags

Axial

cervical body L 1/2; scapula distal edge of blade; pelvis illium frags; rib frags x4, 2x including joint surface for vert transverse process; vertebral frags C1: sup and inf joint surfaces; C2: incl dens + R+L superior joint surface; body of thoracic, lumbar L+R with laminae posterior arch thoracic; + 2x spinous processes (at least 1 thoracic)

Upper Limb

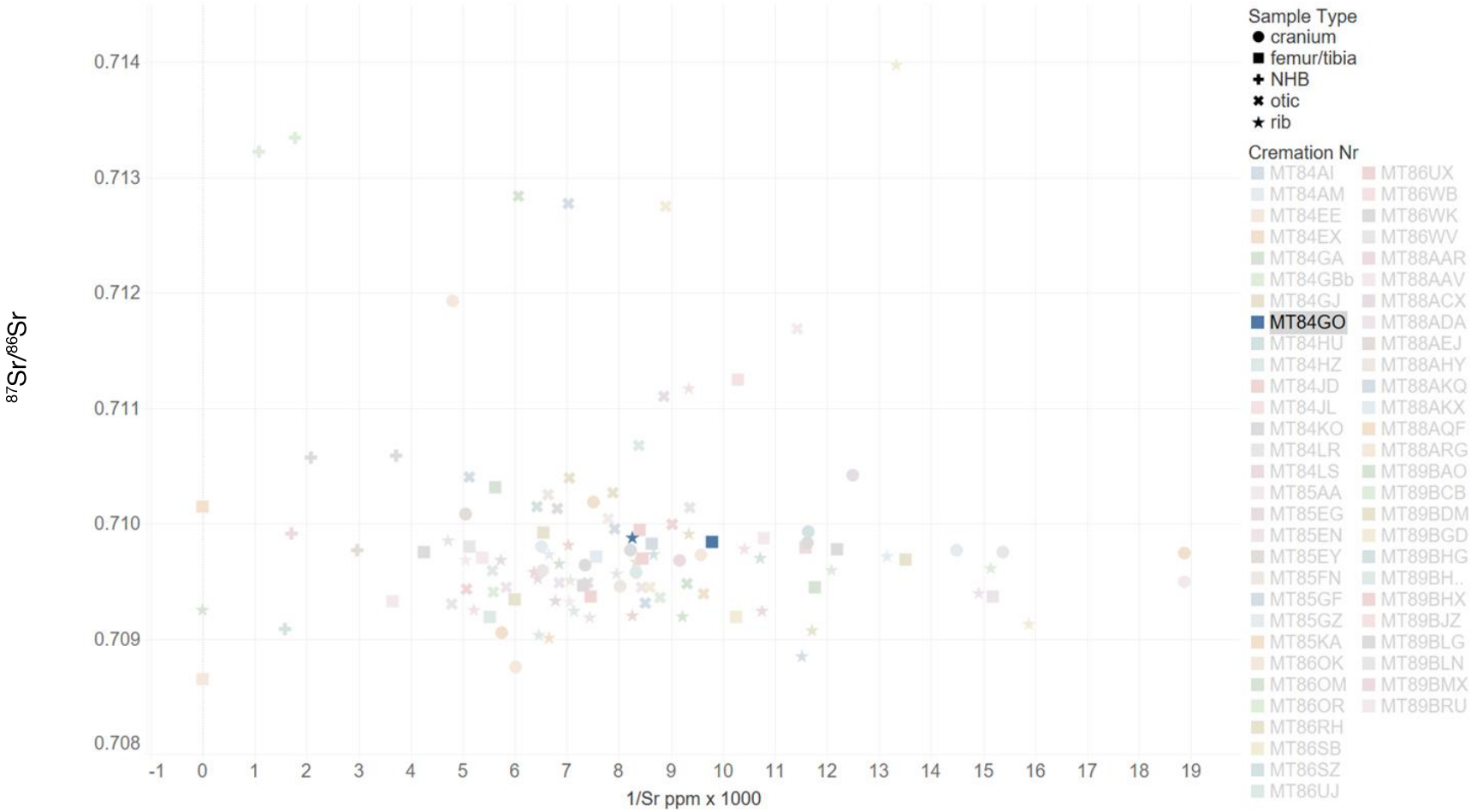
proximal radial joint surface; humeral heads x2 (L+R); ulnae, prox shaft x2 (L+R); ulna shaft frags ; radial shaft frags; humeral shaft frags; carpals: capitate; lunate?; triquetral; ulna prox joint surface; L distal 1st phalanx (feet?); 3 distal phalanges (at least 1 foot); 3x prox phalanges; distal humerus L

Lower Limb

femur frags x2; prox joint surface tibia; distal femur partial joint surface; tibia shaft fragment - crest?; prox femur head including fovea L+R; distal fibula joint surface; patella R; talus fragment joint; fibula shaft (4 joinable frags)

Pathology

slight striations on femoral shaft cortex, non- active; also on tibia shaft; dens of C2 with slight MO around joint surface; periodontal disease mand RM2+3 location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1/Sr ppm x 1000
Sample Type
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femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 24 - CLEATHAM 176 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
210	**MT84KO**			**T135**	**T136**
				Occipital	Femur

Age (KS)	YA	Sex (KS)	F?
Age (TL)	Adult	Sex (TL)	F?

Justification (age)	Only 1/2 of joint surfaces present. Age cannot be closer determined than Adult.	Justification (sex)	Occipital protuberance external; orbital rim.

X	31.90
Y	95.50

Ctxt relationships

-

Cranial

vault frags c. x29; lateral R orbit and ridge/rim of frontal (F?); R zygoma superior; occipital bone (F?/Ind)

Dentition

-

Axial

vertebral fragment joint surface of body = good condition

Upper Limb

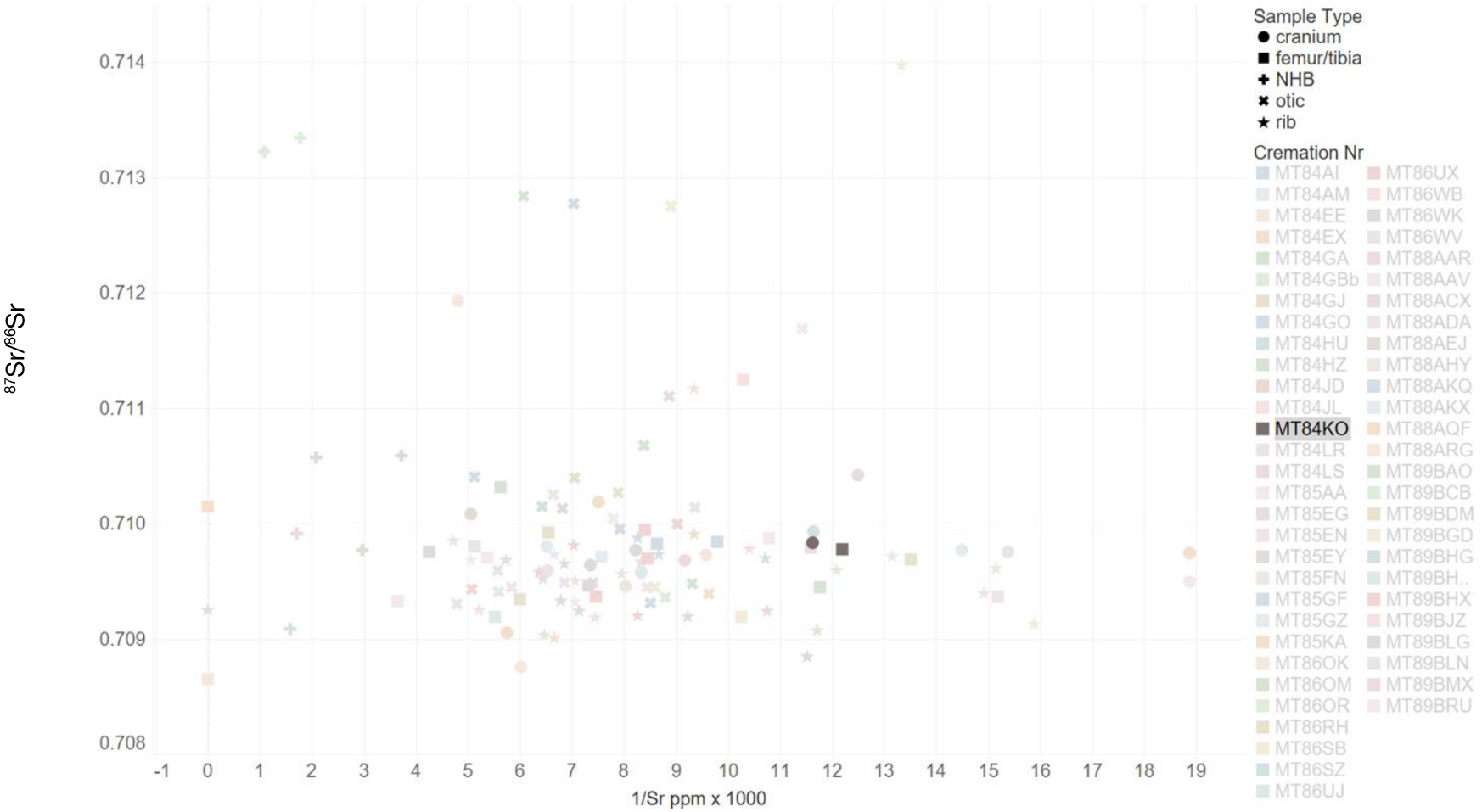
-

Lower Limb

-

Pathology

None observed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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
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MT84AM
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MT84GBb
MT84GJ
MT84GO
MT84HU
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MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 25 – CLEATHAM 210 – OCCIPITAL, FEMUR

Cremation Nr	Cremation	Sample ID			
219	**MT84JL**			**T135**	**T136**
				Occipital	Femur

Age (KS)	YMA	Sex (KS)	F
Age (TL)	OMA	Sex (TL)	F

Justification (age)	Older than YMA based on heavy tooth wear.	Justification (sex)	Very gracile individual; sharp supraorbital rims.

X	30.20
Y	99.20

Ctxt relationships

-

Cranial

vault frags x44; roots and some enamel present; R mand condyle; frontal bone incl lateral orbits L+R; R zygoma (superior aspect); R zygomatic process of temporal bone

Dentition

max RM1 (enamel); max M3 (intact, little wear)

Axial

dens of C2; R cervical vertebra superior facet

Upper Limb

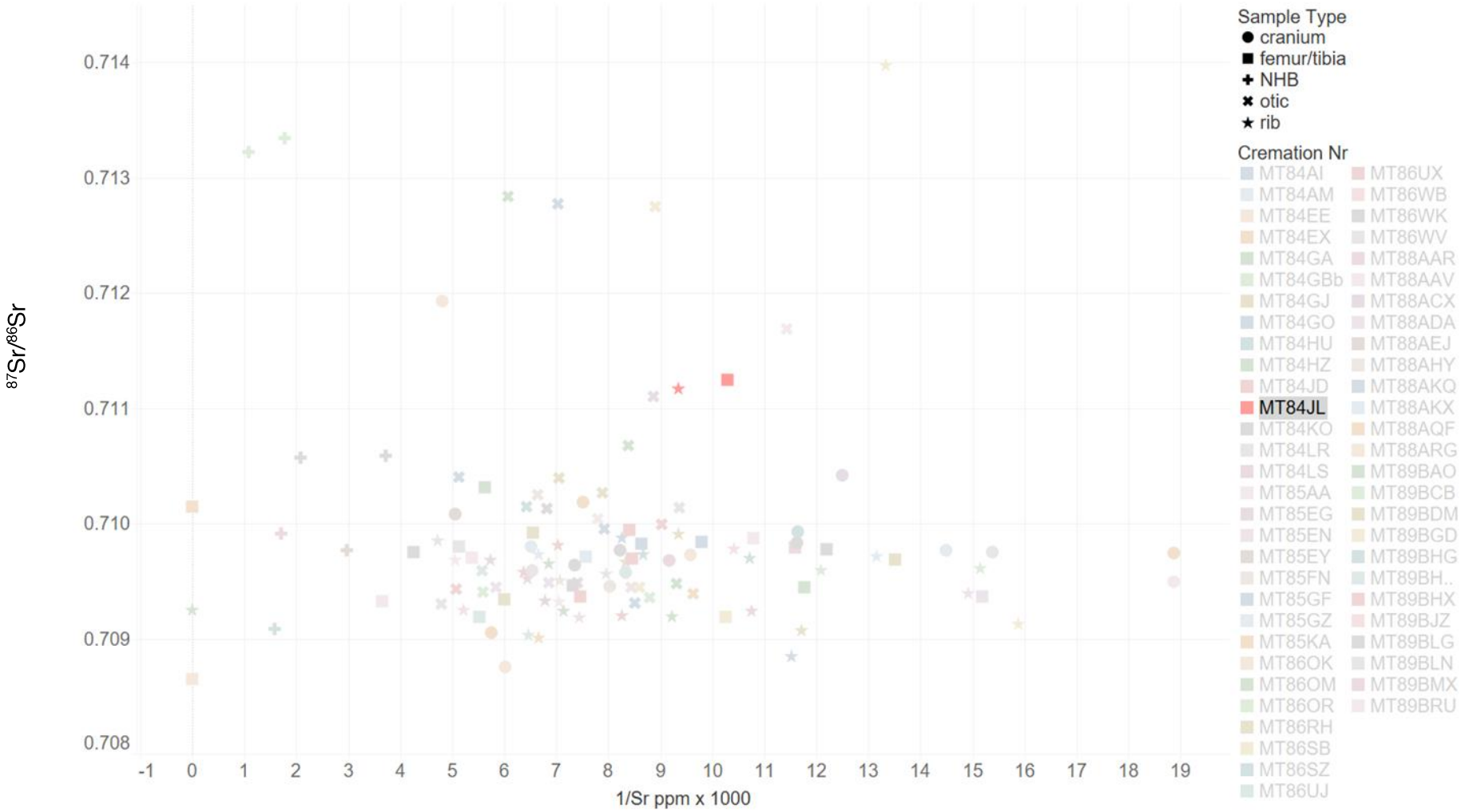
prox/int phalanges; humeral shaft frags; radial shaft frags

Lower Limb

patella L; tibiae (anterior crest frags); femoral shaft fragments including linea aspera

Pathology

porosity on endocranial surface of occipital bone - on internal occipital crest approx centre; heavy dental wear on max RM1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1/Sr ppm x 1000
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femur/tibia
NHB
otic
rib
Cremation Nr
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MT84GO
MT84HU
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MT89BLN
MT89BMX
MT89BRU

FIGURE 26 – CLEATHAM 219 – OCCIPITAL, FEMUR

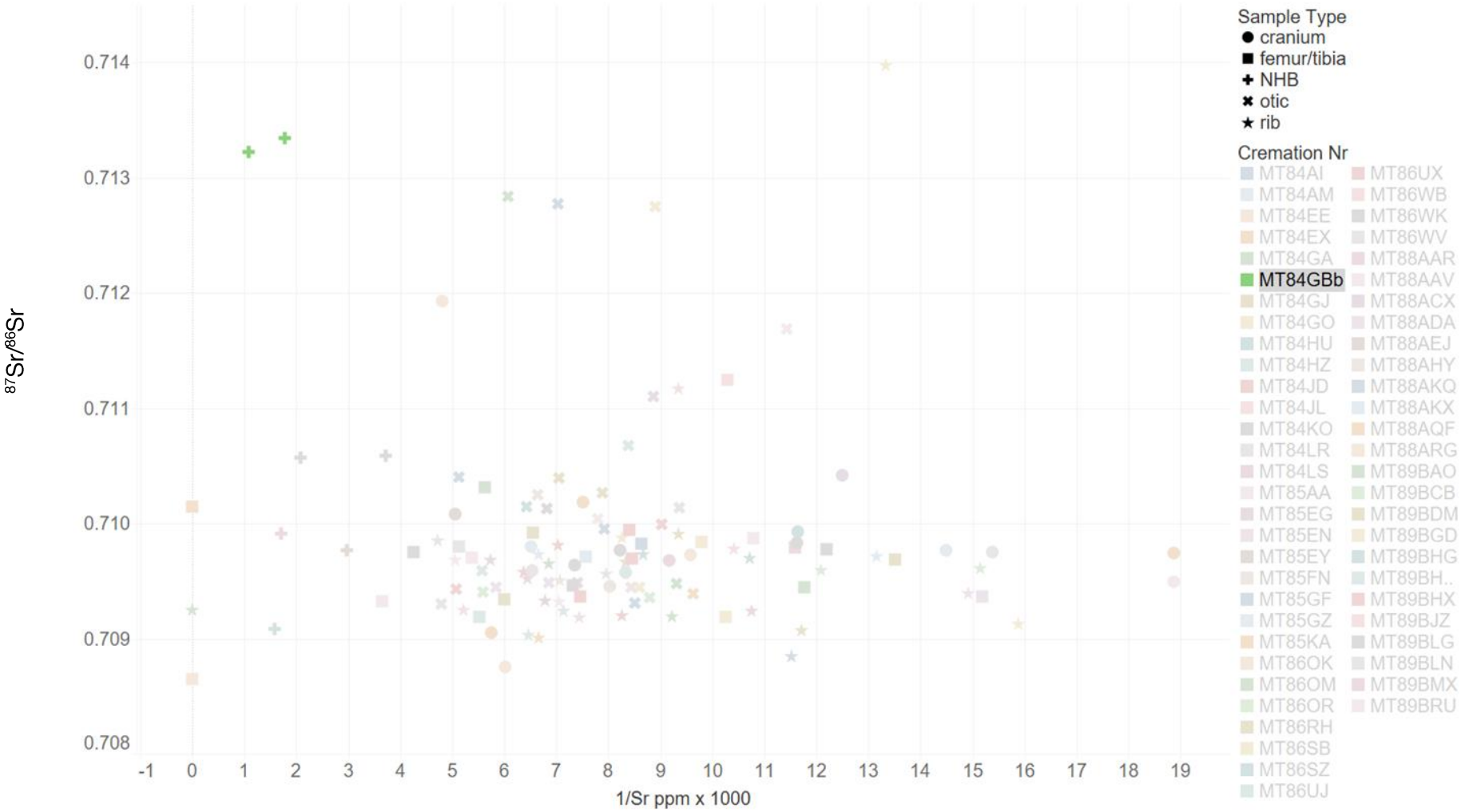
Cremation Nr	Cremation	Sample ID			
242	**MT84GBb**			**T046**	**T148**
				Cranium HORSE?	Sesamoid HORSE

X 28.60

Y 85.30

Ctxt relationships

Urn 71 wasplaced on top of 242 (directly)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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT84JD
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MT88AKQ
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MT88ARG
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 27 – CLEATHAM 242 – CRANIUM, SESAMOID HORSE

Cremation Nr	Cremation	Sample ID			
262	**MT85AA**		**T117**	**T118**	**T119**
			Femur	Occipital	Otic

Age (KS) YA

Sex (KS) F

Age (TL) YA?

Sex (TL) F?

Justification (age) Molar roots complete; sutures sharp and clear.

Justification (sex) Right orbital rim + absent supraorbital ridge; 'gracile'; zygoma small; external occipital protuberance.

X 32.50

Y 99.20

Ctxt relationships

Urn 1178 sherds above this urn

Cranial

R orbit (frontal zygomatic); L lat frontal; max with sockets for RP1+2 + RM1; some sockets on L side; small mand fragment with 1/2 of sockets; PP central with otic intact L; frags of temporal bone with sutures; L zygomatic process of temporal; vault fragments x61

Dentition

x2 single roots (incisors?); molar roots x2 +2 frags

Axial

pelvis cortex fragments; dens of C2

Upper Limb

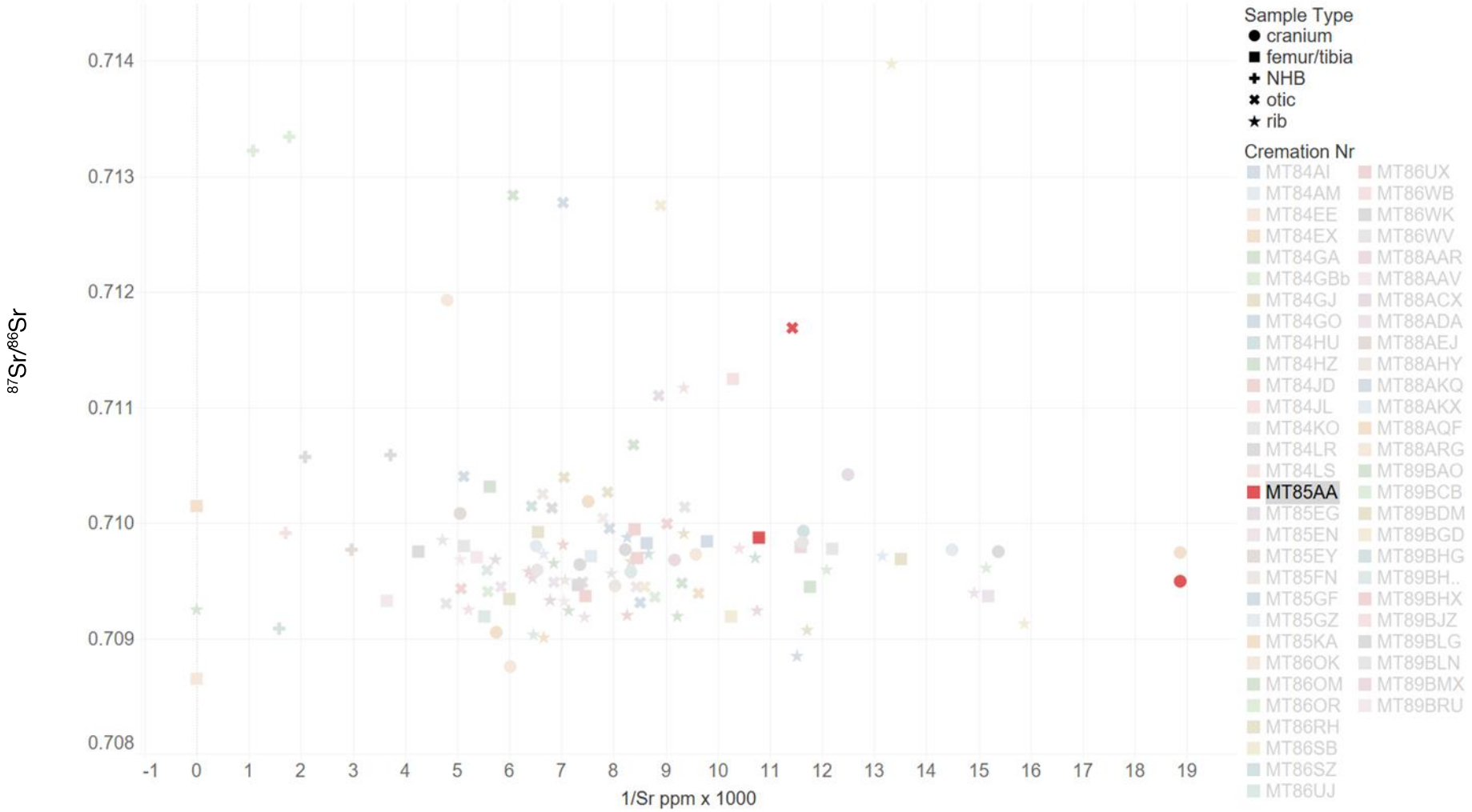
L+R distal humerus - partial epiphysis with trochanteric fossa; int/prox phalanges c.3; distal phalanges x2/3; ulna and radius fragments (shaft); phalanges with entheseal changes on inferior edges of phalanges?

Lower Limb

femoral shaft frags x7; tibiae shaft frags 3+; talus fragments

Pathology

-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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
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MT84AM
MT84EE
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MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 28 – CLEATHAM 262 – FEMUR, OCCIPITAL, OTIC

Cremation Nr	Cremation	Sample ID			
293	**MT85EG**			**T100**	**T101**
				Occipital	Otic

Age (KS)	YMA	Sex (KS)	F
Age (TL)	YMA	Sex (TL)	F?

Justification (age)	Osteoarthritis (OA) of femoral joints – eburnation present; entheseal changes; joint surfaces generally ok, but vertebral bodies + proximal ulna appear older (possibly older	Justification (sex)	Pubic symphysis.

X	33.30
Y	88.50

Ctxt relationships

-

Cranial

R PP central incl otic; Maxilla L with sockets and lateral sinus; occipital bone (porosity on endocranial surface; partial frontal bone with orbital rim (L?); L mandibular condyle; x36 cranial vault fragments

Dentition

-

Axial

R scapula coronoid process partial; pelvis: os coxa L superior portion of lunate surface acromion; vertebral bodies with MO; pubic symphysis L inferior; superior vertebral surfaces

Upper Limb

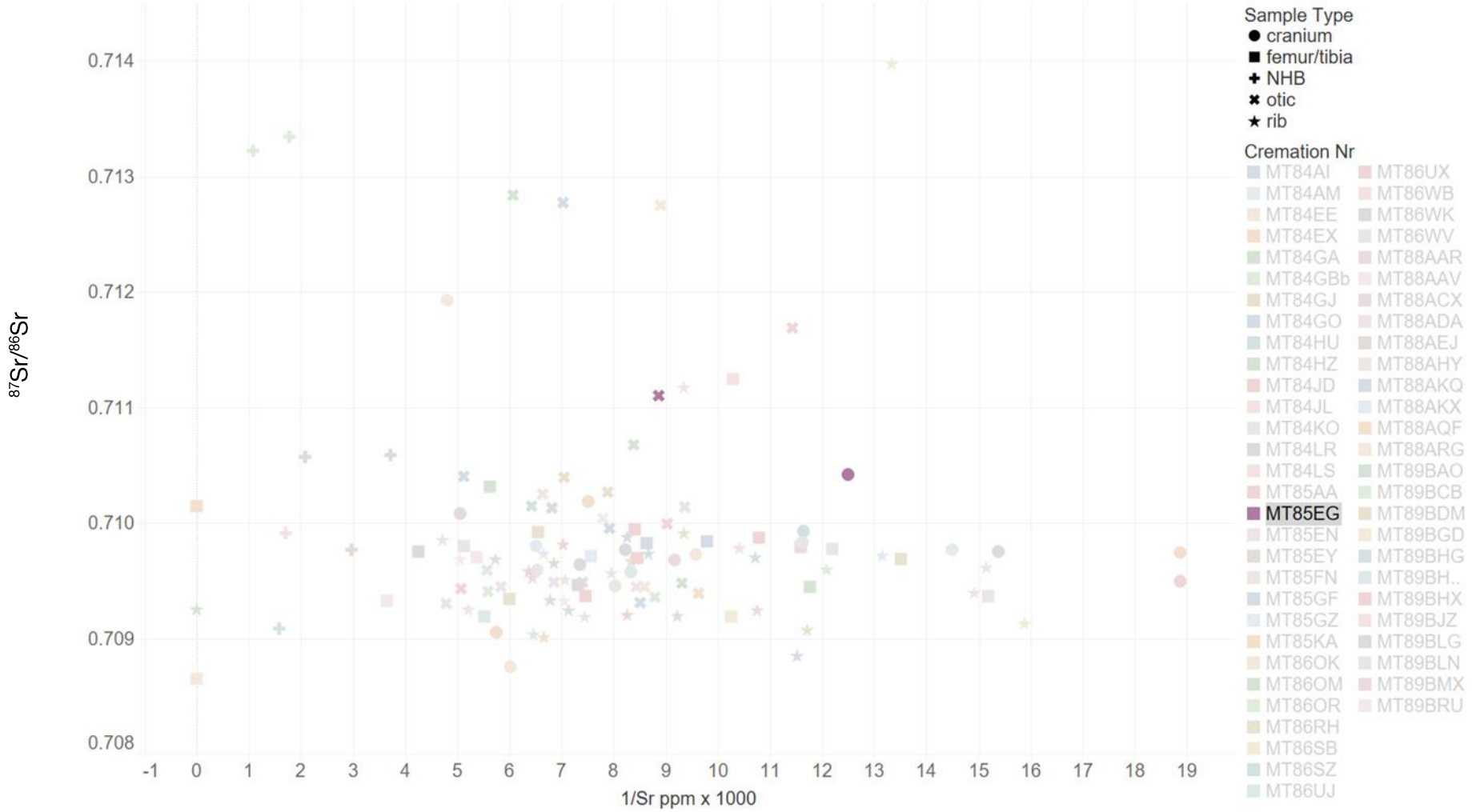
prox radii L+R; prox ulna L; humeral head L+R; radius + ulna shaft fragments; 3 prox/intermediate phalanges

Lower Limb

navicular; prox femoral head;; femoral shaft with entheseal changes; tibia shaft frags

Pathology

porous and smooth lamellar bone spicules in lateral L sinus - SINUSITIS; occipital endocranial surface: porous, smooth lamellar bone (on central crest); prosity on femoral head OA - pitting; vertebral joint surfaces: good condition generally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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 29 – CLEATHAM 293 – OCCIPTAL, OTIC

Cremation Nr	Cremation	Sample ID			
309	**MT85EN**			**T102**	**T104**
				Rib	Otic

Age (KS)	YMA	Sex (KS)	M
Age (TL)	YMA	Sex (TL)	M

Justification (age)	Joint surfaces: slight MO - dens C2 + joint on C1; cranial sutures: mostly fused (estimate).	Justification (sex)	Generally robust and large individual; external occipital protuberance (M); zygoma size (M); supra-auditory ridge (M).

X	34.00
Y	86.40

Ctxt relationships

May have been associated with Urn 310 (close by)

Cranial

otic PP frag central; zygoma L+R; maxilla frags with sockets x3; nasal/maxilla frags; mandibular condyle x2 L+R; occipital with ext protruberance; x30 vault frags

Dentition

-

Axial

scapula frag; dens articulation C1; dens of C2; R cervical vertebra, superior R lumbar joint surface (facet); rib frags

Upper Limb

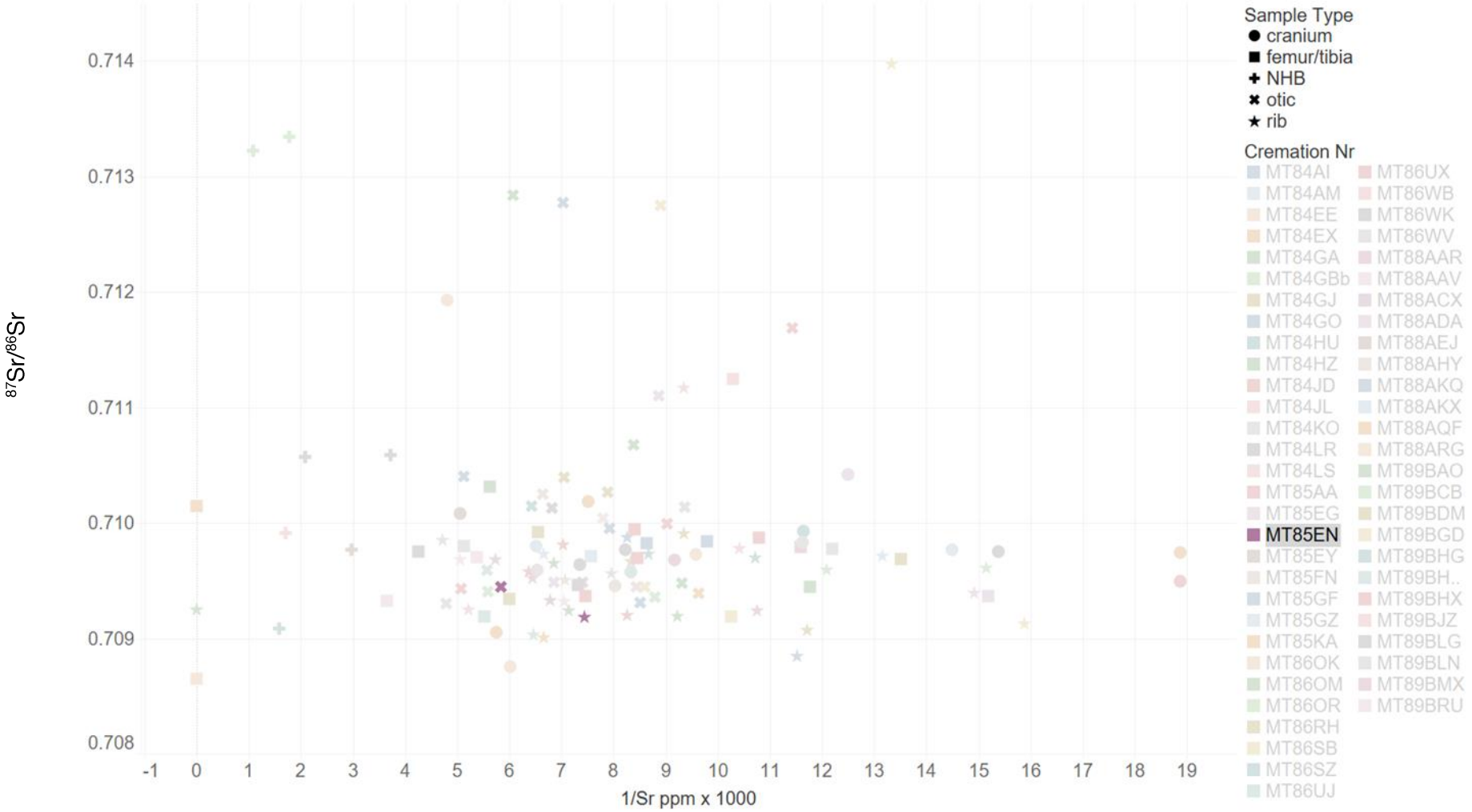
proximal radial surface; distal ulna surface; frags of prox radius joint surface; prox end of MC1; prox ulna joint surface

Lower Limb

navicular R; frag of unidentified tarsal; patella L with vastus notch (NMT); prox end of MT x2; femur shaft including linea aspera x4; tibia shaft frags

Pathology

L patella with vastus notch (NMT);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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
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MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 30 – CLEATHAM 09 – RIB, OTIC

Cremation Nr	Cremation	Sample ID			
320	**MT85FN**			**T141**	**T142**
				Cranium	Otic

Age (KS)	subadult	Sex (KS)	n/a
Age (TL)	non-adult	Sex (TL)	n/a

Justification (age)	Size/thickness of cranial fragments and presence of dental fragments (partial molar crown – infant?).	Justification (sex)	-

X	35.70
Y	95.30

Ctxt relationships

-

Cranial

at least 15 small cranial frags;

Dentition

2x: non-ID root/enamel frags; molar enamel max M1?

Axial

-

Upper Limb

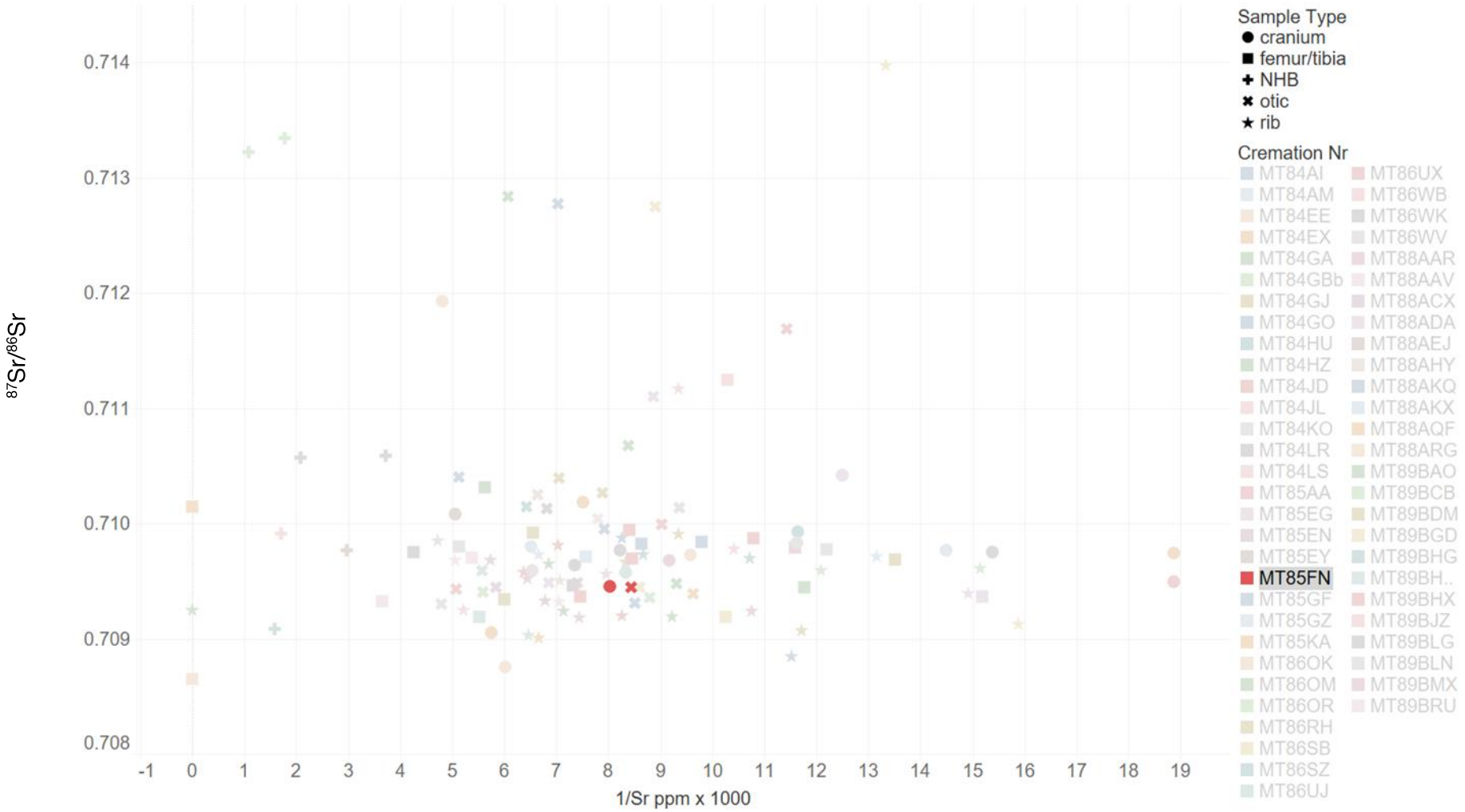
LB frags, no ID possible

Lower Limb

LB frags, no ID possible

Pathology

-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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
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MT84GBb
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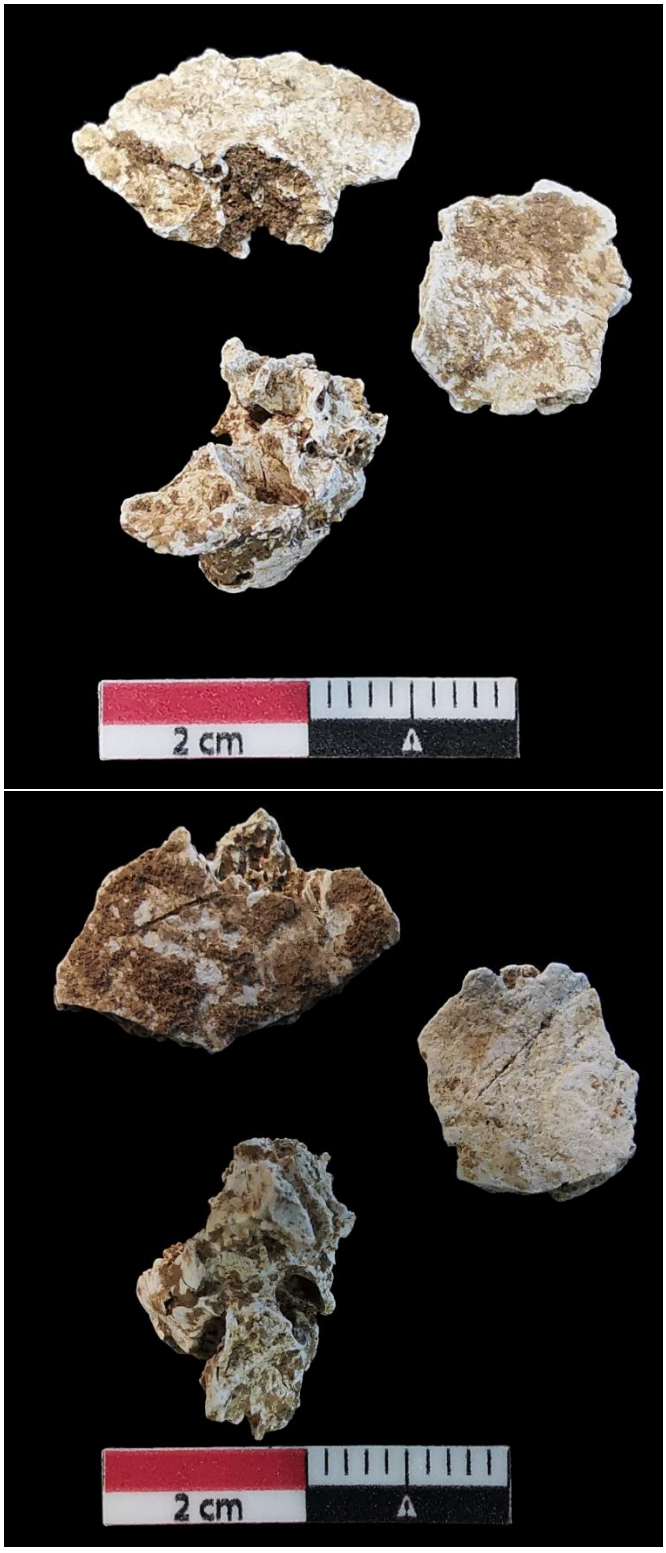


FIGURE 31 – CLEATHAM 320 – CRANIUM, OTIC

Cremation Nr	Cremation	Sample ID			
327	**MT85GZ**				**T143**
					Occipital

Age (KS)	Adult	Sex (KS)	F?
Age (TL)	Adult	Sex (TL)	F?

Justification (age)	Joint surfaces (dens of C2 in good condition as well as vertebral facets); cranial sutures young-looking. Individual is probably a younger adult.	Justification (sex)	External occipital protuberance; supra-auditory ridge.

X	35.60	Ctxt relationships	Associated with 325
Y	101.10		

Cranial	Dentition
posterior temporal bone including supra- auditory ridge (F?); occipital bone (F); anterior mandible	-

Axial

scapula fragments; frags of 3 inferior facets +1 superior facet of lumbar

Upper Limb

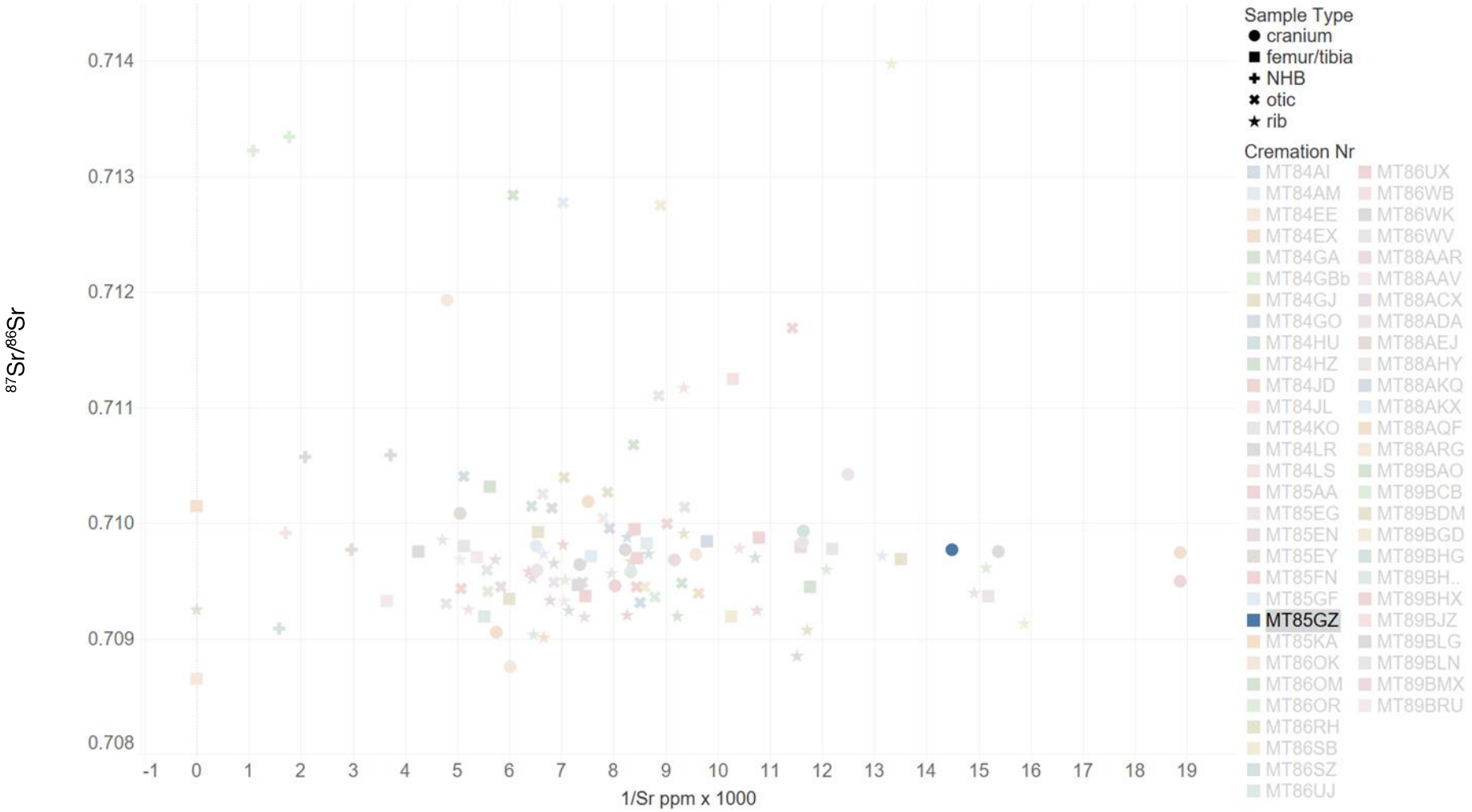
distal 1/2 of prox/intermediate phalanges

Lower Limb

femur? - could be large mammal (black DBG)

Pathology

pitting in palate - infection?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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
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MT84EX
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MT89BRU

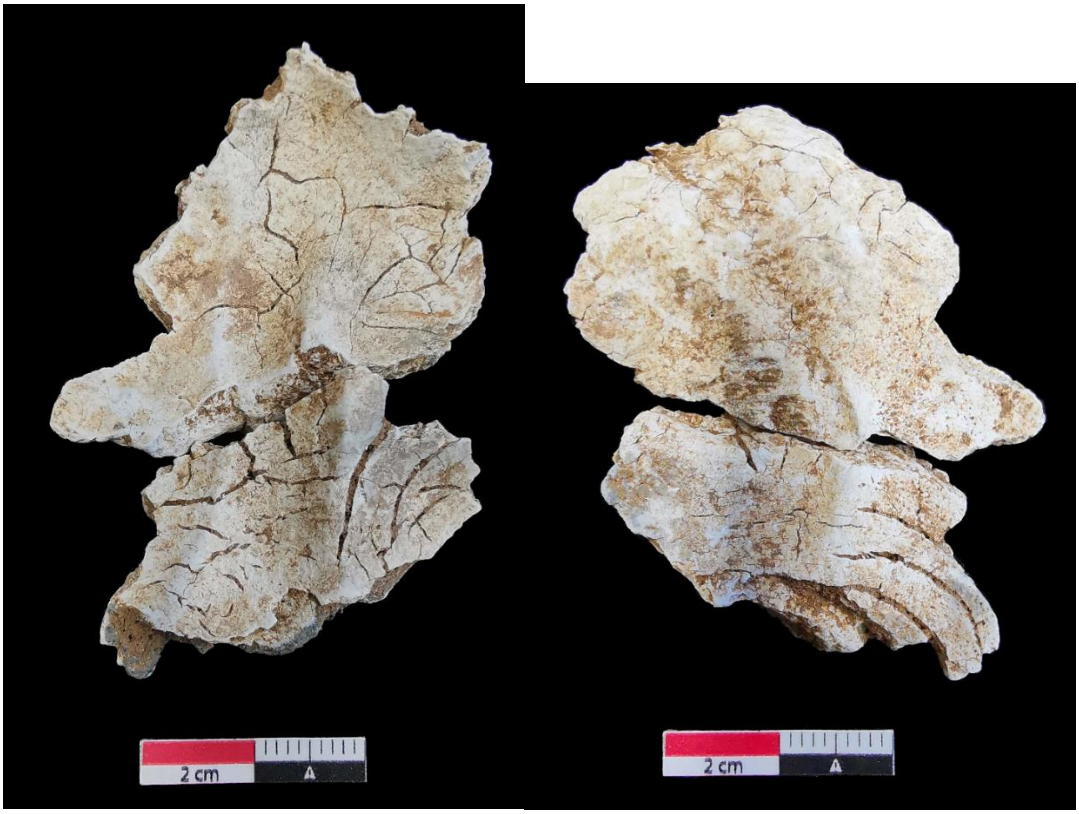


FIGURE 32 – CLEATHAM 327 - OCCIPITAL

Cremation Nr	Cremation	Sample ID			
336	**MT85GF**			**T086**	**T087**
				Femur	Otic

Age (KS)	YMA	Sex (KS)	M
Age (TL)	Adult	Sex (TL)	F?

Justification (age)	Pubic symphysis fragment - older adult; joints look OK - fair condition without severe degenerative joint changes.	Justification (sex)	Gracile - F?; external occipital protruberance - F?

X	35.60	Ctxt relationships	Associated with 338
Y	96.30		

Cranial	Dentition
34x cranial frags; lateral orbits frontal bone; R sup zygomatic bone; mandibular condyles; mandibular cortical bone (interior) including sockets; PP x2; L superior auditory meatus	roots of max canine; inferior incisors x2; 9x double rooted frags/molar frags

Axial

C2 body with dens; facets of vertebrae; vertebaral bodies x4; fragment of pubic symphysis

Upper Limb

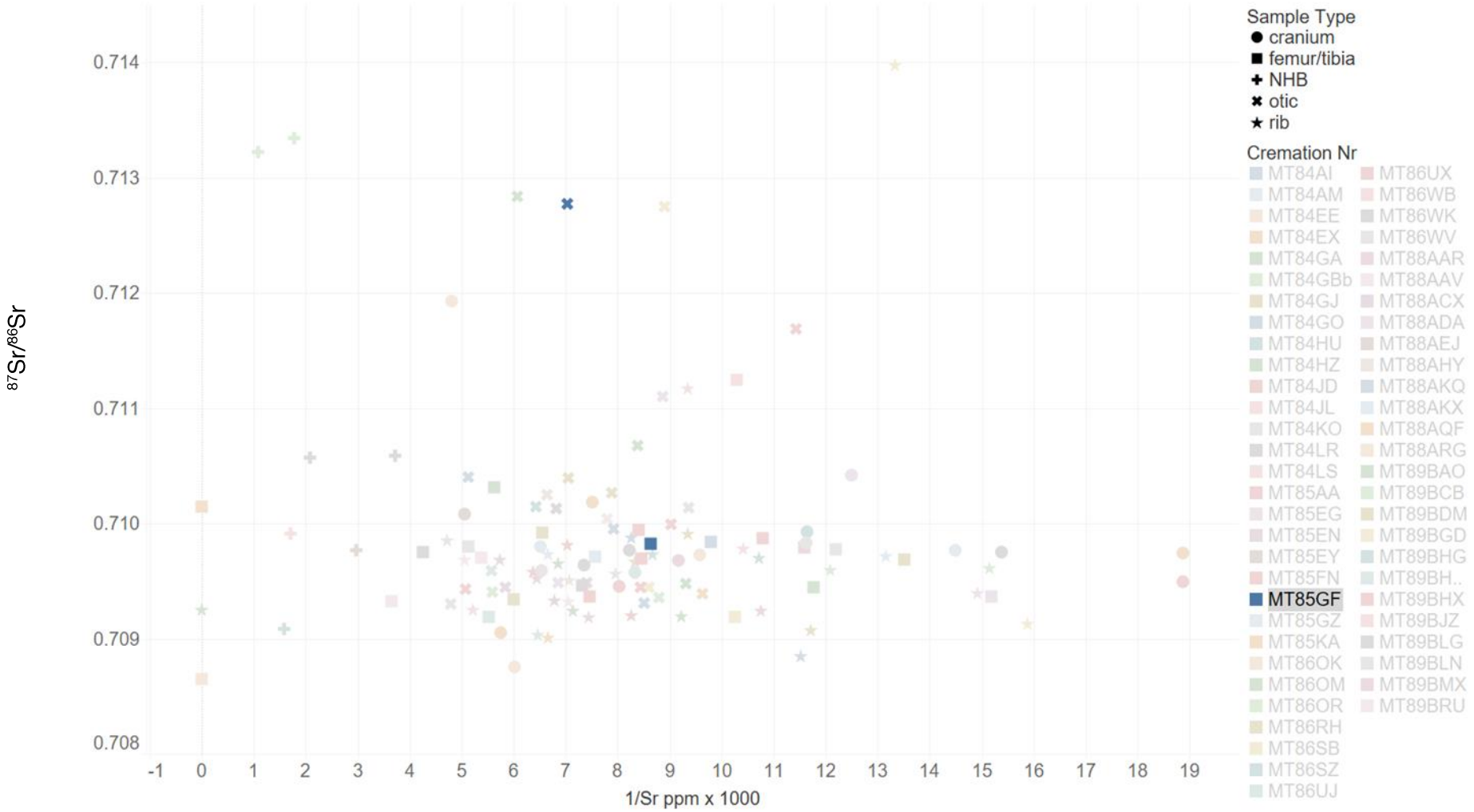
head of radius; ulna proximal joint surface (olecranon); distal radius fragment (joint surface); scaphoid and lunate? Frags; 3 distal phalanges; 6x int/prox phalanges; 1x head of MC

Lower Limb

patella fragment; tibial tuberosity; navicular frag; proximal talus; femoral shaft frag including linea aspera; tibial shaft frags including crest

Pathology

joints look OK - fair condition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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT84JD
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MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 33 – CLEATHAM 336 – FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
363	**MT85EY**				**T083**
					Frontal

Age (KS) YMA

Sex (KS) F

Age (TL) YMA?

Sex (TL) F?

Justification (age) Cranial sutures partially closed where observable; technically inclined to age as Adult only.

Justification (sex) Bones are very gracile - especially femur! - F?; anterior mandible - narrow: F?.

X 35.00

Y 88.70

Ctxt relationships

362, 1093

Cranial

vault frags x37; fragmentary concha PP; mandible frags anterior and internal; maxillary fragments; partial frontal bone; mandibular condyle; temporal bone fragment posterior

Dentition

-

Axial

acromial joint surface frag; dens of C2 with joint surface

Upper Limb

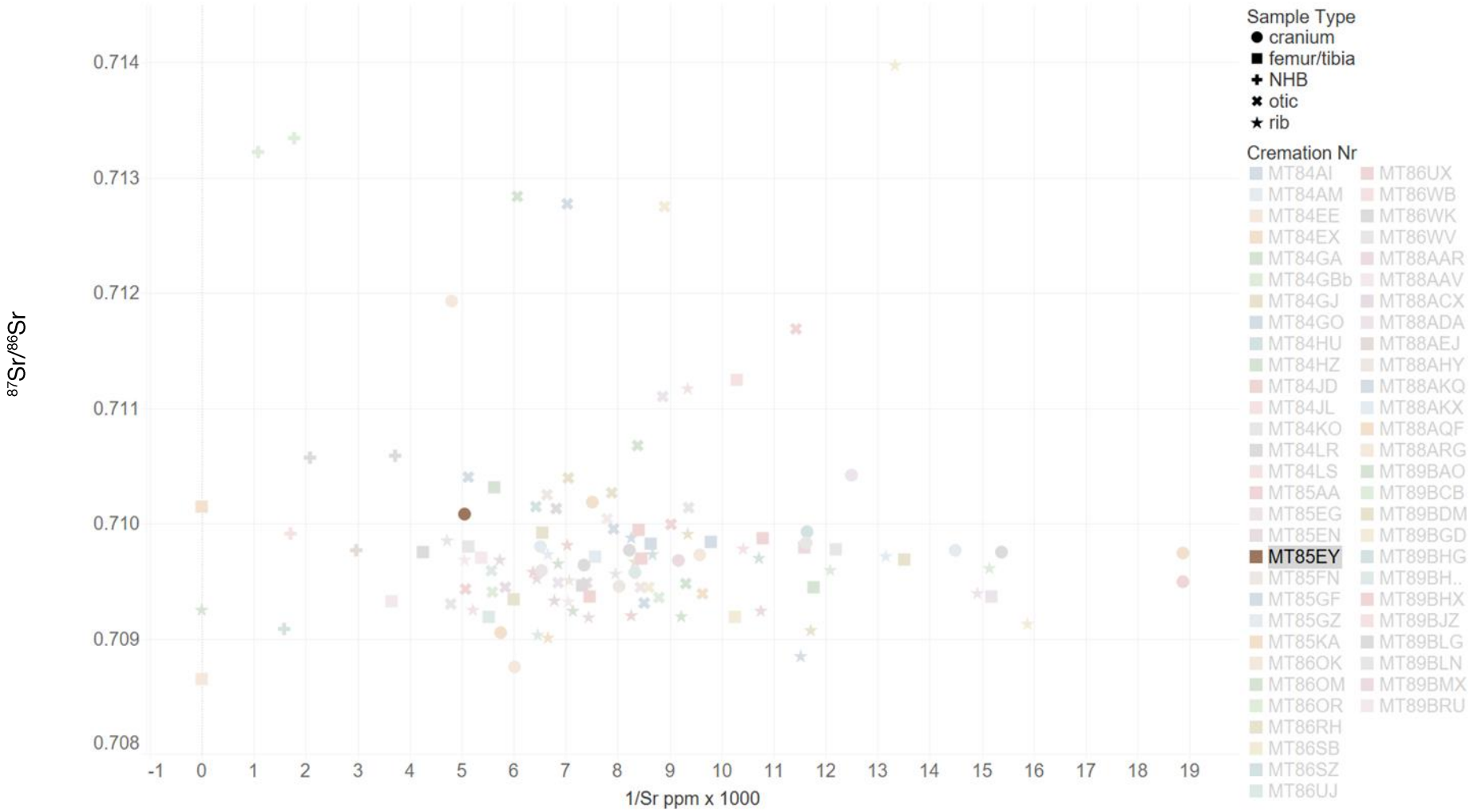
prox/int phalanx, distal 1/5th

Lower Limb

anterior crest tibia fragments; 2x femoral shaft fragments, fairly small - with linea aspera; patella frag; talus fragment superior joint surface; fibular shaft fragments

Pathology

pitting on palate where palate is present (small extent); periodontal disease?; entheseal changes on phalanges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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 34 – CLEATHAM 363 – FRONTAL BONE

Cremation Nr	Cremation	Sample ID			
443	**MT86OM**			**T115**	**T116**
				Femur	Otic

Age (KS)	YA	Sex (KS)	F
Age (TL)	YMA	Sex (TL)	F?

Justification (age)	Joint surface condition - vertebral bodies with slight MO; Adult; auricular surface fragment - granular with irregular surface and some porosity, cratering, MO -	Justification (sex)	L zygomatic bone relatively narrow - F?; supraorbital ridge – F.

X	5.60	Ctxt relationships	-
Y	84.90		

Cranial	Dentition
x35 cranial vault fragments; sphenoid fragments including greater wing; zygomatic bone L; mandible internal cortex including socket impressions	-

Axial

partial auricular surface; min 4 vertebral bodies; vertebral facets

Upper Limb

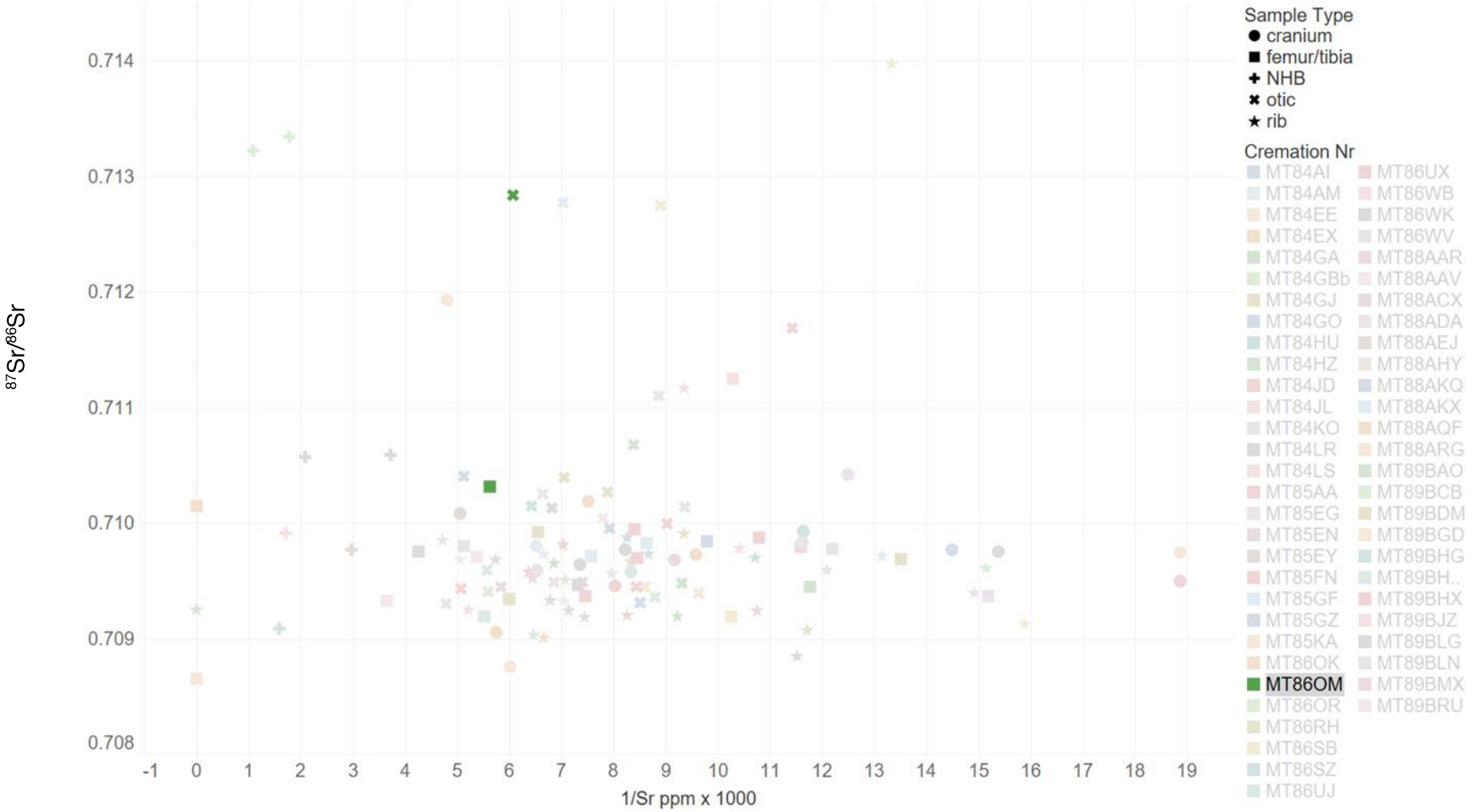
distal ulna joint surface; prox radius surface; prox radial shaft; distal humeral joint surface; lunate fragment

Lower Limb

L+R partial patellae; femoral shaft fragments incl linea aspera; tibial shaft fragments L+R x7

Pathology

vertebral bodies with MO + P; entheseal changes on deltoid of humerus + alsong upper/proximal linea aspera of femur; vastus notch (NMT)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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
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MT88AHY
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MT88ARG
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MT89BCB
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MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 35 – CLEATHAM 443 – FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
452	**MT86OK**				**T044**
					Parietal

Age (KS)	YA	Sex (KS)	M
Age (TL)	YMA/OMA?	Sex (TL)	M?

Justification (age)	Joints look good (few present), no degenerative changes to the joint surfaces observable; sutures completely closed, mostly obliterated where present - older	Justification (sex)	Supra-mastoid ridge R: M, very distinct.

X	3.80
Y	84.00

Ctxt relationships

cut urn 454; contained sherds from 1188, 1189,
1190

Cranial

cranial vault fragments x46; partial supraorbital rim L; R orbital rim lat; temporal bone with supramastoid ridge; partial mastoid R; PP L+R

Dentition

roots: max? M3 root; mand? M2 root R; Mand? Canine root

Axial

rib? Fragment

Upper Limb

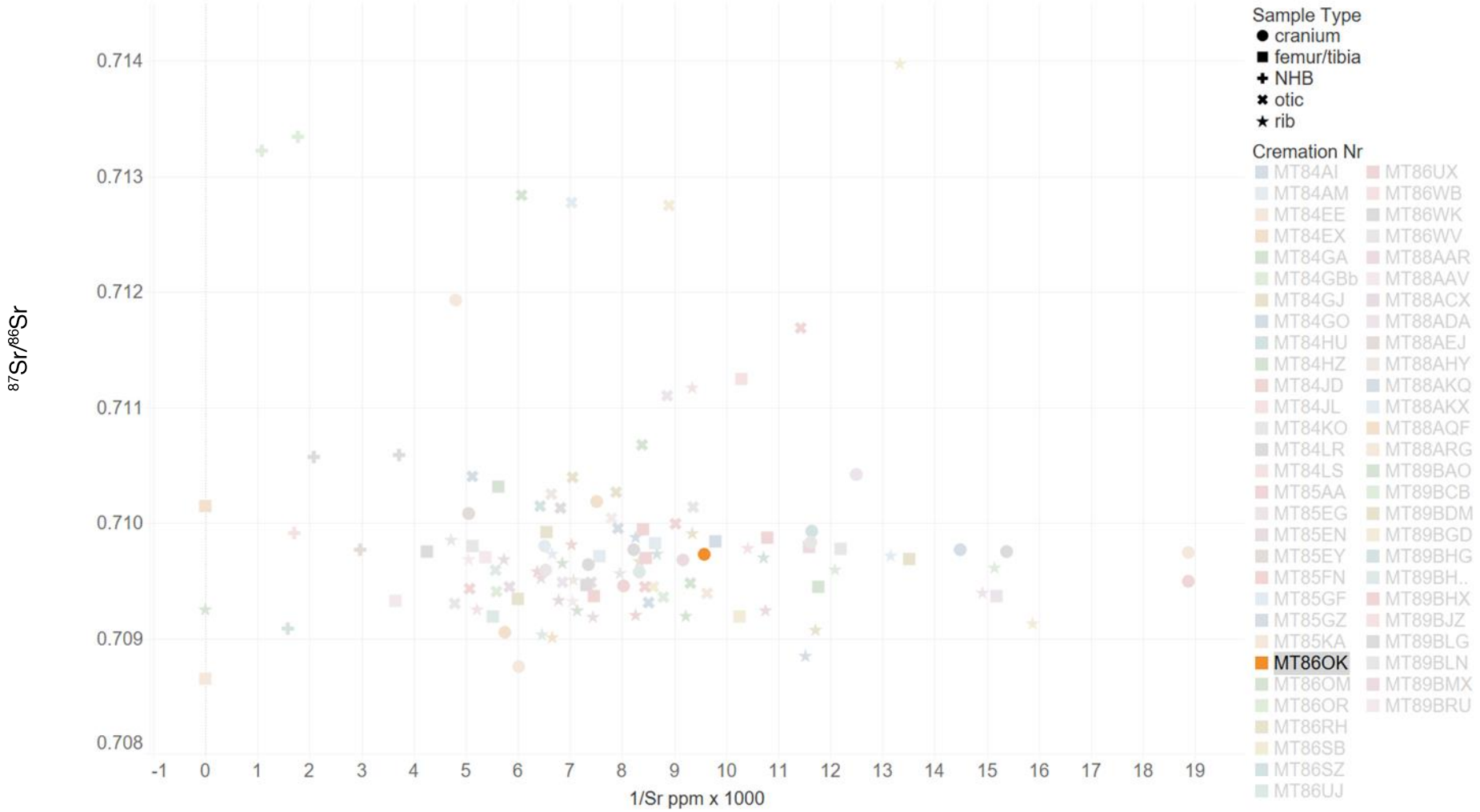
humeral head fragment; distal distal phalanx; distal int/prox phalanx

Lower Limb

distal femoral joint surface fragment; prox phalanx x1; tibial shaft frags

Pathology

small foramina on supraorbital rim and ridge


$^{87}Sr/^{86}Sr$
0.714
0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT86OR
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MT86SB
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MT88ADA
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MT88AHY
MT88AKQ
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MT88AQF
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MT89BMX
MT89BRU

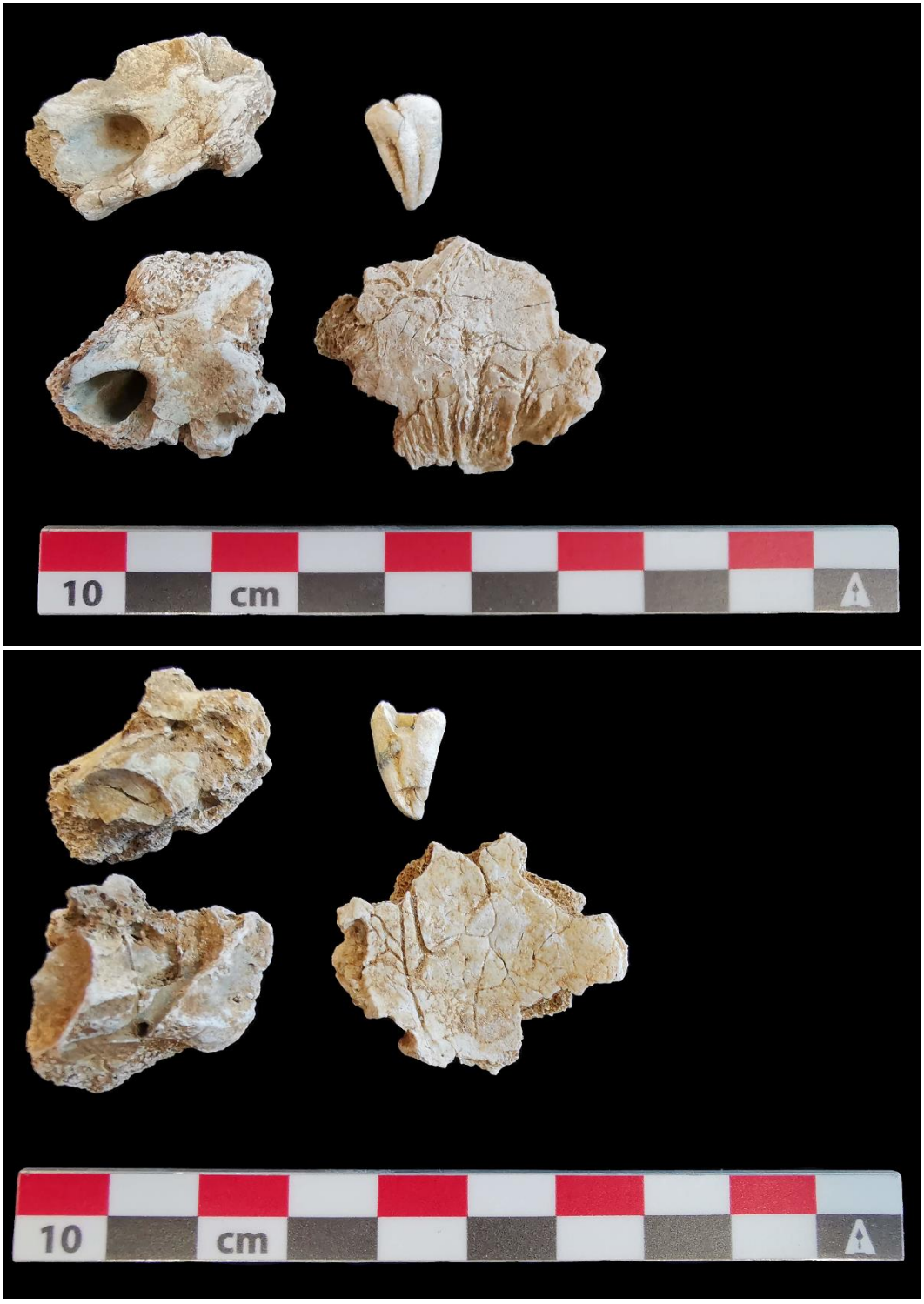


FIGURE 36 – CLEATHAM 452 – PARIETAL BONE

Cremation Nr	Cremation	Sample ID			
458	**MT86SB**			**T111**	**T112**
				Rib	Otic

Age (KS) YMA

Sex (KS) F

Age (TL) OMA?

Sex (TL) F

Justification (age) Joint surface condition; presence of OA - at least YMA or pathological.

Justification (sex) External occipital protuberance - F?; orbital rim - F? (fairly sharp); zygoma narrow and zygomatic process small; frontal slope straight - F.

X 8.50

Y 80.50

Ctxt relationships

Placed next to urn 459 (same pit)

Cranial

min 79 cranial vault fragments; L+R zygoma; L+R frontal: lateral superior orbits; central frontal bone; R mandibular ramus fragment; internal mandibular surface sockets partial; L zygomatic process of temporal bone; L mandibular condyle; 2 maxillary fragments with sockets; 6 otic/concha frags, L+R side

Dentition

roots: at least 10 single rooted teeth; at least 8- 10 molar roots +17 partial molars (singles off)

Axial

partial auricular surface of ilium; 23 rib frags; clavicle shaft fragment OR scapula coronoid; min 3 rib heads - CO + MO + P = OA; min 3 superior cervical facets; c. 4 thoracic fragments; dens articulation of C1

Upper Limb

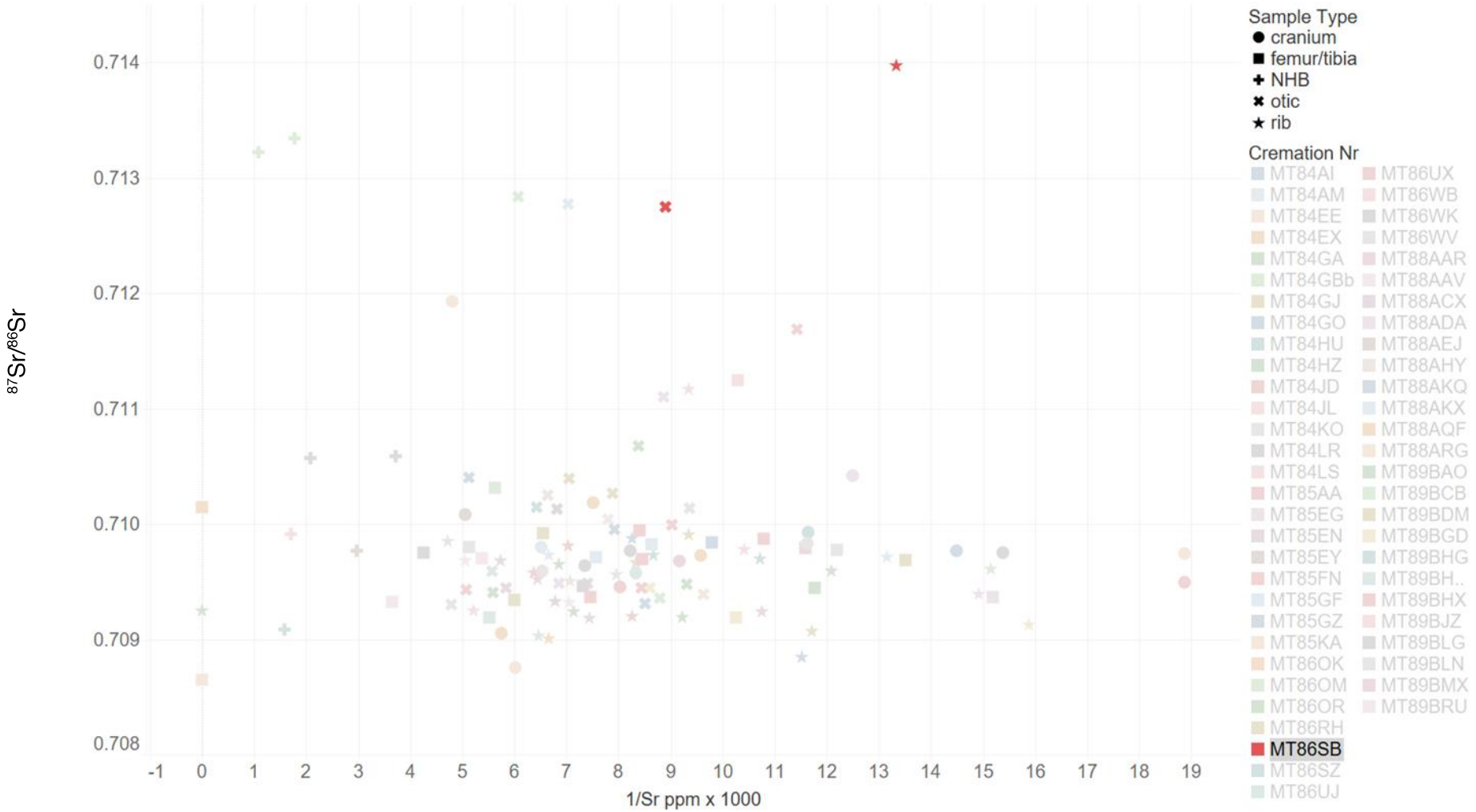
L+R distal humeral joint surfaces; prox radius joint; carpals: R hamate hook, scaphoid?; min 4 distal phalanges; min 5 ibnt/prox phalanges

Lower Limb

patella fragments L+R; fragment of superior talus joint surface; tibial shaft fragments; navicular fragment (was with animal bone)

Pathology

OA (3 indicators) on at least 3 rib heads; R cervical with MO+ P; Thoracic? Facet with mayor P and contour change - OA?; slight porosity on supraorbital rims/margins laterally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0.712
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 37 – CLEATHAM 458 – RIB, OTIC

Cremation Nr	Cremation	Sample ID			
488	**MT86SZ**				**T144**
					Cranium

Age (KS)	subadult	Sex (KS)	n/a
Age (TL)	non-adult	Sex (TL)	n/a

Justification (age)	Dentition suggests infant/juvenile (younger non-adult).	Justification (sex)	-

X	7.70
Y	81.30

Ctxt relationships

5cm apart from 485

Cranial

fragments of otic capsule x6; at least 10 fragments of cranial vault; tooth crowns

Dentition

-

Axial

-

Upper Limb

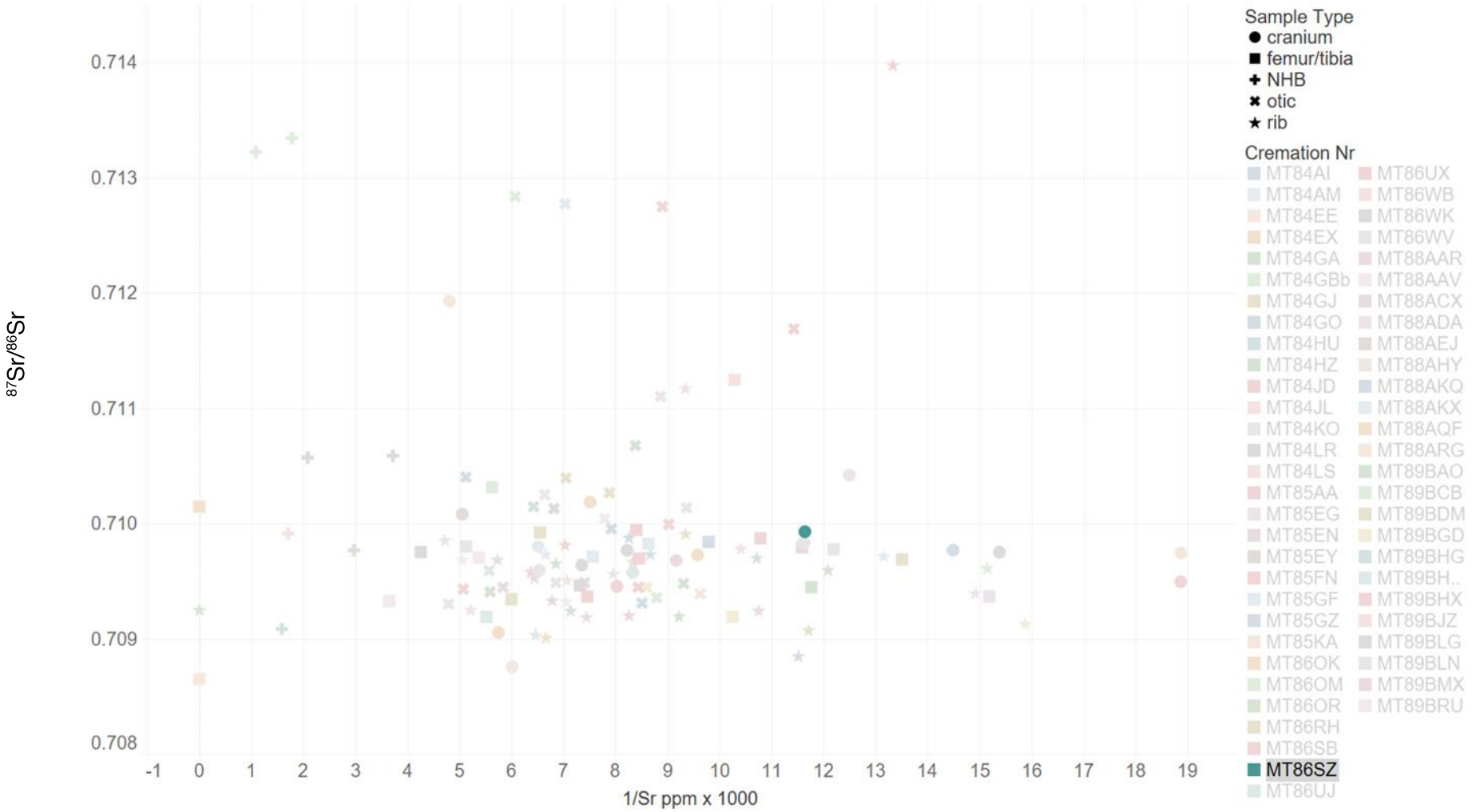
-

Lower Limb

-

Pathology

-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0.713
0.712
0.711
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0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT85EY
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MT85GF
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MT86OR
MT86RH
MT86SB
MT86SZ
MT86UJ
MT86UX
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MT86WK
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MT88AQF
MT88ARG
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 38 – CLEATHAM 488 - CRANIUM

Cremation Nr	Cremation	Sample ID			
492	**MT86UX**			**T088**	**T089**
				Femur	Rib

Age (KS)	Adult	Sex (KS)	Indeterminate
Age (TL)	Adult	Sex (TL)	Ind

Justification (age)	Auricular surface: MO around margin; fine granular/ with densification areas?; consider damage of fire.	Justification (sex)	Supra-orbital rim: blunt - M?; overall bones not necessarily robust; no other indicators.

X	2.00	Ctxt relationships	-
Y	86.20		

Cranial	Dentition
min 9 cranial vault fragments; lateral frontal with orbital rim R; R superior zygoma fragment; interior surface of mandible x2; PP fragment - no otic	roots: 4x partial molar roots; 1x single

Axial

central rib fragment; vertebrae: C1 superior facet fragment; cervical body; lumbar/thoracic partial sup facet; vertebral arch; auricular surface fragment

Upper Limb

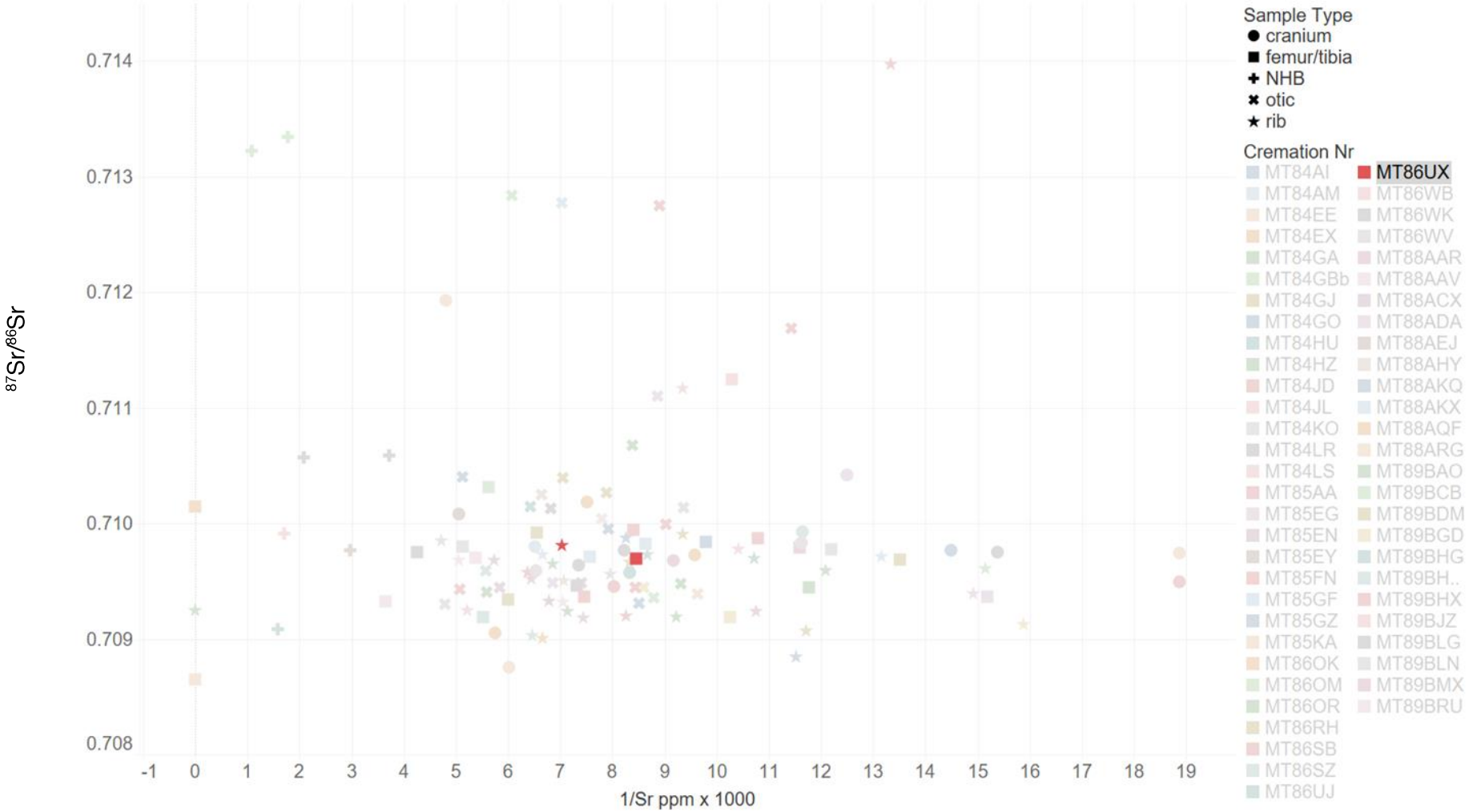
humeral head joint surface; 1 distal phalanx (head); 1 int/prox phalanx; humeral shaft fragments

Lower Limb

tibial shaft fragments; femoral shaft fragments

Pathology

None observed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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
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MT84GBb
MT84GJ
MT84GO
MT84HU
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MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 39 – CLEATHAM 492 – FEMUR, RIB

Cremation Nr	Cremation	Sample ID			
523	**MT86RH**		**T105**	**T106**	**T107**
			Rib	Femur	Otic

Age (KS)	YMA	Sex (KS)	M
Age (TL)?	YMA	Sex (TL)	F?

Justification (age)	Cranial sutures closing where observable.	Justification (sex)	Narrow zygoma - F?

X	10.30	Ctxt relationships	-
Y	87.90		

Cranial	Dentition
mandible: fragment of sockets + cortical bone + condyle; zygoma x2 (L+R); c 39 cranial vault fragments; maxillary fragment including sockets	-

Axial

vertebral fragments: C2 dens - joint surface ok; rib fragments

Upper Limb

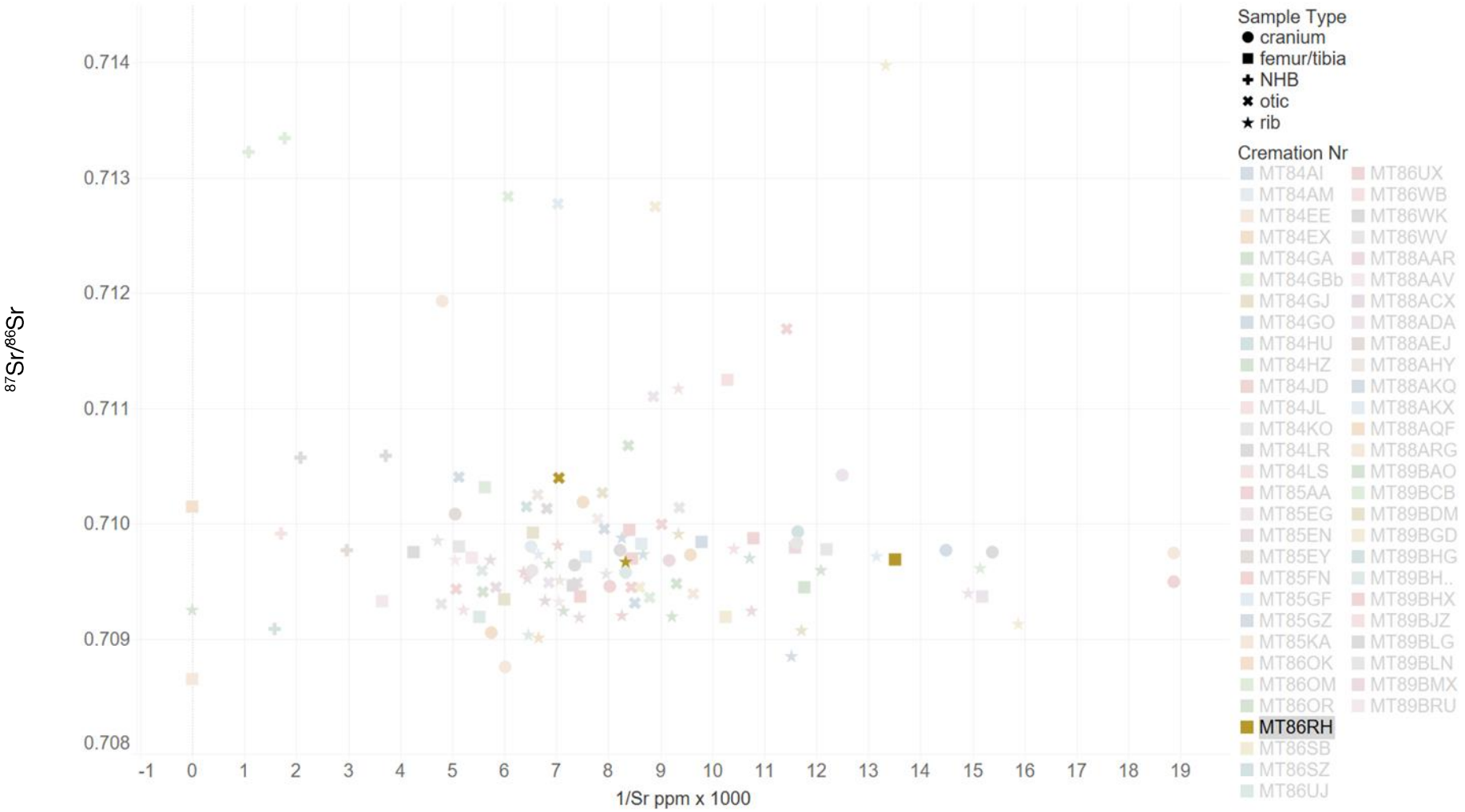
x3 distal humerus joint frags; proximal radius: head; distal 1st phalanx R?; partial phalanx

Lower Limb

distal femur; femoral shaft inclusive linea aspera; tarsals: navicular?

Pathology

non-active, smooth lamellar striations on tibial shaft fragments; parietal foramen (NMT)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0.712
0.711
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
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MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 40 – CLEATHAM 523 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
548	**MT86WK**			**T090**	**T091**
				Femur	Occipital

Age (KS)	Adult	Sex (KS)	F?
Age (TL)	YMA	Sex (TL)	F

Justification (age)	Good condition of joints where observable, no degenerative changes to the joint surfaces; joints fully fused - Adult.	Justification (sex)	Supra-auditory ridge - small, shallow - F?; supraorbital rim sharp - F?; supraorbital ridge, fairly flat - F?; external occipital protuberance - F?; thin cranium - 'gracile'

X	41.30	Ctxt relationships	-
Y	87.60		

Cranial	Dentition
16x cranial vault frags; PP frag without otic; R frontal bone with superior orbit; internal cortex of mandible; occipital ext protruberance	-

Axial

L superior and inferior cervical facet, good condition

Upper Limb

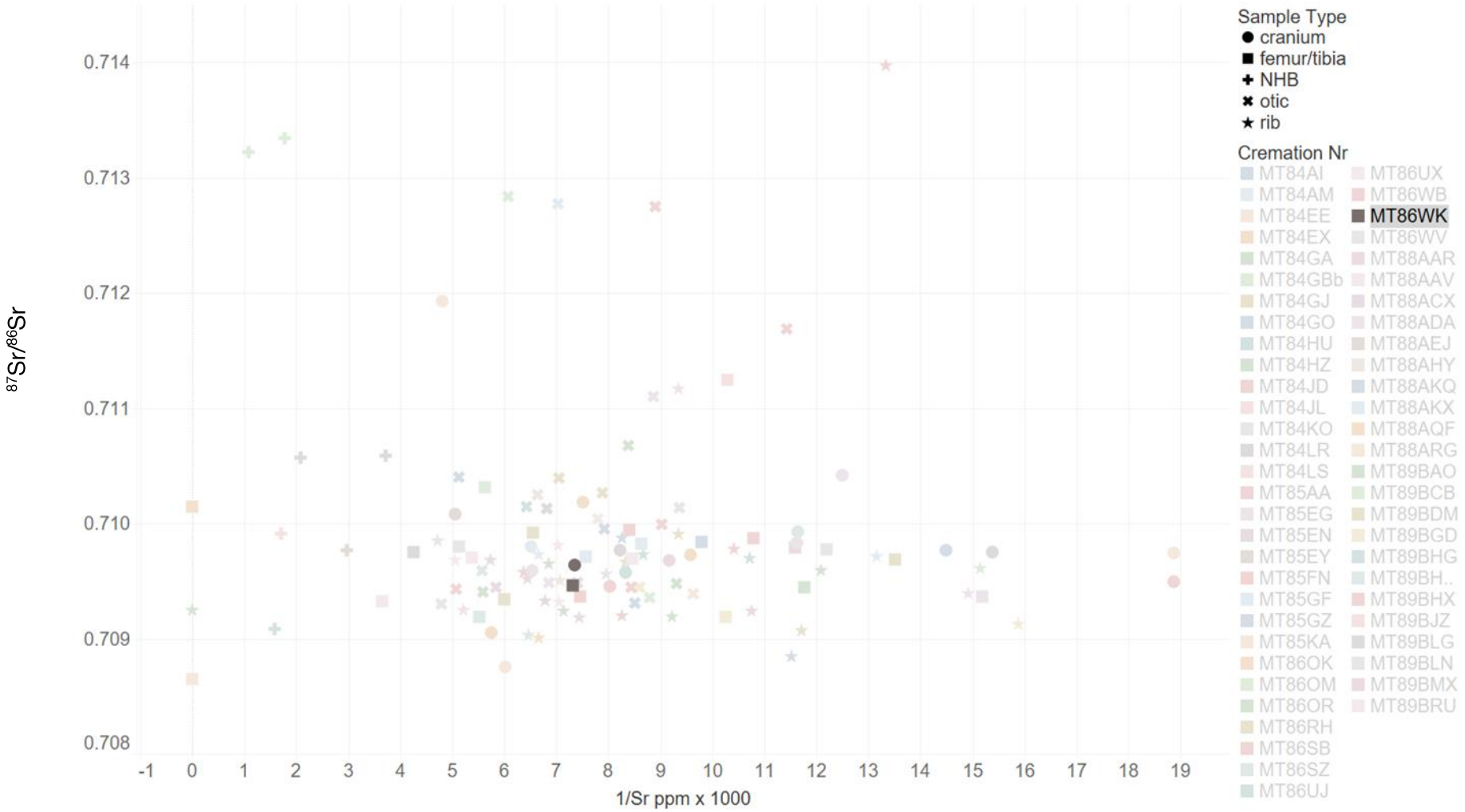
int/prox phalanx; distal distal phalanx frag; joint surface of distal humerus

Lower Limb

femoral shaft fragments including linea aspera

Pathology

porosity on ectocranial surfac, small foramina - smooth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0.712
0.711
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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 41 – CLEATHAM 548 – FEMUR, OCCIPITAL BONE

Cremation Nr	Cremation	Sample ID			
550	**MT86UJ**				**T128**
					Cranium

Age (KS)	YA	Sex (KS)	?
Age (TL)	Adult	Sex (TL)	?

Justification (age)	Only indication is apex closure in dentition, and cranial sutures (clear, open, and well defined); thin cranial diploe.	Justification (sex)	Not enough indicators present.

X	4.50	Ctxt relationships	-
Y	78.20		

Cranial	Dentition
c. 14 cranial vault fragments	mandibular incisor root

Axial

-

Upper Limb

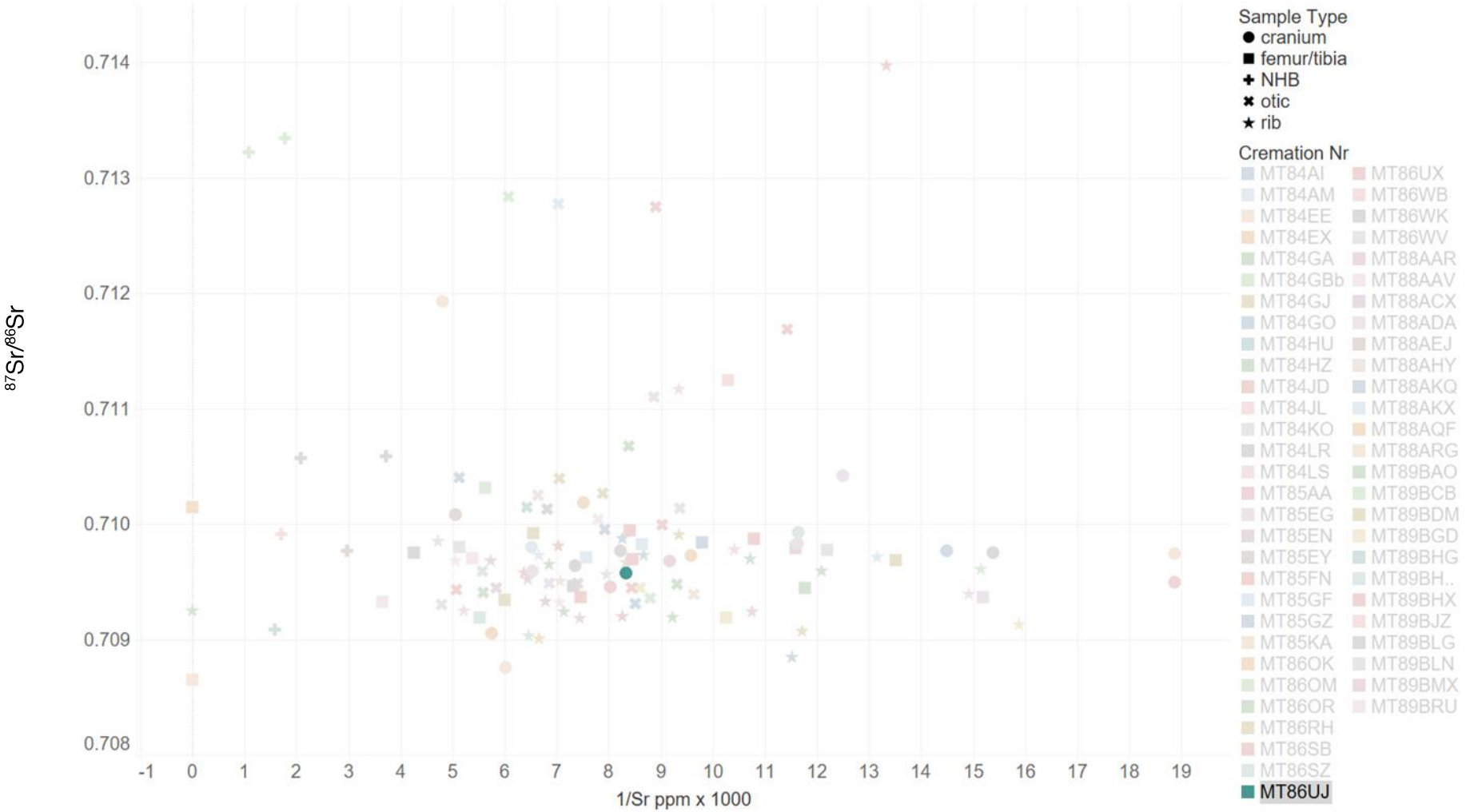
1 phalanx (prox/intermediate) distal half

Lower Limb

-

Pathology

-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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
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MT84EX
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MT84GBb
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MT84GO
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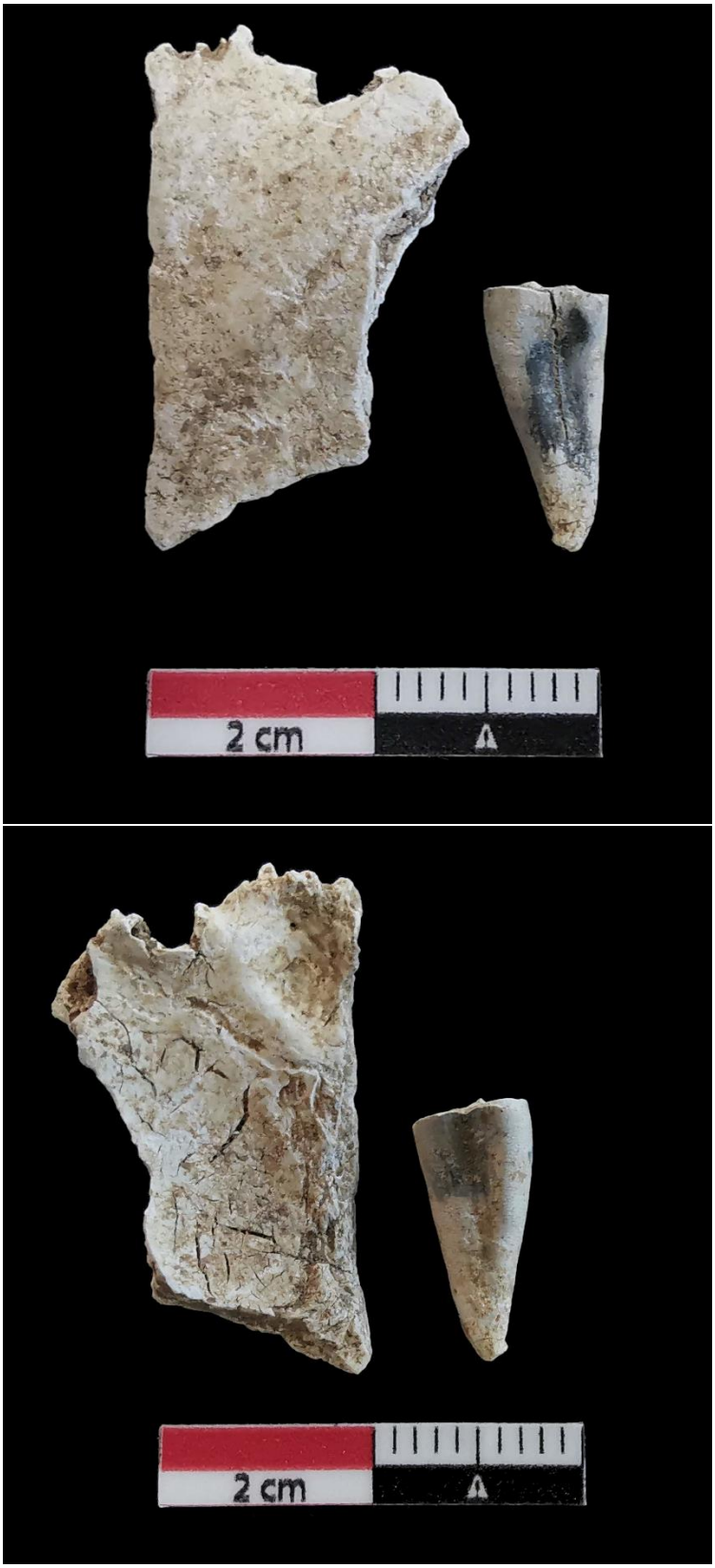


FIGURE 42 – CLEATHAM 550 - CRANIUM

Cremation Nr	Cremation	Sample ID			
563	**MT86WB**				**T063**
					Rib

Age (KS)	subadult	Sex (KS)	?
Age (TL)	Adult	Sex (TL)	?

Justification (age)	Epiphyseal fusion, and dentition - this is an adult.	Justification (sex)	Not enough indicators present.

X	42.40
Y	84.00

Ctxt relationships

cuts urn 1192; associated with sherds from 1061, 1192

Cranial

15 cranial vault fragments; PP fragment with otic partial (exposed)

Dentition

roots: 2x molar, apex closed

Axial

R vertebral frag with body and lamina; rib fragments

Upper Limb

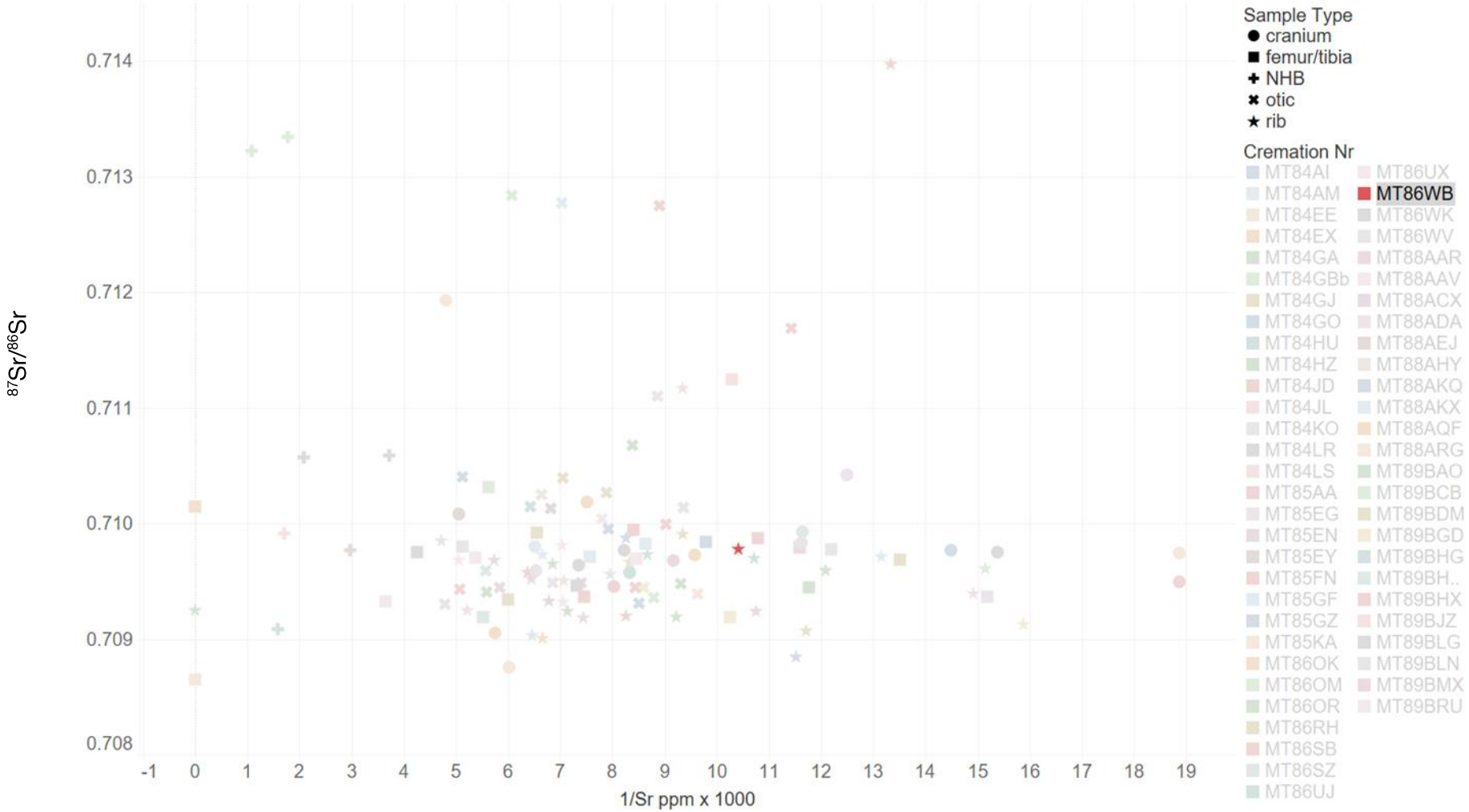
phalanx shaft int/prox; prox phalanx articular facet

Lower Limb

-

Pathology

-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0.712
0.711
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0.709
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
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MT84AM
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MT84EX
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MT84GJ
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MT89BLN
MT89BMX
MT89BRU

FIGURE 43 – CLEATHAM 563 - RIB

Cremation Nr	Cremation	Sample ID			
566	**MT86OR**	**T065**	**T066**	**T067**	**T068**
		Rib	Femur	Otic	Occipital

Age (KS) YMA

Sex (KS) F

Age (TL) YMA/OMA?

Sex (TL) M

Justification (age) MT1 - joint extension through osteophyte formation; distal 1st phalanx of foot with MO; based on joint condition, this is at least YMA.

Justification (sex) Supraorbital rims and ridges - M; supra-mastoid ridge - M; occipital protuberance - M; zygomatic process - M; gonial angle - M; gonial flare - M.

X 43.20

Y 85.60

Ctxt relationships

-

Cranial

at least 47 cranial vault fragments; PP frag including otic; mandible fragments (internal cortical bone and sockets) x4; gonial angles of mandible; both zygomata; zygomatic bone; 1 maxillary fragment with sockets

Dentition

roots: mandibular? Molar roots x2

Axial

vertebrae: dens of C2; facets of thoracic and lumbar vertebrae; partial body x4

Upper Limb

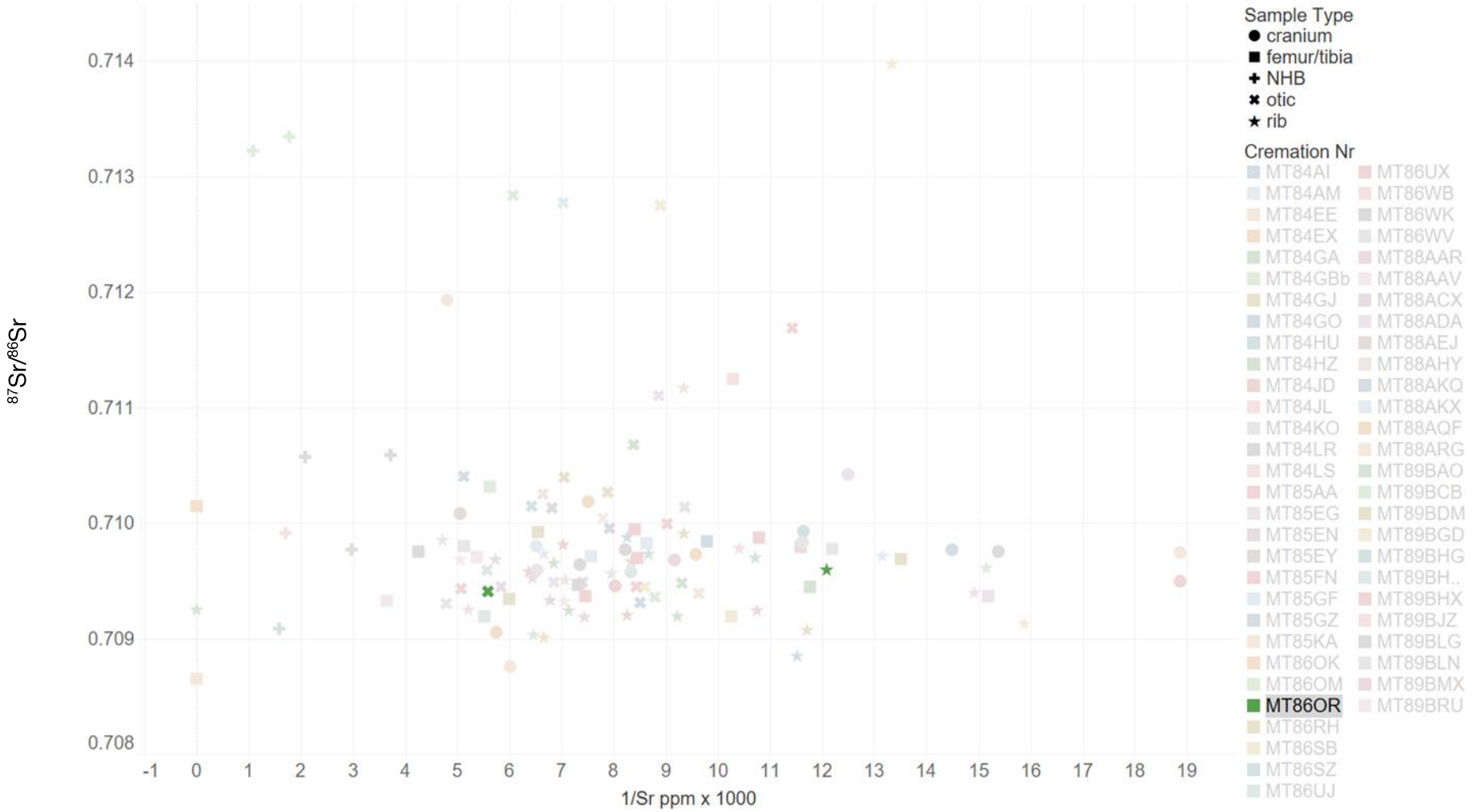
proximal phalanx; 10x int/prox phalanges (distal 1/2); ulna/radius shaft fragments; carpals: scaphoid, x2 frags; both radial heads (superior surface); proximal ulna (olecranon); MC3 prox R

Lower Limb

femoral shaft fragments, at least 5 large frags; tibia: 2x large shaft fragments; talus superior surface; R patella; destal femur joint surface; 3x distal phalanges (hand/foot?)

Pathology

MT1 distal (head) with significant osteophytes (joint extension); entheseal changes on lateral shaft of phalanges; MO on superior dens joint surface - DJD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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
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MT85EN
MT85EY
MT85FN
MT85GF
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MT85KA
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MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 44 – CLEATHAM 506 – RIB, FEMUR, OTIC, OCCIPITAL

Cremation Nr	Cremation	Sample ID			
627	**MT88AHY**			**T145**	**146**
				Rib	Otic

Age (KS)	OA	Sex (KS)	M?
Age (TL)	OA	Sex (TL)	M?

Justification (age)	Joint/disc degeneration present on the vertebral bodies and on the facets; cupping on vert bodies, especially C2 and C3. Individual is older.	Justification (sex)	External occipital protuberance - M??; could be F however, because of the thickening of the cranial vault - might just appear larger, more robust;

X	31.50
Y	43.80

Ctxt relationships

-

Cranial

L zygomatic bone fragment; maxillary frag with sockets; mandibular internal cortical bone with sockets; central PP frag including otic; 26x cranial vault fragments

Dentition

roots: 2x molar fragments; 2x single rooted teeth including 1 central maxillary incisor

Axial

C2 with body and dens; C3 body fragment; c. 4 further body fragments; c. 4 vertebral facets; 3? Rib fragments including neck; partial auricular surface?

Upper Limb

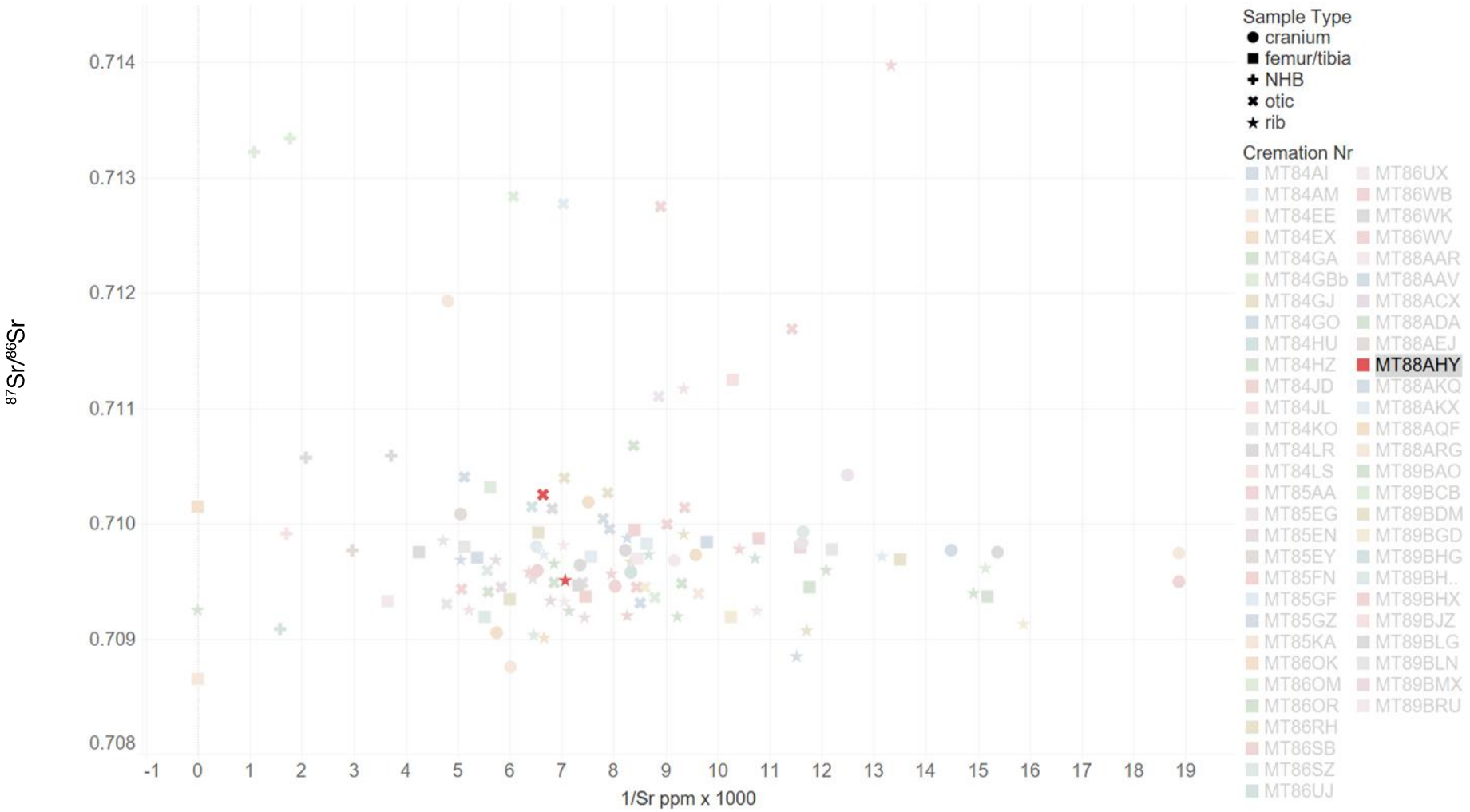
prox/intermediate phalanx - distal fragment; radius and ulna shaft fragments;

Lower Limb

poss femoral shaft fragments; MT5 looks small and gracile

Pathology

cranial diploe appears thickened; Diploic structure intact; Contour change on inferior body of C2; anterior body of C2 is bulging outwards anteriorly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0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 45 – CLEATHAM 627, RIB, OTIC

Cremation Nr	Cremation	Sample ID			
639	**MT88AEJ**				**T093**
					Rib

Age (KS) YA

Sex (KS) ?

Age (TL) YMA

Sex (TL) ?

Justification (age) Joint surfaces appear fair. No heavy degenerative changes.

Justification (sex) Not enough indicators present.

X 33.80

Y 59.00

Ctxt relationships

Urn 639 cut by urn 624

Cranial

8x cranial vault fragment;

Dentition

3 tooth roots present: including poss maxillary RI1 or RC1; maxillary? Premolar? With enamel

Axial

vertebral body fragment; superior facet thoracic; 2 rib frags

Upper Limb

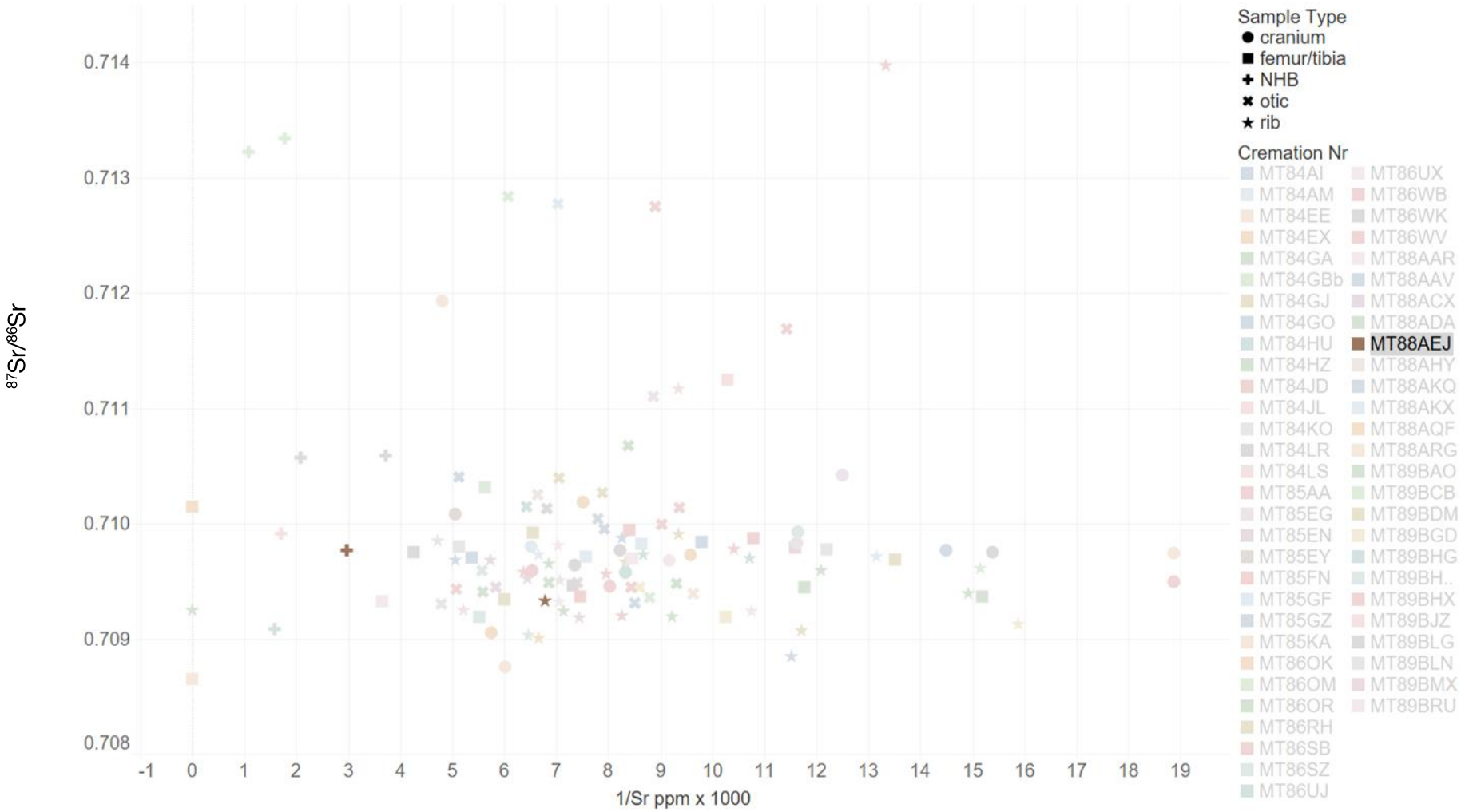
radial head (2x); 2x int/prox phalanges; hamate hook

Lower Limb

-

Pathology

slight foramina on ectocranial surface of diploe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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
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MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 46 – CLEATHAM 639 - RIB

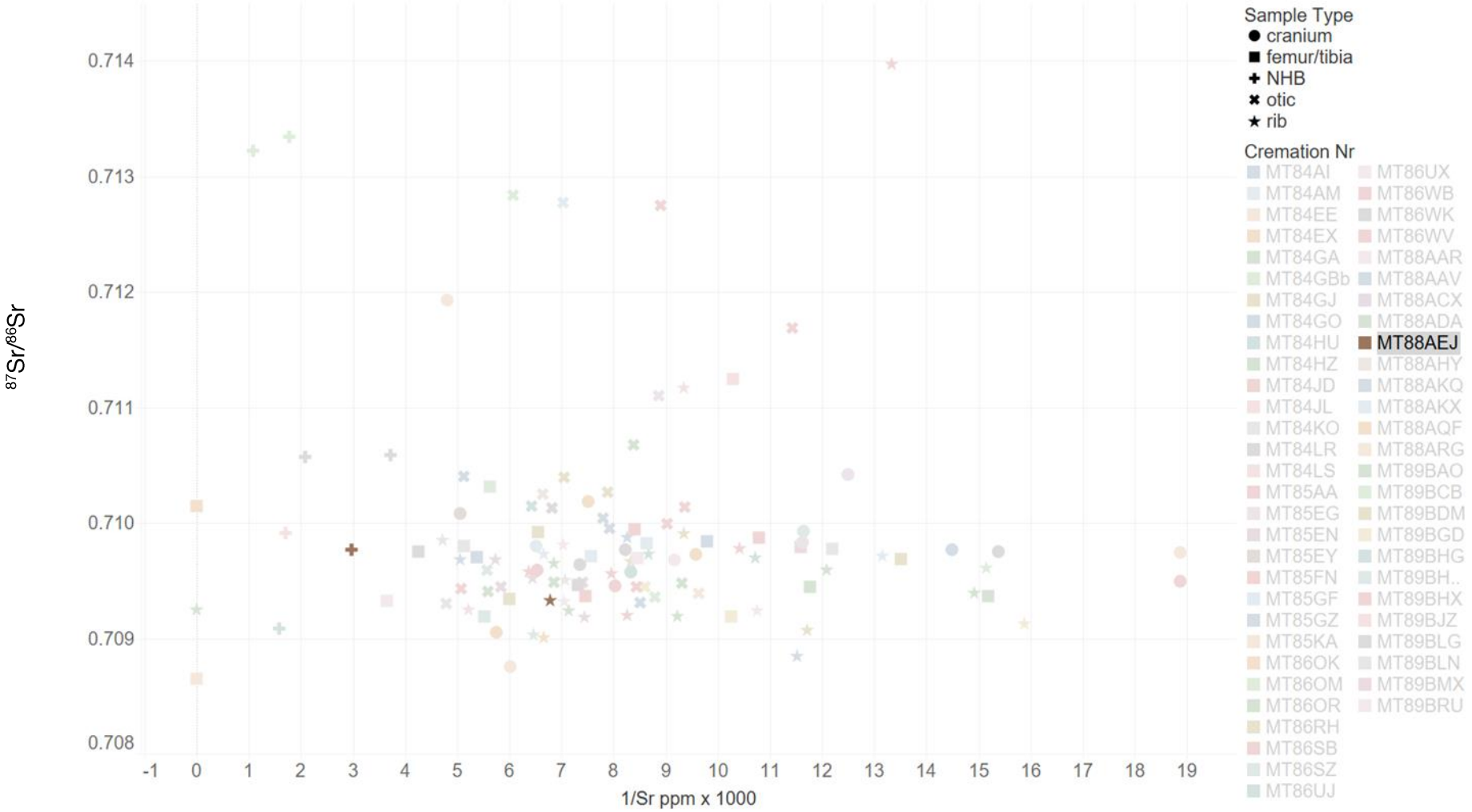
Cremation Nr	Cremation	Sample ID			
639	**MT88AEJ**				**T149**
					Sesamoid HORSE

X 33.80

Y 59.00

Ctxt relationships

Urn 639 cut by urn 624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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT88ARG
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 47 – CLEATHAM 639 – SESAMOID HORSE

Cremation Nr	Cremation	Sample ID			
649	**MT88AKX**			**T020**	**T022**
				Rib	Otic

Age (KS)	YMA	Sex (KS)	F
Age (TL)	YA/YMA	Sex (TL)	M

Justification (age)	Joint condition, fusion stage - looks clear and smooth, younger individual.	Justification (sex)	Orbital rim R - M; external occipital protuberance - M; wide sacral body vs ala.

X	30.90	Ctxt relationships	touching urn 650
Y	45.60		

Cranial	Dentition
min 48 cranial fragments; partial PP with otic exposed; lateral frontal bone with orbital rim R; ext occ protruberance	maxillary RC1

Axial

S1 of sacrum including alae L; several lumbar vertebral bodies (c.3); rib (1 or 2nd) fragment; min 4 vertebral facets

Upper Limb

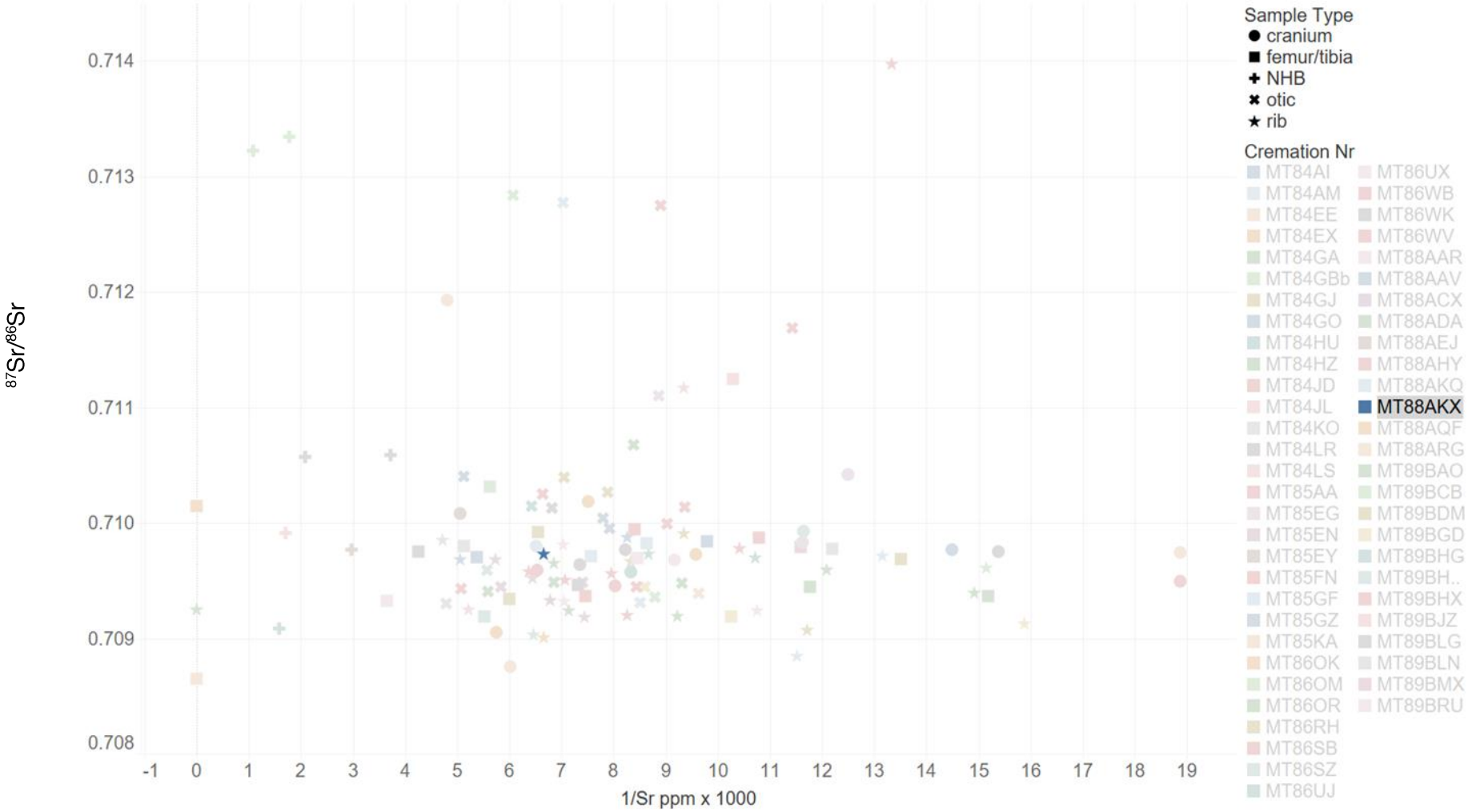
ulna proximal joint surface of olecranon process; lunate and pisiform; 4x prox/intermediate phalanges (distal); humeral shaft fragments; distal humeral shaft frags (L+R); prox shaft radius

Lower Limb

tibial shaft fragments x4; femoral shaft frags including linea aspera x2; navicular L+R; femoral? Prox shaft frag; head of femur with fovea capitis; [5x heads of MT (MC?)+ 4x prox end of prox phalanges - hand/foot?]

Pathology

parietal foramen L (NMT); No CO in R orbit, but small foramina in L; joint surfaces clear and in fair condition; Schmorl's node? On vert body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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT88AHY
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MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 48 – CLEATHAM 649 – RIB, OTIC

Cremation Nr	Cremation	Sample ID			
702	**MT88ADA**		**T030**	**T031**	**T032**
			Rib	Femur	Otic

Age (KS)	YMA	Sex (KS)	?
Age (TL)	YMA	Sex (TL)	?

Justification (age)	Joint surfaces in good condition, but completely fused, therefore individual is an adult; cranial sutures still well defined, clear, but endocranially partially fused	Justification (sex)	Zygoma width - fairly wide - M?

X	32.20	Ctxt relationships	-
Y	73.80		

Cranial	Dentition
c 50 cranial vault fragments; superior zygoma L+R; L+R mad condyles; mandibular fragments including internal cortical bone; maxillary fragment	roots: c 12x single rooted teeth; c 3x double rooted; + 29 frags of poss molar roots/double roots -- a lot of teeth! Poss. 2 individuals?

Axial

partial acromion with lunate (rim) x3; partial superior ischium; 25x vertebral fragments including body and facets; 12x rib frags minimum

Upper Limb

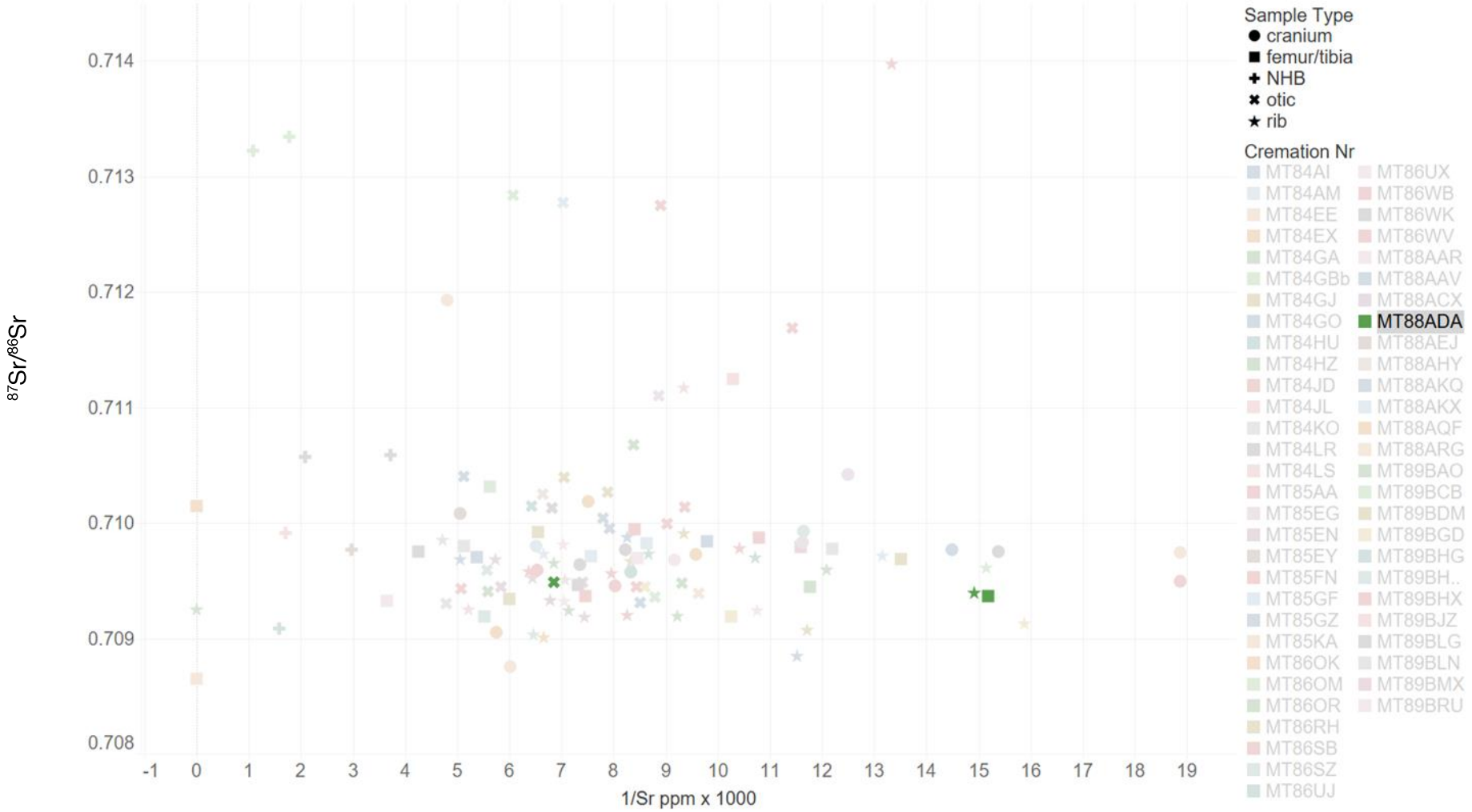
humeral shaft fragments; 2x distal phalanges; 6x int/prox phalanges

Lower Limb

poss femoral shaft frags x3; frags of tibial shaft; head of MT

Pathology

maxillary fragment exhibits porosity in palate; porosity on ectocranial skull fragments (not all); parietal foramen x1 (L) (NMT);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0.713
0.712
0.711
0.710
0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 49 – CLEATHAM 702 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
711	**MT88ACX**			**T018**	**T019**
				Rib	Otic

Age (KS) OMA

Sex (KS) M?

Age (TL) YMA?

Sex (TL) M?

Justification (age) Vertebral joint surfaces are in good condition, no pathology; auricular surface fragment: finely granular + some striae visible? (transverse organisation) - YMA?; cranial sutures almost all

Justification (sex) External occipital protuberance - M?; supraorbital rim R - M?; supraorbital ridge - (M?); sciatic notch - ?

X 30.00

Y 52.30

Ctxt relationships

cut by urn 710

Cranial

c 50 cranial vault fragments (occipital x3); R supraorbital frontal bone; partial PP includin otic; mandible internal cortical bone surface with sockets (single);

Dentition

roots: most are molar fragments, not well cremated

Axial

patial sciatic notch, fragment of auricular surface; fragments of ribs x9

Upper Limb

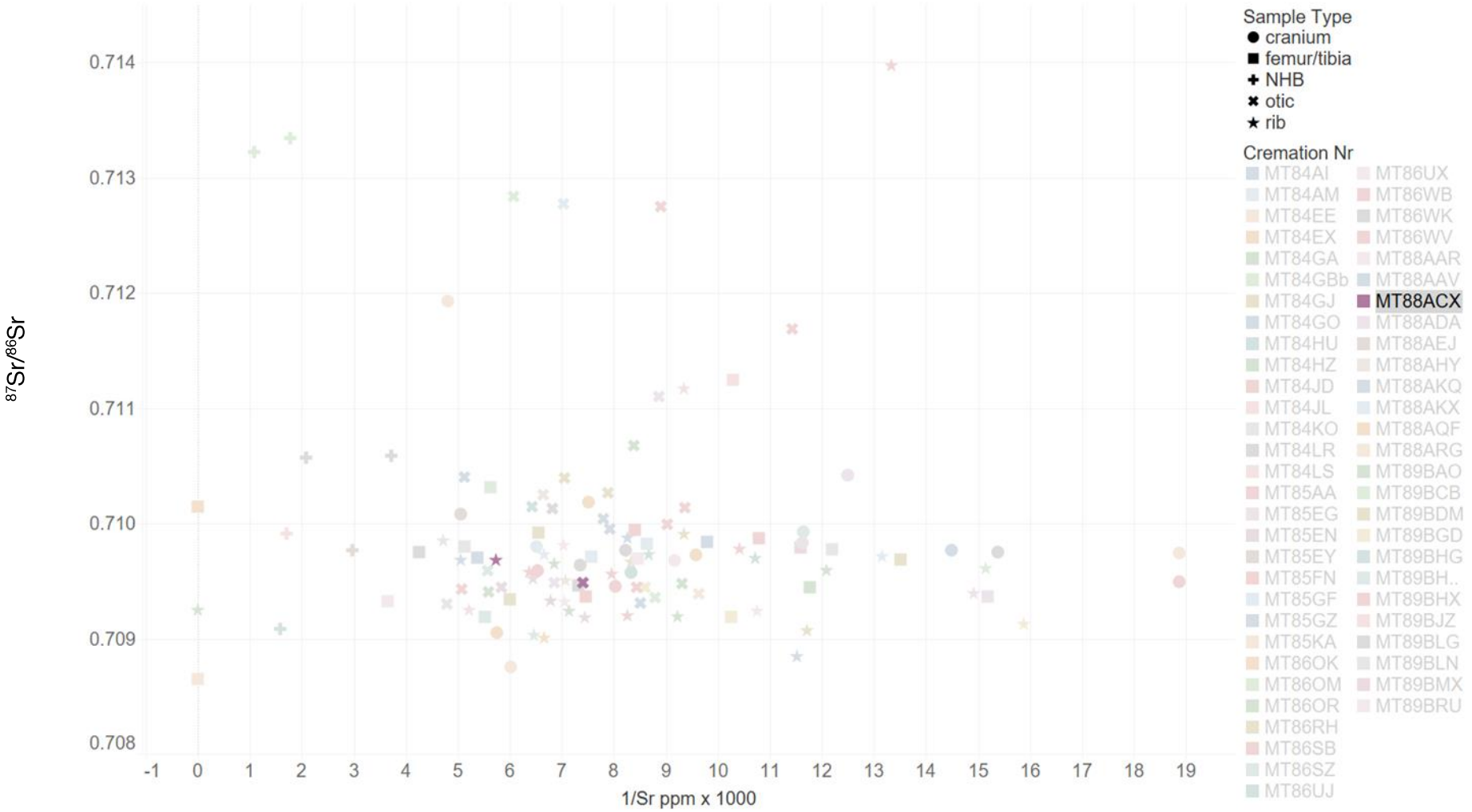
5x distal phalanges (LBG); distal joint frag of humerus; distal joint fragment ulna, partial proximal joint surface of MC; ulna trochanter prox (olecranon)

Lower Limb

superior talus fragment; distal (head) of MT; navicular; femoral fragment?; tibial crest fragments (anterior); [min 6 int/prox phalanges - hand/foot?]

Pathology

CO in L orbit (unilateral) - small foramina, small extent; small pitting on external supraorbital ridge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0.712
0.711
0.710
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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
MT85EG
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 50 – CLEATHAM 711 – RIB, OTIC

Cremation Nr	Cremation	Sample ID			
728	**MT88AAV**		**T023**	**T024**	**T025**
			Rib	Femur	Otic

Age (KS) YA

Sex (KS) F?

Age (TL) YA/YMA

Sex (TL) F?

Justification (age) Vertebral bodies and joint surfaces in good condition; one facet with degenerative changes to the joint surface (YMA?).

Justification (sex) Supraorbital rim, sharp - F; supraorbital ridge, straight - (F); supra-auditory ridge - F?/I; gonial angle - F? (warping?)

X 29.00

Y 81.30

Ctxt relationships

almost touching urn 730

Cranial

30+ cranial vault fragments; central frontal bone and R superior orbit; mandibular caronoid process and condyle; temporal frags; sphenoid wing

Dentition

-

Axial

min 6 vertebral body fragments; C2 central body with dens; S1 body fragment

Upper Limb

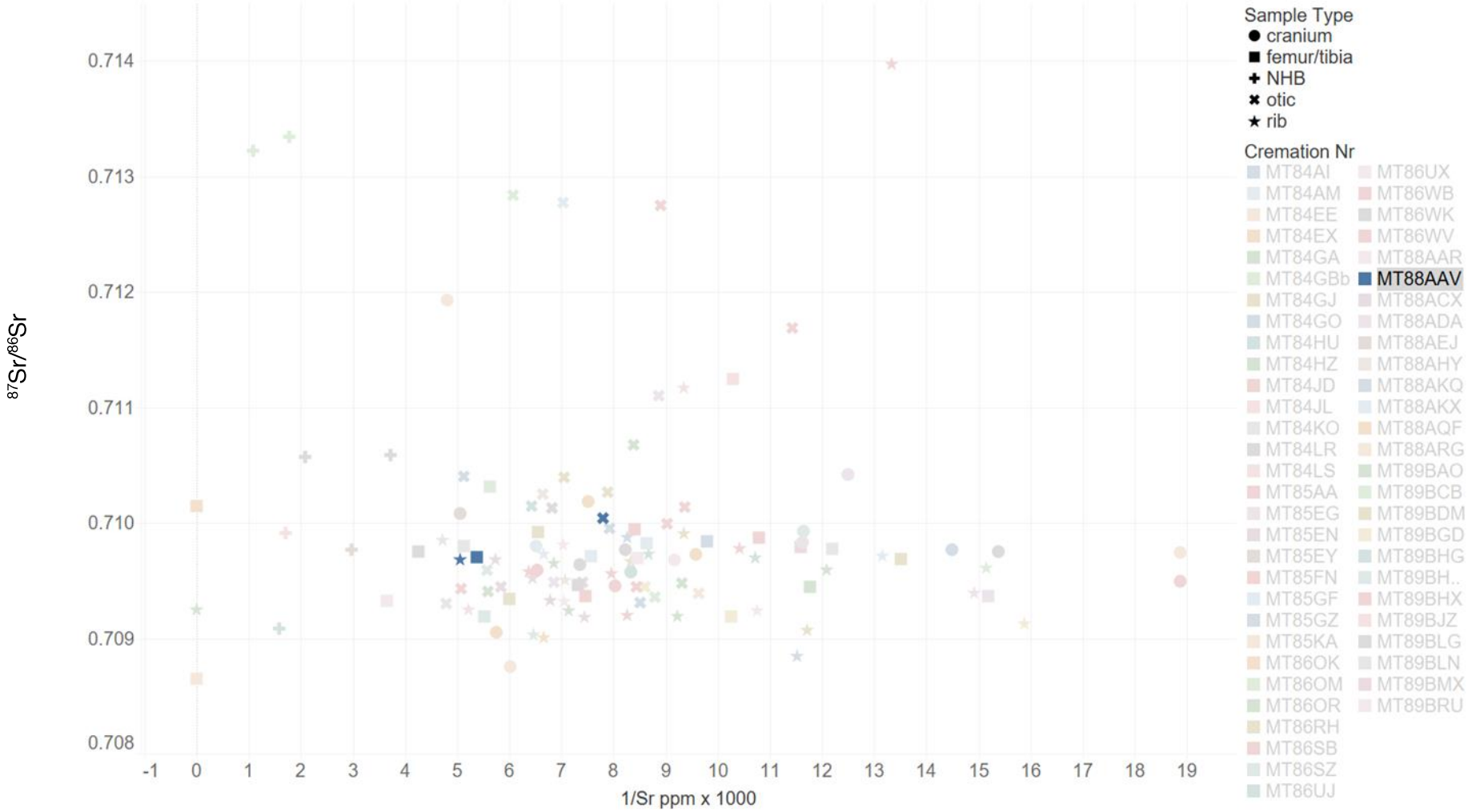
distal joint surface fragment of humerus, int/prox phalanges x2 distal; frags of radial and ulnar shaft

Lower Limb

patella fragment; frags of femoral shaft and tibia (anterior crest)

Pathology

None observed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0.712
0.711
0.710
0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
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MT84JD
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MT84LR
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 51 – CLEATHAM 728 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
730	**MT88AAR**			**T012**	**T013**
				Occipital	Rib

Age (KS)	Adult	Sex (KS)	F??
Age (TL)	Adult	Sex (TL)	F?

Justification (age)	Cranial sutures partially fused; size.	Justification (sex)	F? - gracile, especially L temporal bone and supra-auditory ridge; external occipital protuberance - smooth, slightly bulging - F?

X	19.40	Ctxt relationships	almost touching 728
Y	81.40		

Cranial	Dentition
c 37 cranial vault fragments; occipital frag; L temporal - aspect around auditory meatus; internal cortical surface mandible; PP including otic frag	-

Axial

rib fragments x2?

Upper Limb

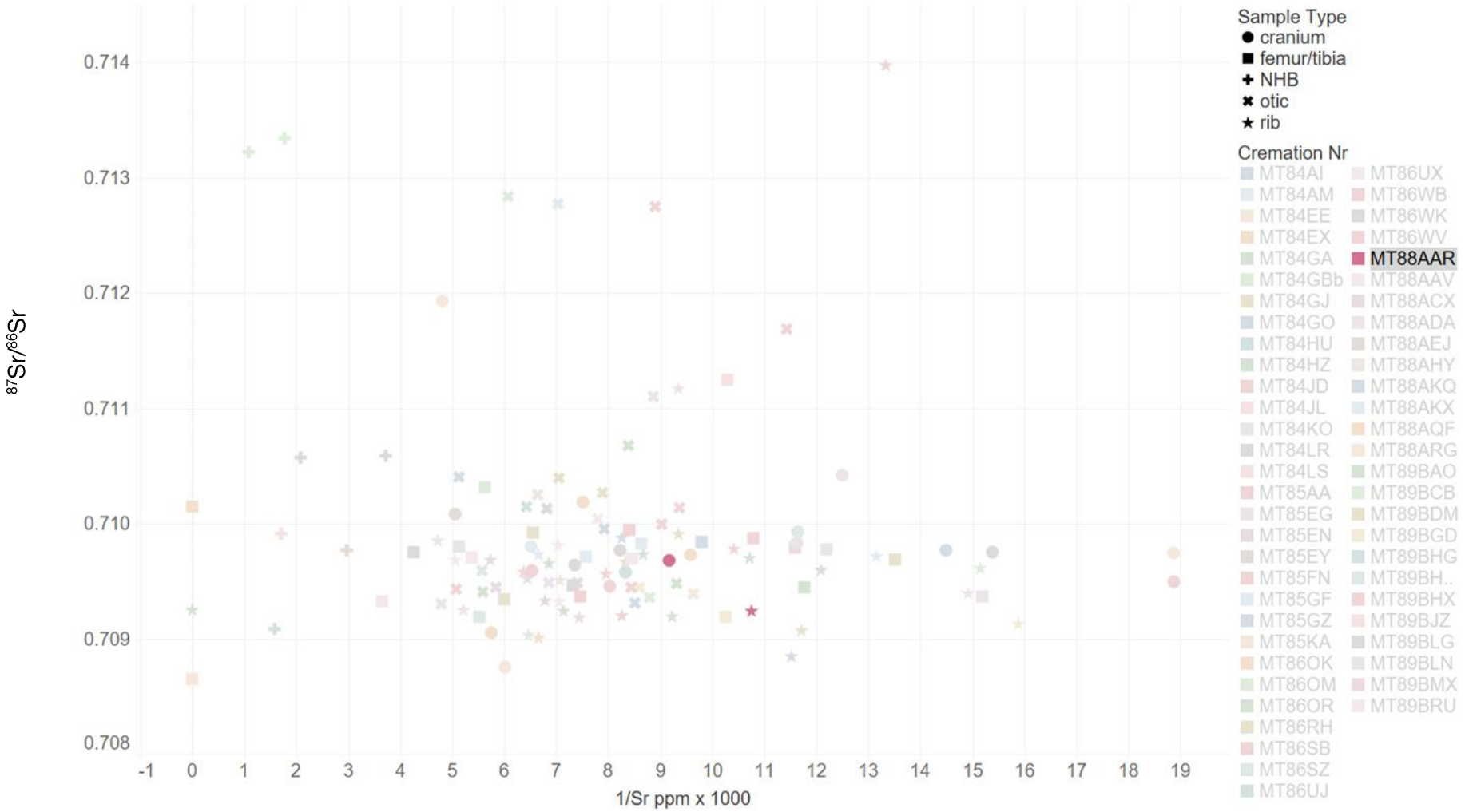
-

Lower Limb

-

Pathology

None observed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0.709
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
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MT84AM
MT84EE
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MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 52 – CLEATHAM 730 – OCCIPITAL, RIB

Cremation Nr	Cremation	Sample ID			
809	**MT88ARG**				**T056**
					Cranium

Age (KS) YMA

Sex (KS) ?

Age (TL) YMA?

Sex (TL) ?

Justification (age) Cranial sutures clear and well defined, teethy; roots complete (only 2 present); YA/YMA, younger spectrum.

Justification (sex) Not enough indicators present.

X 9.40

Y 71.40

Ctxt relationships

Possibly 808

Cranial

19 cranial vault fragments, L temporal bone with TMJ (DBG); partial PP

Dentition

2 root fragments

Axial

-

Upper Limb

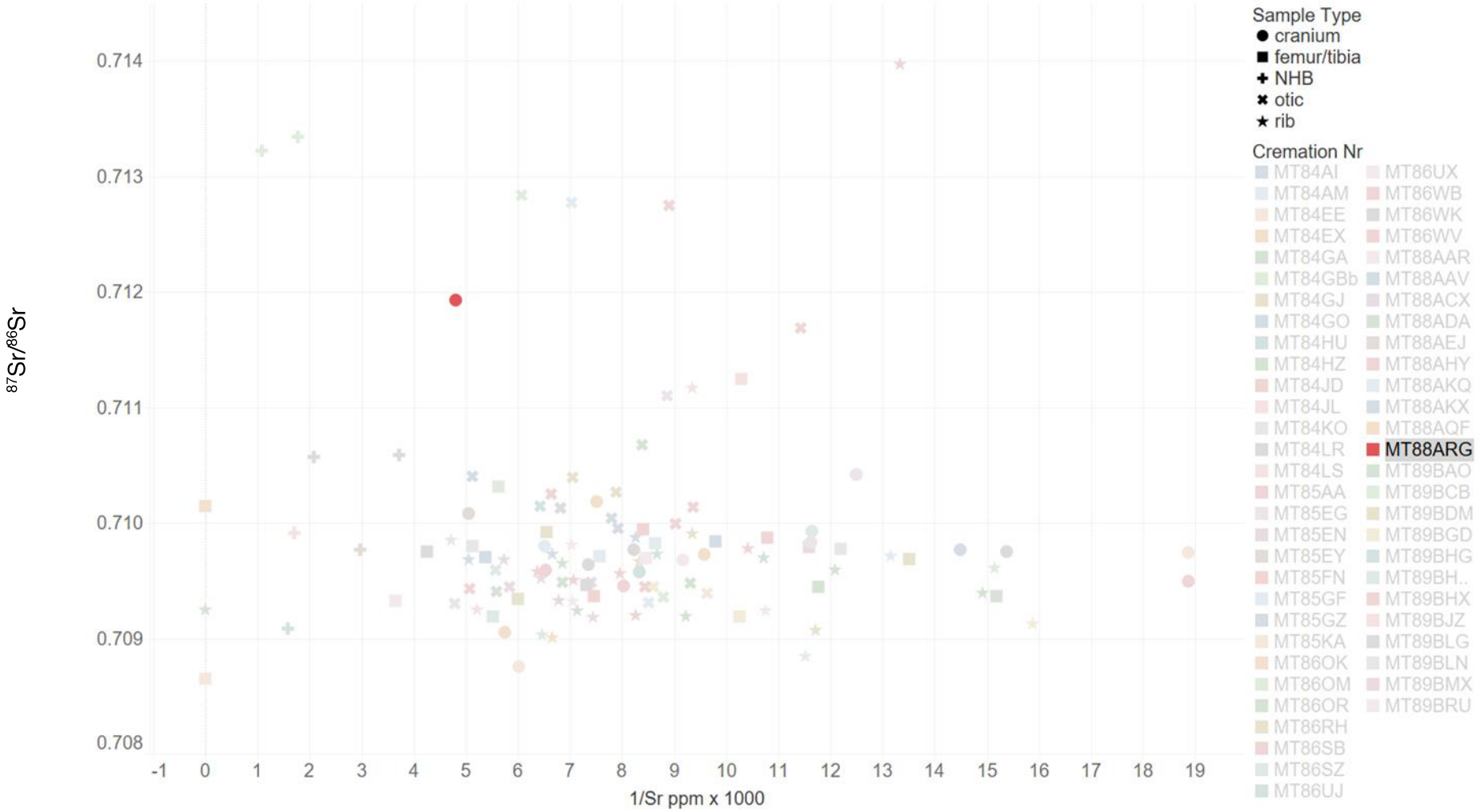
-

Lower Limb

4x distal ends of prox/intermediate phalanges - hand/foot?

Pathology

None observed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0.712
0.711
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0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
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MT88ARG
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 53 – CLEATHAM 809 - CRANIUM

Cremation Nr	Cremation	Sample ID			
815	**MT88AKQ**			**T061**	**T062**
				Rib	Otic

Age (KS)	YMA	Sex (KS)	F
Age (TL)	YA	Sex (TL)	F

Justification (age)	Adult according to joint fusion stages; pubic symphysis ageing: clear ridging, furrows – Suchey-Brooks Phase I-I or I-II: ca 15-24 YA; vertebral joints/facets in good condition - YA possible.	Justification (sex)	Pubic symphysis L - F; zygoma narrow - F?; gonial flare/ angle - F?; R lateral orbit - F?

X	41.20
Y	92.30

Ctxt relationships

-

Cranial

51x cranial vault fragments (thin); narrow zygomatic process; PP central; L gonium mandible; R lateral frontal including orbit; partial sphenoid bone

Dentition

roots: 8x molar root frags or double roots; 3x single rooted teeth inclunding max RI' poss max C1

Axial

pubic symphisis (with partial surface); at least 6 larger rib frags - 1 unburnt; scapular fragments of acromion

Upper Limb

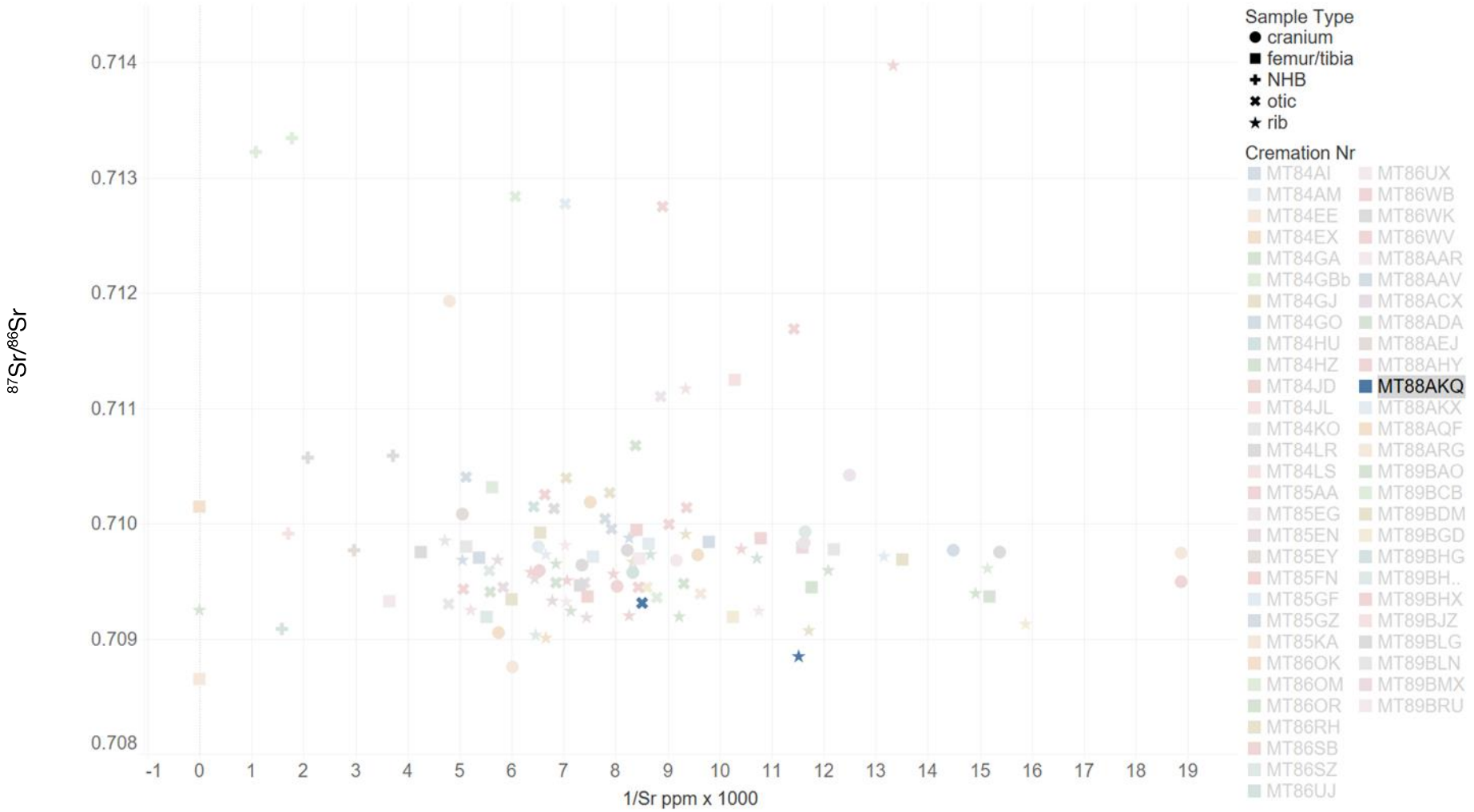
shaft of ulna x3;

Lower Limb

femoral? Shaft frags

Pathology

None observed


$^{87}Sr/^{86}Sr$
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0.712
0.711
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0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
MT85EG
MT85EN
MT85EY
MT85FN
MT85GF
MT85GZ
MT85KA
MT86OK
MT86OM
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MT86WV
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MT88ACX
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 54 – CLEATHAM 815 – RIB, OTIC

Cremation Nr	Cremation	Sample ID			
828	**MT88AQF**			**T095**	**T096**
				Occipital	Femur

Age (KS)	YMA	Sex (KS)	?
Age (TL)	YMA	Sex (TL)	M

Justification (age)	Joint surfaces appear to be in fair condition where observable, but some entheseal changes to them.	Justification (sex)	External occipital protuberance, very well defined and bulky - M; zygoma (frag), wide - M?; zygomatic process also quite large - M?

X	7.40
Y	48.50

Ctxt relationships

-

Cranial

cranial vault frags incl at least 2 occipital; frontal: lateral R orbit and R superior zygoma

Dentition

roots: 6x frags including ca 3 from molar teeth

Axial

fragment of auricular surface

Upper Limb

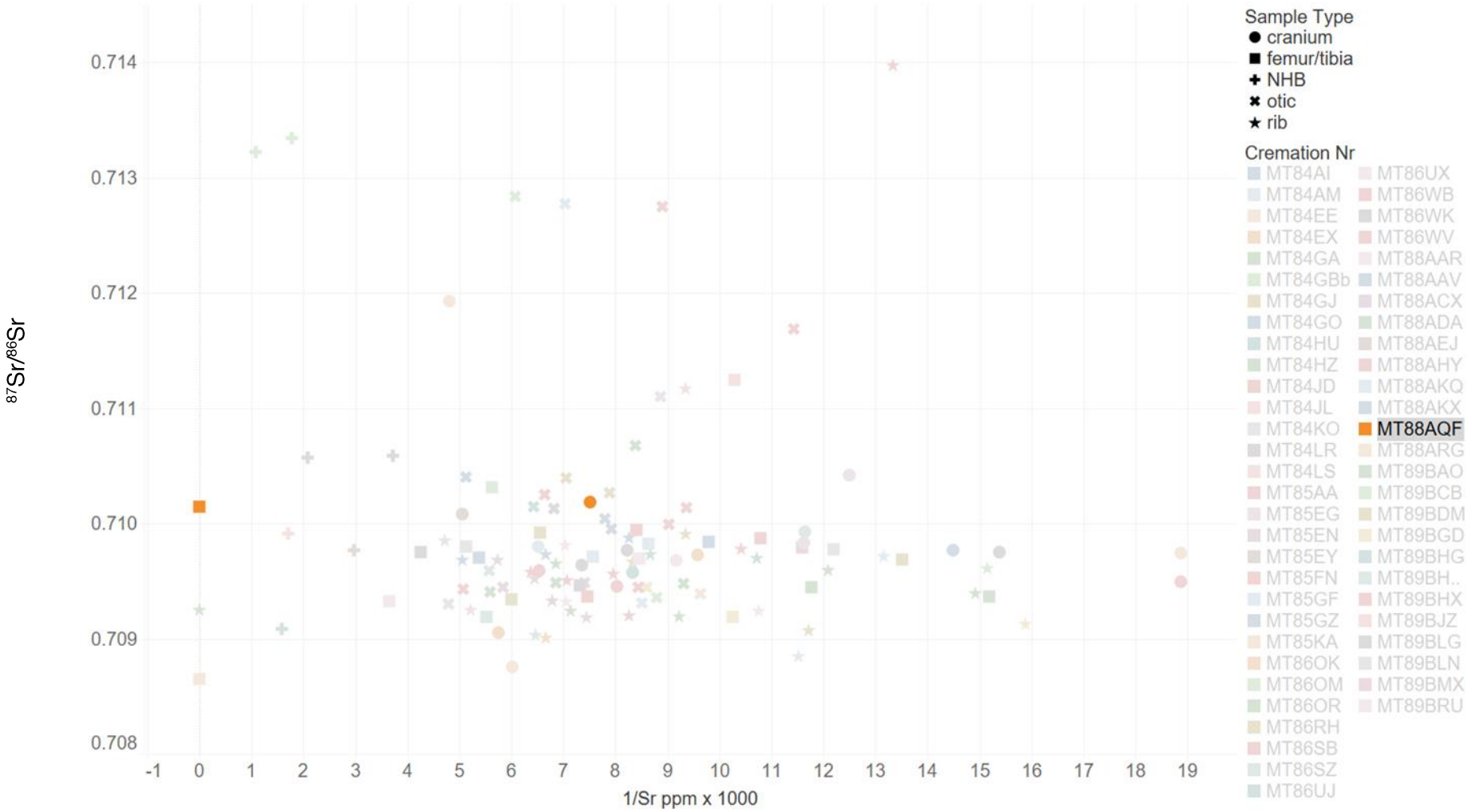
distal phalanx x1; distal ulna joint fragment; humeral shaft fragments ca 5

Lower Limb

femur including linea aspera; tibia including fragment of crest; talus frags x2

Pathology

entheseal changes on proximal femur and on humeral shaft


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
0.710
0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 55 – CLEATHAM 828 – OCCIPITAL, FEMUR

Cremation Nr	Cremation	Sample ID			
852	**MT89BGD**		**T130**	**T131**	**T132**
			Rib	Femur	Otic

Age (KS)	Adult	Sex (KS)	F
Age (TL)	OMA	Sex (TL)	M?

Justification (age)	Degenerative changes to the joint surface of on hand phalanx and in spine (DDD); most of the cranial sutures are fairly well fused - advanced age.	Justification (sex)	Supra-mastoid ridge, distinct - M?; R lateral supraorbital rim, blunt - M?; L superior aspect of zygoma, narrow - ?

X	26.70
Y	83.10

Ctxt relationships

-

Cranial

18x crtanial vault fragments; R lateral superior orbit of frontal bone including zygomaticofrontal suture; L zygoma superior, central PP frag with partial otic capsule; temporal bone fragment with supra-auditory ridge

Dentition

-

Axial

vertebral fragments: x3 facets; 4x rib fragments

Upper Limb

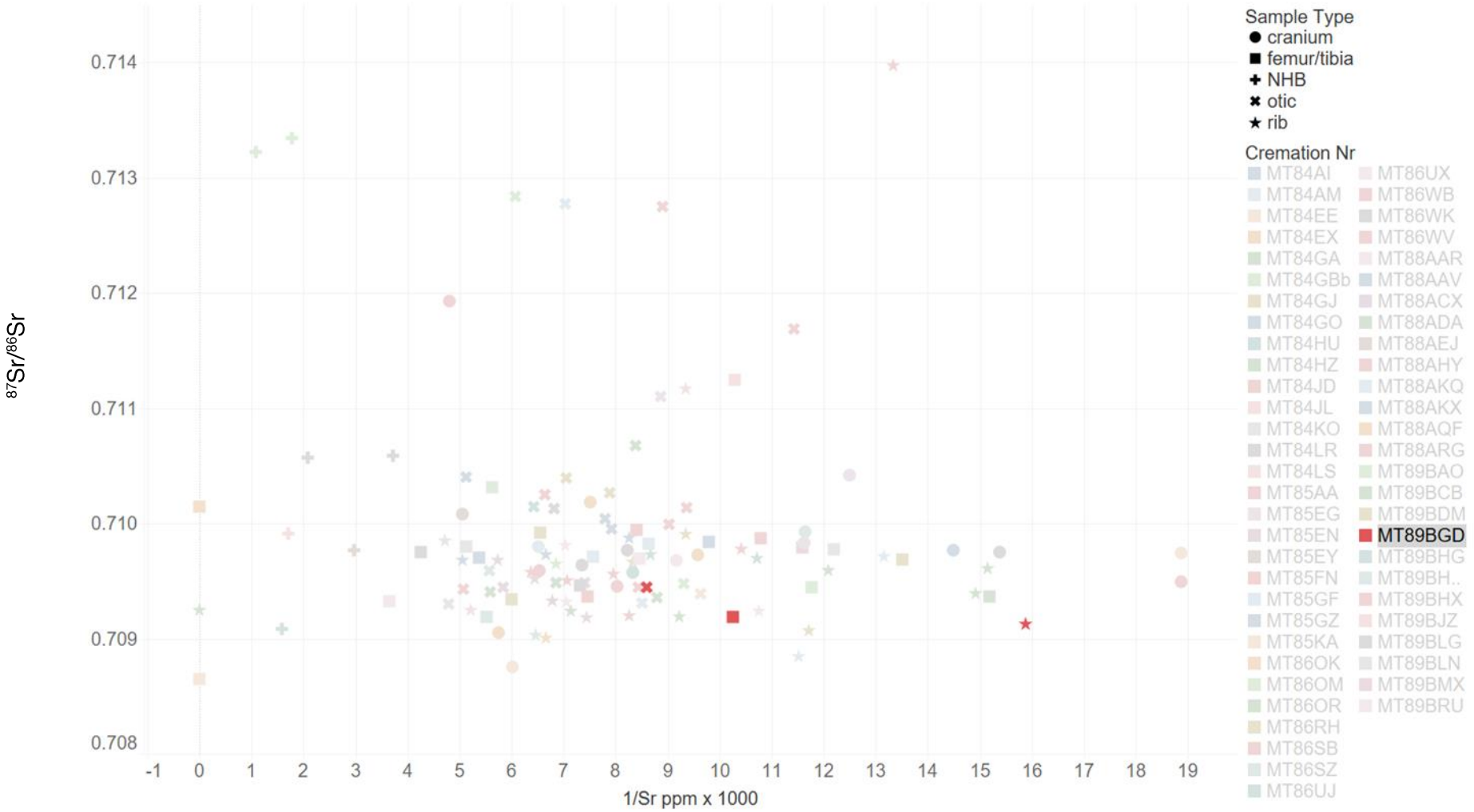
3x phalanges int/prox - distal aspect; 1 distal phalanx with osteophytes on distal end; ulna shaft? Frags/ may be radial shaft

Lower Limb

talus fragment; tibiae anterior crest; femoral frags x1

Pathology

osteophytes around vertebral facet; also around distal phalanx


$^{87}Sr/^{86}Sr$
0.714
0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
MT85EG
MT85EN
MT85EY
MT85FN
MT85GF
MT85GZ
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MT88AHY
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MT88AKX
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MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 56 – CLEATHAM 852 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
873	**MT89BDM**		**T041**	**T042**	**T043**
			Rib	Femur	Otic

Age (KS)	OMA	Sex (KS)	F
Age (TL)	Adult	Sex (TL)	F?

Justification (age)	Joint surfaces look fair and clear, age cannot be narrowed down but individual is likely at younger spectrum.	Justification (sex)	Supraorbital rim - F?; external occipital protuberance - F?; mastoid process R – F.

X	39.80
Y	80.80

Ctxt relationships

-

Cranial

c 34x cranial vault fragments; superior aspect of mandibular ramus; anterior surface of internal mandible; R frontal bone fragment including orbital rim; occipital bone; PP fragment x2; mastoid process R; R temporal and zygomatic process

Dentition

roots: 18 fragments of mainly molar teeth

Axial

scapula fragment with partial coronoid process; spinous processes of min 2 vertebrae; facest: C1 R sup + L inf; lunate surface of acromion

Upper Limb

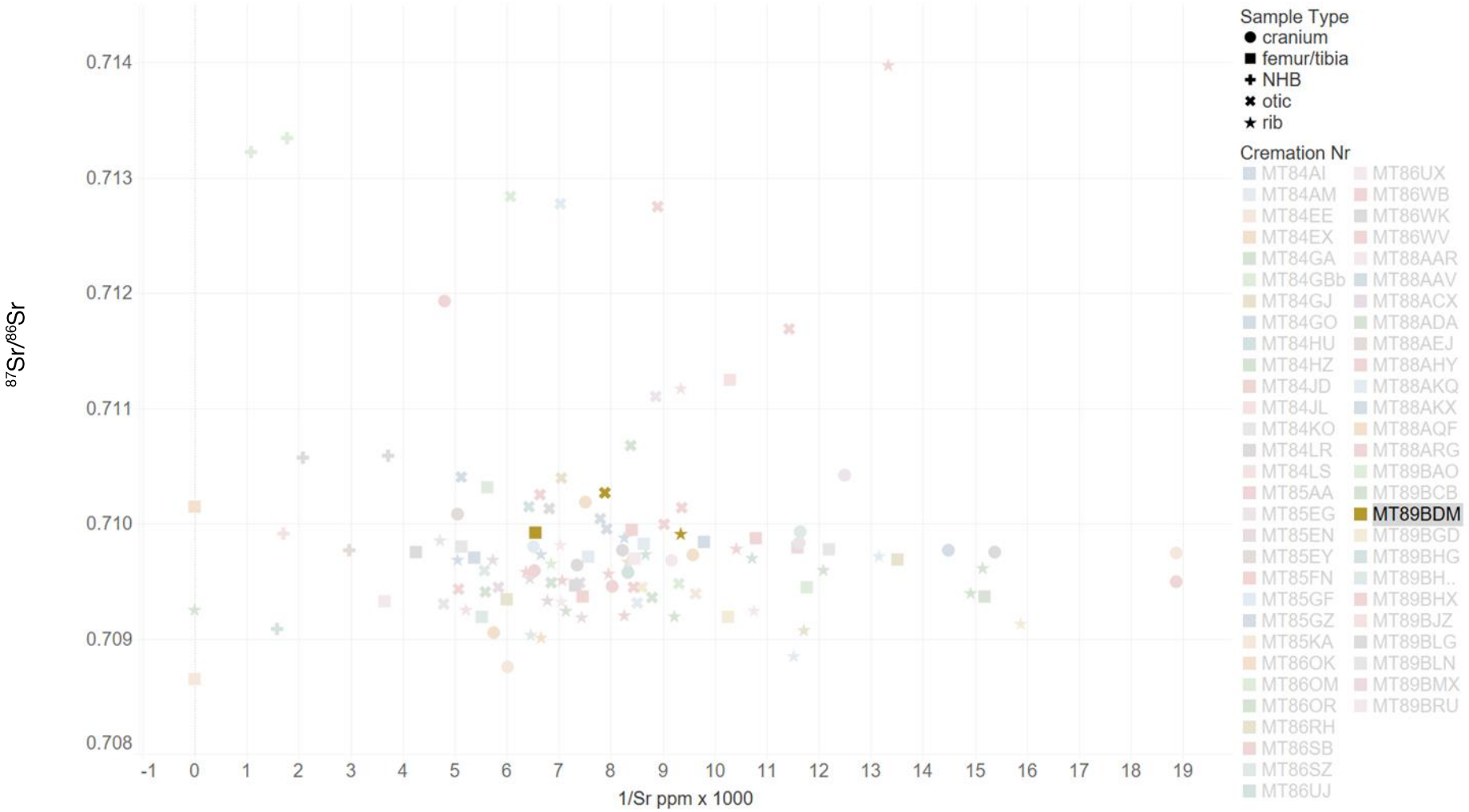
distal humerus joint surface fragment; radial heads x2 L+R including proximal shaft; radius/ulna shaft frags min 3; humeral head

Lower Limb

femoral shaft fragments including linea aspera; calcaneous R almost complete; navicular fragment L+R' patella 2x fragments; distal femur joint surface; tibial shaft frags min x5

Pathology

some slight porosity on R frontal bone and on some ectocranial surfaces; some entheseal changes along linea aspera of femor; slight entheseal changes along tibial shaft?


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
MT85EG
MT85EN
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 57 – CLEATHAM 873 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
889	**MT89BAO**		**T006**	**T007**	**T008**
			Rib	Femur	Otic

Age (KS)	YMA	Sex (KS)	M
Age (TL)	YMA/OMA?	Sex (TL)	M?

Justification (age)	Auricular surface does not exhibit much macroporosity and appears mostly dense. No apical activity, no transverse organisation - older individual?; cranial sutures are mostly closed and completely fused where observable.	Justification (sex)	Supraorbital rim, blunt - M?; robust bones.

X	47.60	Ctxt relationships	-
Y	81.70		

Cranial	Dentition
c 26 cranial vault frags; L temporal: superior aspect of auditory meatus; and zygomatic process; mastoid process; PP fragment; R lateral frontal with supraorbital rim; L+R mandibular condyles; 4x internal cortical surface of mandible including sockets	roots: max? I2?;

Axial

L+R partial auricular surfaces (only R present); partial superior aspect of scapula; humeral head; several rib fragments including head and necks; several vertebral body fragments; C1 dens articular surface; C2 dens

Upper Limb

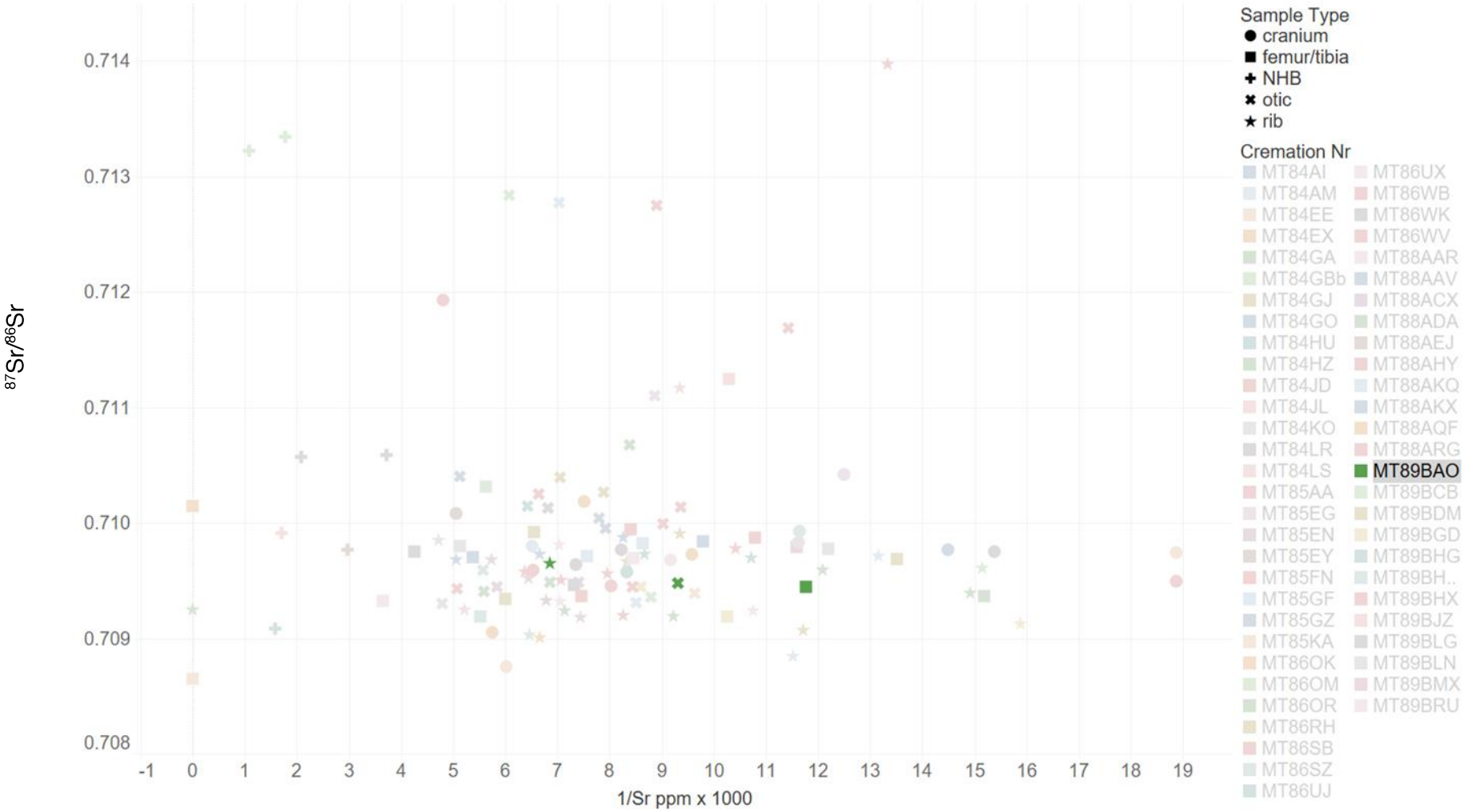
humeral shaft fragments, radial heads L+R; joint surface of distal ulna; c 4x distal prox/intermediate phalanges

Lower Limb

femoral shaft fragments including linea aspera x4; talus fragments; navicular fragments; at least 1 proximal proximal phalanx with cortical defect; distal phalanx with articulation on dorsal surface - L+R with changes

Pathology

DJD on vertebrae (bodies and facets); osteophytes on distal phalanges (feet?) and pseudo-facets


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT84LS
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MT88AHY
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MT88AQF
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 58 – CLEATHAM 889 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
897	**MT89BCB**			**T126**	**T127**
				Rib	Otic

Age (KS)	YMA	Sex (KS)	M
Age (TL)	YMA	Sex (TL)	M?

Justification (age)	Joints are mostly smooth and well defined; cranial sutures are still clear and sharp - YMA.	Justification (sex)	Supraorbital rim (damaged), fairly blunt - M?; robust size of bones, especially the unburnt clavicle, scapula, and the pelvis - M?.

X	42.60	Ctxt relationships	-
Y	79.10		

Cranial	Dentition
minimum 18 cranial vault fragments; lateral aspect of L frontal bone including orbital rim; R superior zygoma; partial maxilla with sockets (premolar?); R mandible (black) with condyle; mandibular fragment with socket; PP fragment; otic frag small	roots: max LI1; lateral? Max incisor; additional frag of root

Axial

min 28 rib fragments; acromion (black) x2 probably L+R; vertebral fragments: facets and bodies, 2 thoracic vert either fused or stuck together by mud; dens of C2

Upper Limb

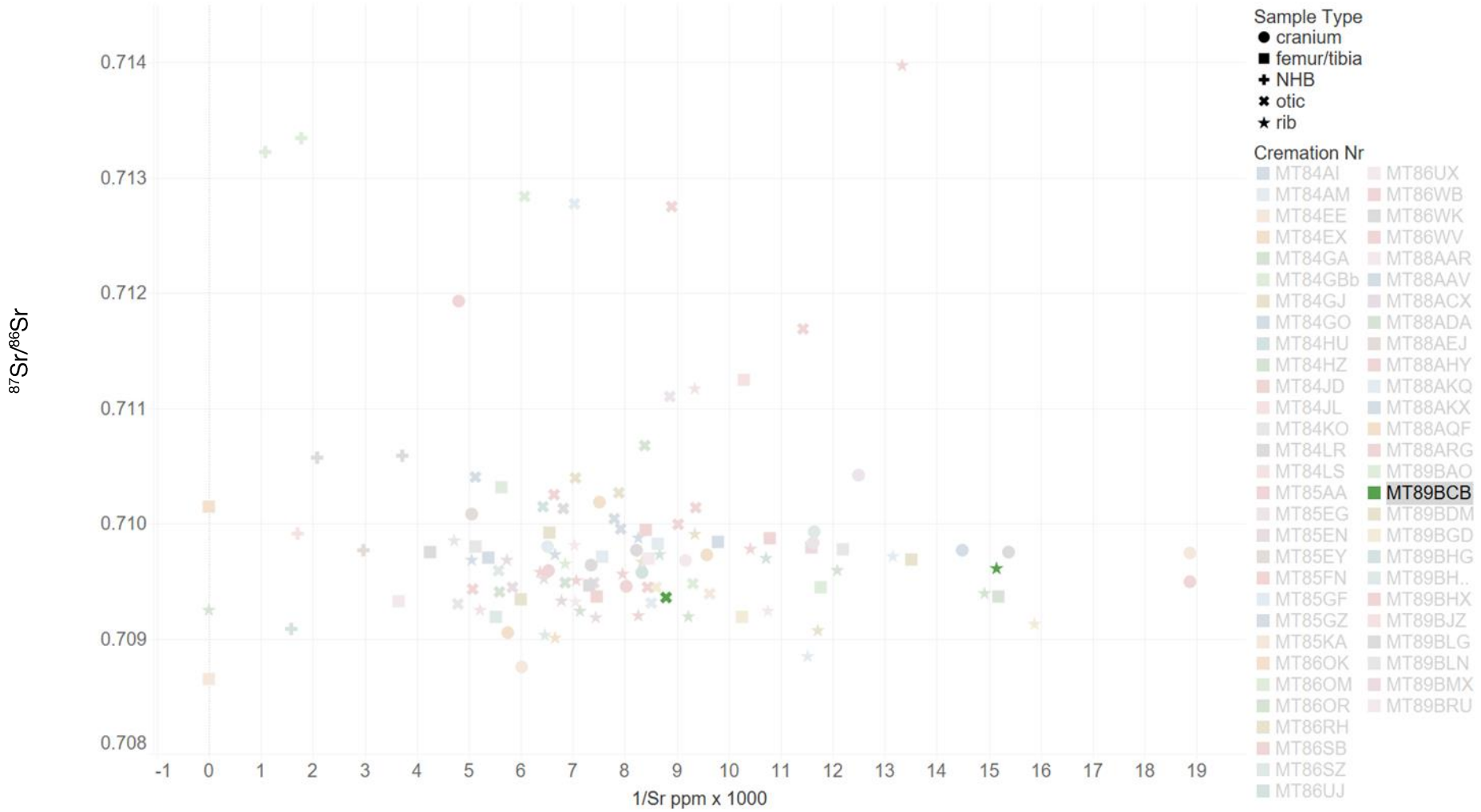
humeral head (Black/DBG); prox ulna shaft frag (white); phalanges 3x prox/int (distal)

Lower Limb

some LB fragments (black); anterior tibiae (white)

Pathology

porosity on lateral orbital ridge of frontal bone; slight porosity and contour change on lower rib head, others look in good condition; most vertebral facets appear smooth and clear


$^{87}Sr/^{86}Sr$
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0.713
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0.711
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0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 59 – CLEATHAM 897 – RIB, OTIC

Cremation Nr	Cremation	Sample ID			
900	**MT89BHX**		**T009**	**T010**	**T011**
			Rib	Femur	Otic

Age (KS)	YA	Sex (KS)	F
Age (TL)	YMA-OMA	Sex (TL)	F?/Ind

Justification (age)

Joint surfaces are fairly used; C1 dens articulation with MO; C1 superior and inferior facets in good condition; lumbar? Body + rib articulation with porosity and contour change; partial fusion of cranial sutures - likely YMA-OMA.

Justification (sex)

Zygoma narrow - F?.

X	34.80
Y	79.40

Ctxt relationships

-

Cranial

c 41 cranial vault fragments; temporal bone fragment including superior auditory meatus; PP frag; fragment of auricular surface; mandible x2 with internal sockets x2; mandibular condyle; superior zygoma x2 L+R

Dentition

roots: ca 17 frags, most of these are from multiple-rooted teeth

Axial

lateral 1/2 of R clavicle; sciatic notch of pelvis L; partial scapula; vertebral fragments: 6x bodies' 8x facets, C1 dens articular facet, C1 L superior and inferior facets; occipital condyle; acromion with contour change; c 10 rib fragments

Upper Limb

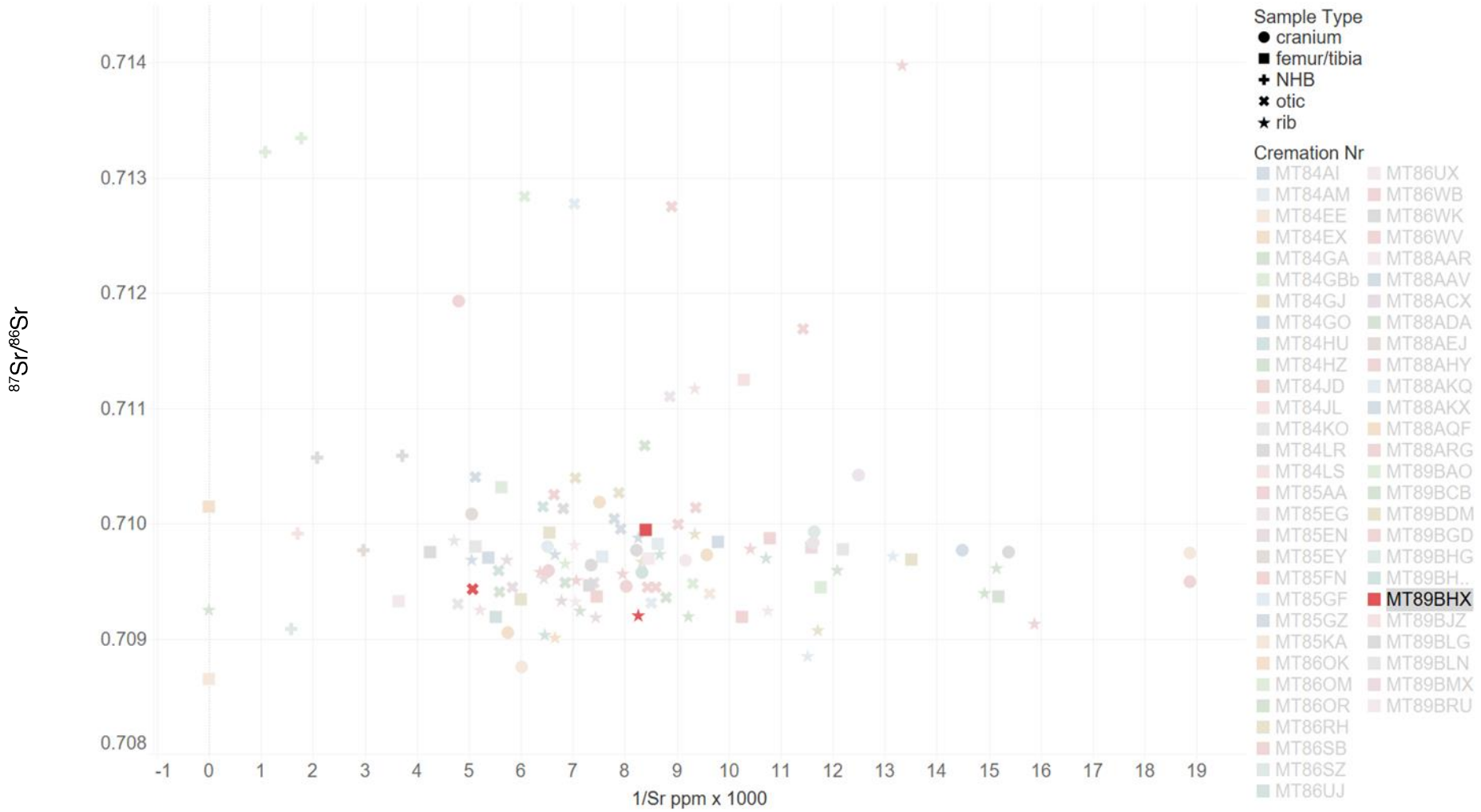
proximal radius (radial head) - unburnt; humerus? Fragments with possible fracture and osteomyelitis

Lower Limb

femoral shaft fragments with linea aspera; talus superior fragment; patella fragment?; 5th MT prox end, distal end (head) of MT, long bone fragment - probable tibia, with lamellar striae - active!; distal femoral joint surface, epicondyles x2; [2x int/prox phalanges - hand/foot?]

Pathology

This individual appears to have had a fracture/ injury in one of their longbones - probably the humerus or tibia. Disorganised areas of trabecular bone with ossification around cortical bone, the cortical structure is disorganised in some areas - osteomyelitis?; additional smaller bone fragment (less well cremated) showing a fracture with external ossification of soft tissue; fragment of likely tibia with lamellar striations which appear sharp and fairly active - transitionsl new bone - periostits? including a small nodule of lamellar-woven bone (transitional); mandibular torus (DD: button osteoma) 5mm dia, very distinct nodule of dense cortical bone, extending ca 3mm above normal bone surface (NMT?); cortical defect in acromion.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0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
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MT88ADA
MT88AEJ
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MT88AQF
MT88ARG
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 60 – CLEATHAM 900 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
910	**MT89BHW**		**T079**	**T080**	**T081**
			Rib	Femur	Otic

Age (KS)	Adult	Sex (KS)	F?
Age (TL)	Adult	Sex (TL)	Ind

Justification (age)	Joint surfaces (only few available) - YMA, maybe YA, appear smooth and clear; cranial sutures fairly clear and sharp, partially fused - YMA - younger adult.	Justification (sex)	Supraorbital rim L - ?; gracile - F?

X	35.70	Ctxt relationships	touching urn 899
Y	79.20		

Cranial	Dentition
25 cranial vault fragments; 2x greater wing of sphenoid; small maxilla fragment with socket; central PP; frontal bone lateral aspect L, supraorbital rim	roots: some fragments of molar roots and single-rooted teeth (hypercementosis)

Axial

3x rib fragments; 3x vertebrae fragments; C1 L vertebra, superior and inferior facets (superior is double facet

Upper Limb

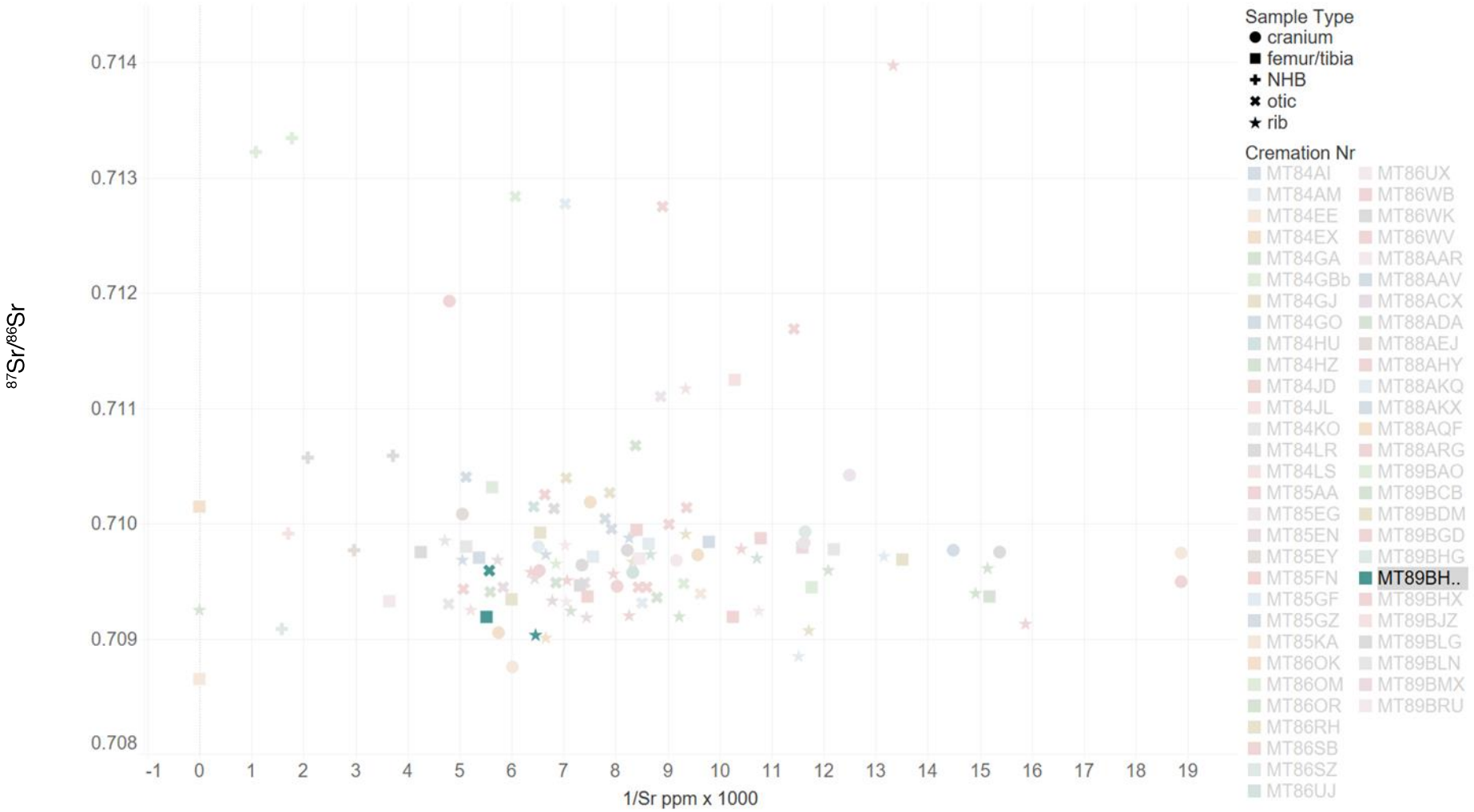
-

Lower Limb

tibia shaft fragment x2; distal fragment of phalanx (1st?)

Pathology

porosity (small foramina) on endocranial surface of cranium; hypercementation on molar and single-rooted tooth


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
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0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 61 – CLEATHAM 910 – RIB, FEMUR, OTIC

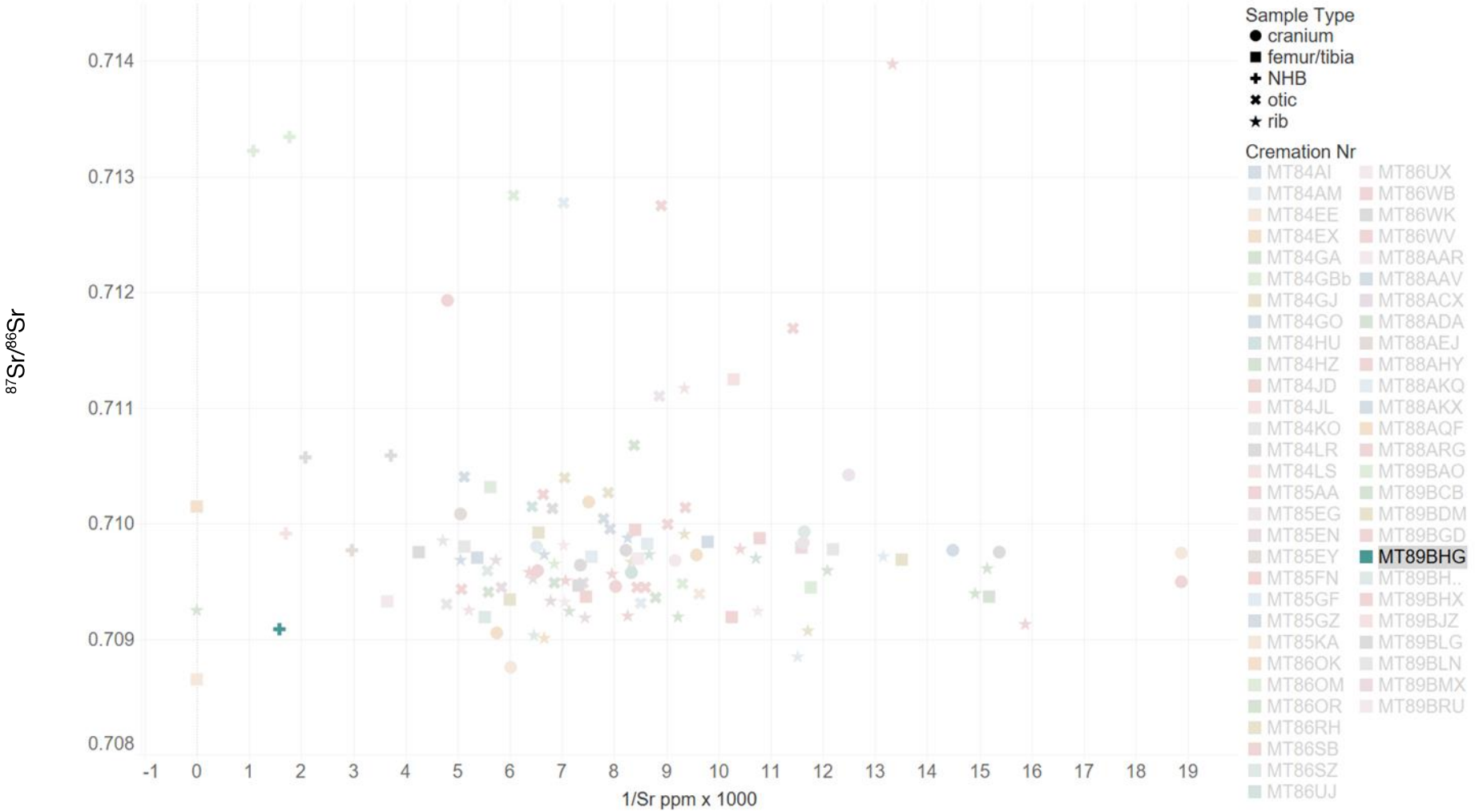
Cremation Nr	Cremation	Sample ID			
920	**MT89BHG**				**T150**
					Sesamoid HORSE

X 36.30

Y 76.40

Ctxt relationships

sherds of 1196, 1197 with this urn


$^{87}Sr/^{86}Sr$
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0.713
0.712
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
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MT89BGD
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MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 62 – CLEATHAM 920 – SESAMOID HORSE

Cremation Nr	Cremation	Sample ID			
961	**MT89BJZ**				**T039**
					Rib

Age (KS)	subadult	Sex (KS)	?
Age (TL)	OMA	Sex (TL)	?

Justification (age)	Suture fusion of cranium suggest adult; sagittal suture of cranium almost completely fused and obliterated; max LM1 or LM2 is worn down to CEJ (cementoenamel junction) - older adult.	Justification (sex)	External occipital protuberance, small nodule pointing inferiorly - ?; Gonial angle appears rounded, no large flare - F?; 'gracile'

X	34.60
Y	72.60

Ctxt relationships

Cranial

27x cranial vault fragments; L lateral orbital rim of frontal bone; occipital part with ext occ protruberance; mandibular angle

Dentition

max RC; max incisor; max L molar (1st/2nd); 4/5x molar roots of mandible

Axial

ribs: min 4x fragments

Upper Limb

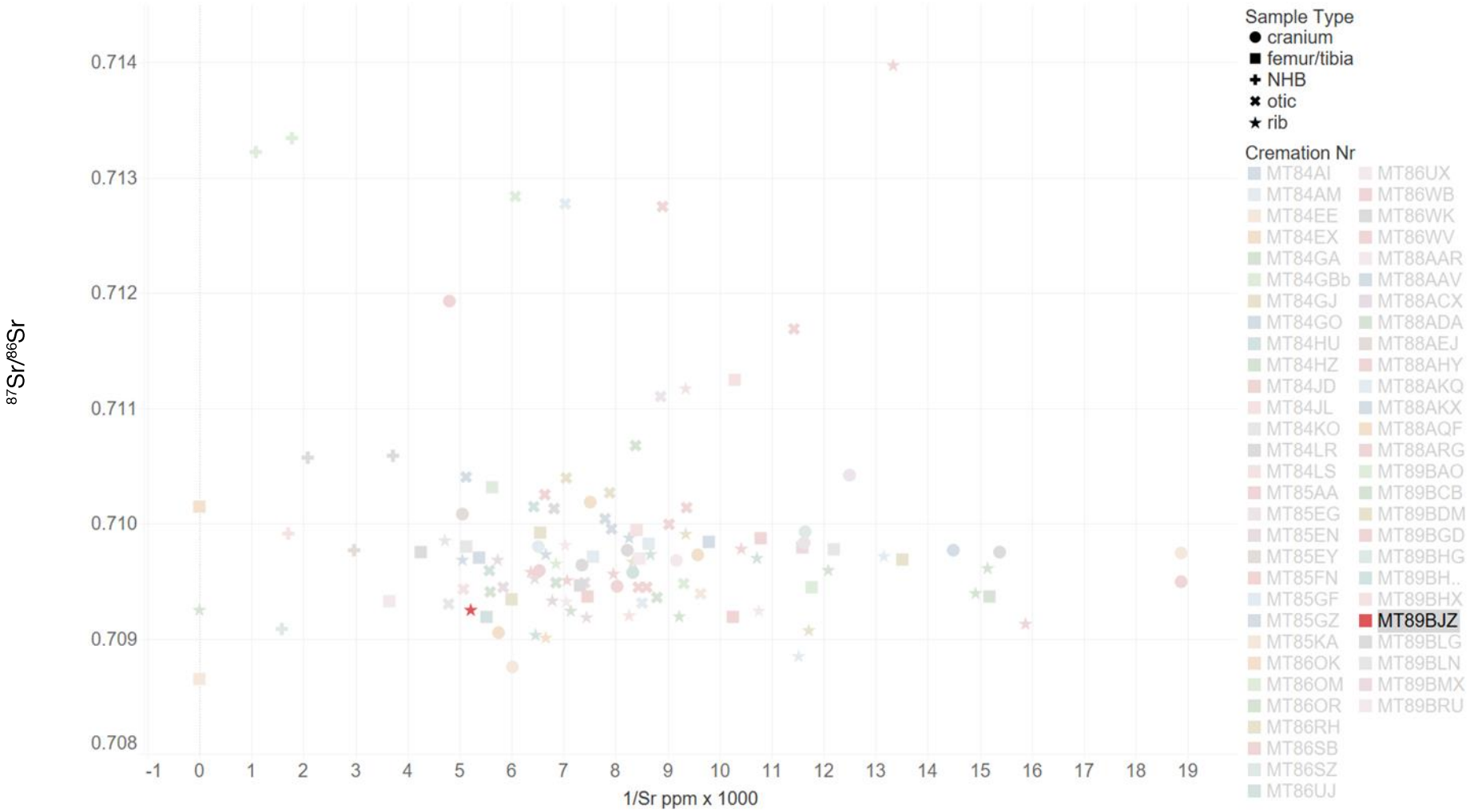
fragment of distal humeral joint surface

Lower Limb

femoral shaft fragments

Pathology

slight porosity on ectocranial surface of vault fragments (parietals along sagittal suture


$^{87}Sr/^{86}Sr$
0.714
0.713
0.712
0.711
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0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
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MT85EY
MT85FN
MT85GF
MT85GZ
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 63 – CLEATHAM 961 - RIB

Cremation Nr	Cremation	Sample ID			
977	**MT89BLN**		**T076**	**T077**	**T078**
			Rib	Femur	Otic

Age (KS)	YMA	Sex (KS)	F
Age (TL)	YMA/OMA	Sex (TL)	F?

Justification (age)	Maxillary RM1 and 2 are substantially worn down - this is likely an older individual (alt: working with teeth).	Justification (sex)	External occipital protuberance - F; orbital rim, sharp - F; orbital ridge, straight - F; 'gracile'.

X	27.40	Ctxt relationships	Urn 977 next to urn 983
Y	75.50		

Cranial	Dentition
ca 46 cranial vault fragments; occipital bone frags; frontal both including both L+R orbital rims; L superior zygoma; maxilla fragment with teeth in sockets; mandibular fragments including sockets; L+R otic fragments x2; L+R mandibular condyles; TMJ L+R	roots: max RM1/2 - worn, some enamel left; 6 molar root fragemnts; max R or LM3; Teeth in sockets: max RI1, RI2, RC

Axial

vertebral fragments including c 4 bodies; pelvis acromion fragment/rim; min 6 rib fragmnets

Upper Limb

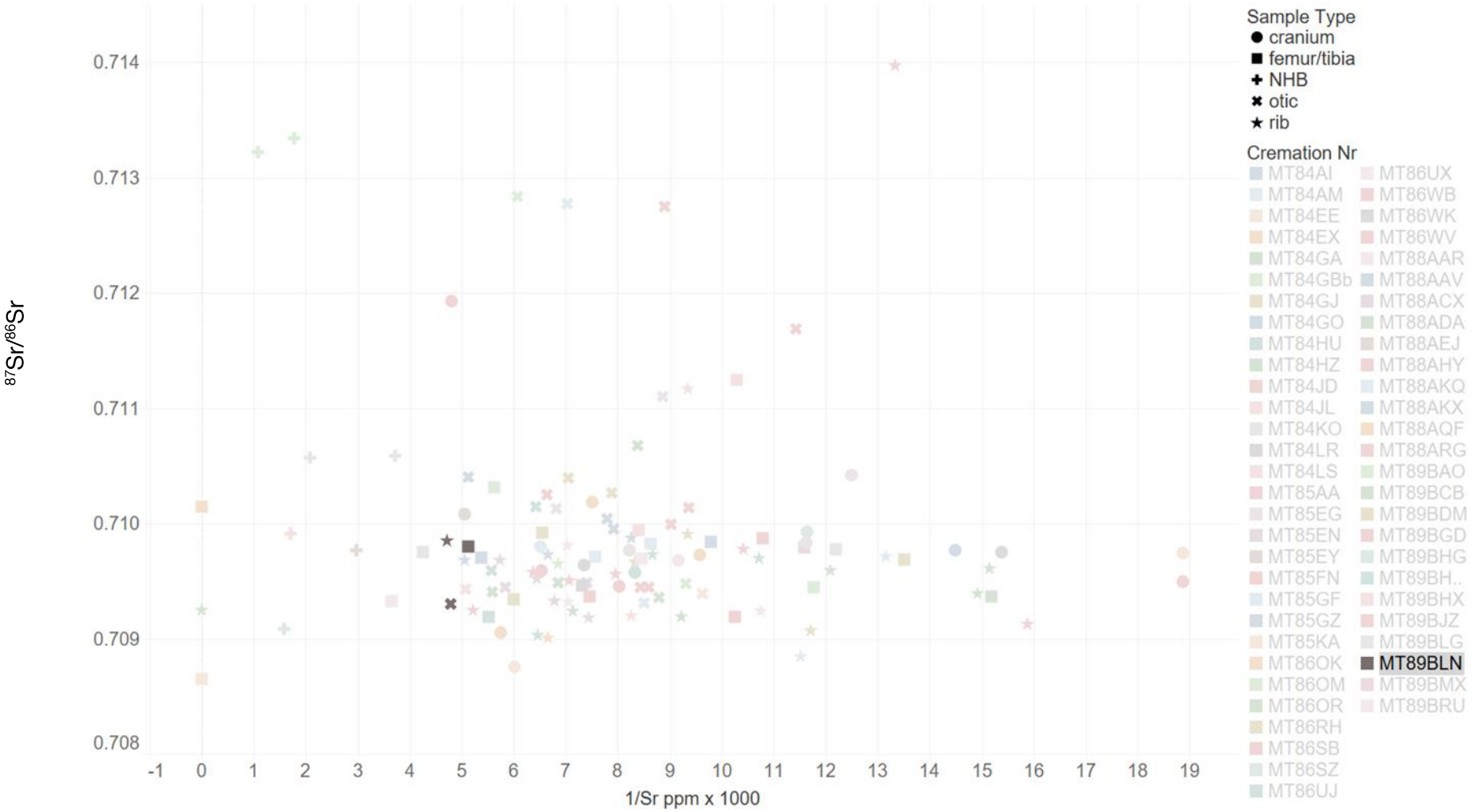
proximal radius (head) L+R fragments; lunate?; scaphoid?; L 1st distal phalanx; radius/ulna shaft fragments

Lower Limb

patella fragment (alt. prox ulna?); frag of distal phalanx; navicular; superior aspect of talus L+R; distal femoral joint surface; femoral shaft fragments including linea aspera; tibial shaft fragments; [heads of 5 MTs/MCs - hands/feet?]

Pathology

no CO; small foramen, porosity on ectocranial surface; vertebral surfaces of bodies in ok condition, but do not appear very young; fusion of 2 thoracic/cervical vertebrae (may be sticking together through mud?)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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
MT85EG
MT85EN
MT85EY
MT85FN
MT85GF
MT85GZ
MT85KA
MT86OK
MT86OM
MT86OR
MT86RH
MT86SB
MT86SZ
MT86UJ
MT86UX
MT86WB
MT86WK
MT86WV
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MT88ACX
MT88ADA
MT88AEJ
MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 64 – CLEATHAM 977 – RIB, FEMUR, OTIC

Cremation Nr	Cremation	Sample ID			
983	**MT89BLG**		**T047**	**T048**	**T049**
			Femur	Temporal	Otic

Age (KS) OA

Sex (KS) ?

Age (TL) OMA

Sex (TL) ?

Justification (age) Tooth wear suggests OMA; sutures closed and tight.

Justification (sex) Supramastoid ridge, subtle - F?

X 27.60

Y 75.40

Ctxt relationships

with sherds of urn 1082; next to urn 977 (tile fragment between them)

Cranial

11 cranial vault fragments; R temporal bone x3; central PP; R temporal auditory meatus (superior aspect); small maxillary fragment

Dentition

roots: mandibular canine - root worn down to dentine, wear facet diagonally sloping inferiorly; mandibular molar; lateral maxillary incisor; double-rooted maxillary premolar?; molar root fragments; maxillary incisor root worn down to dentine - flat surface sloping antero-proximal (lingually); further molar worn down beyond CEJ; carious lesion in worn down in lateral incisor? Root

Axial

vertebral fragments: facets and small body fragments

Upper Limb

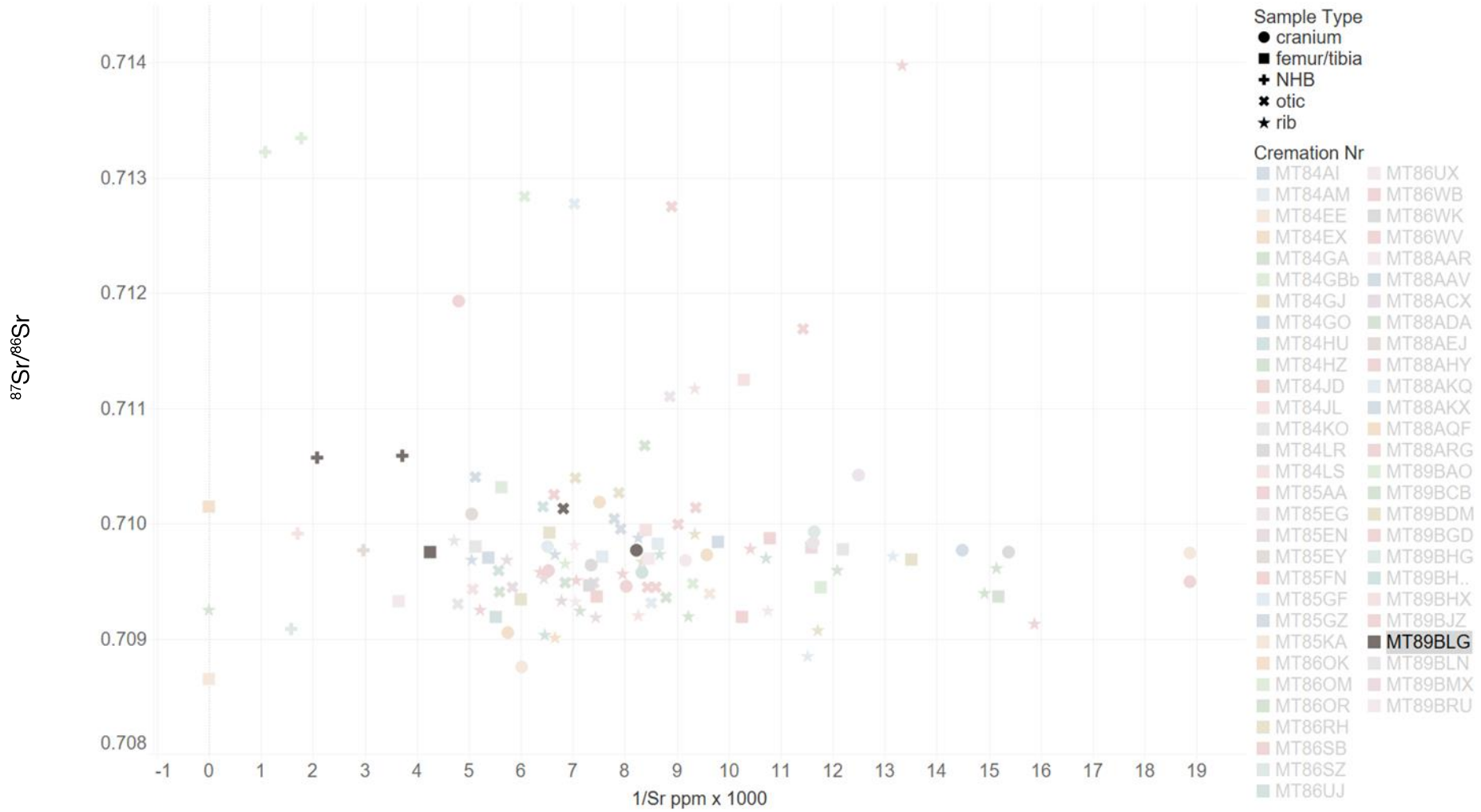
2x proimal/intermediate phalanges

Lower Limb

femoral shaft fragments x3; tibial shaft fragments x2

Pathology

heavy tooth wear and caries present (max P4 and M1)


$^{87}Sr/^{86}Sr$
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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
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MT88AHY
MT88AKQ
MT88AKX
MT88AQF
MT88ARG
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MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 65 – CLEATHAM 983 – FEMUR, TEMPORAL BONE, OTIC

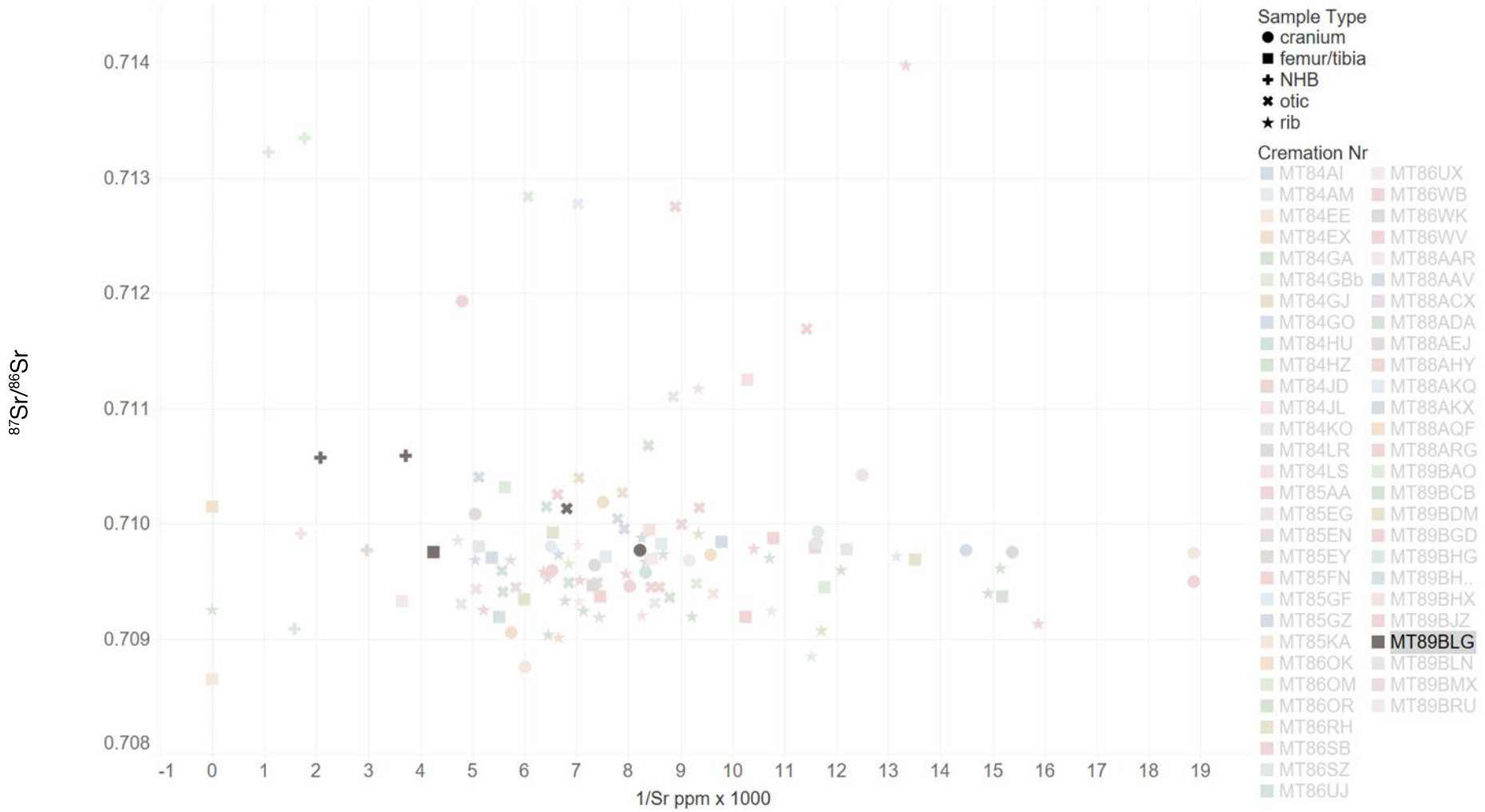
Cremation Nr	Cremation	Sample ID			
983	**MT89BLG**			**T133**	**T134**
				Distal Phalanx BEAR	Intermediate Phalanx BEAR

X 27.60

Y 75.40

Ctxt relationships

with sherds of urn 1082; next to urn 977 (tile fragment between them)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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
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MT85EG
MT85EN
MT85EY
MT85FN
MT85GF
MT85GZ
MT85KA
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MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 66 - CLEATHAM 983 – DISTAL PHALANX BEAR, INTERMEDIATE PHALANX BEAR

Cremation Nr	Cremation	Sample ID			
1003	**MT89BRU**			**T053**	**T054**
				Rib	Femur

Age (KS)	YMA	Sex (KS)	M
Age (TL)	YMA	Sex (TL)	M

Justification (age)	Cranial sutures still well defined and clear; dentition still fairly complete; some slight degenerative changes to the joint surfaces.	Justification (sex)	External occipital protuberance - M; supra-mastoid ridge - M; radial head, large - M

X	1.50
Y	79.10

Ctxt relationships

-

Cranial

cranial vault fragments x48; L+R otic x2; occipital bone; wide L superior zygoma; maxillary fragment with sockets; mandibular fragments with socket impressions

Dentition

roots: mand LM1; max canaines L+R; max incisor; lots of partial fragemnts of molars

Axial

C2 dens; vertebral body fragments, min 2 and partials; 2 rib fragments; lateral aspect of L clavicle

Upper Limb

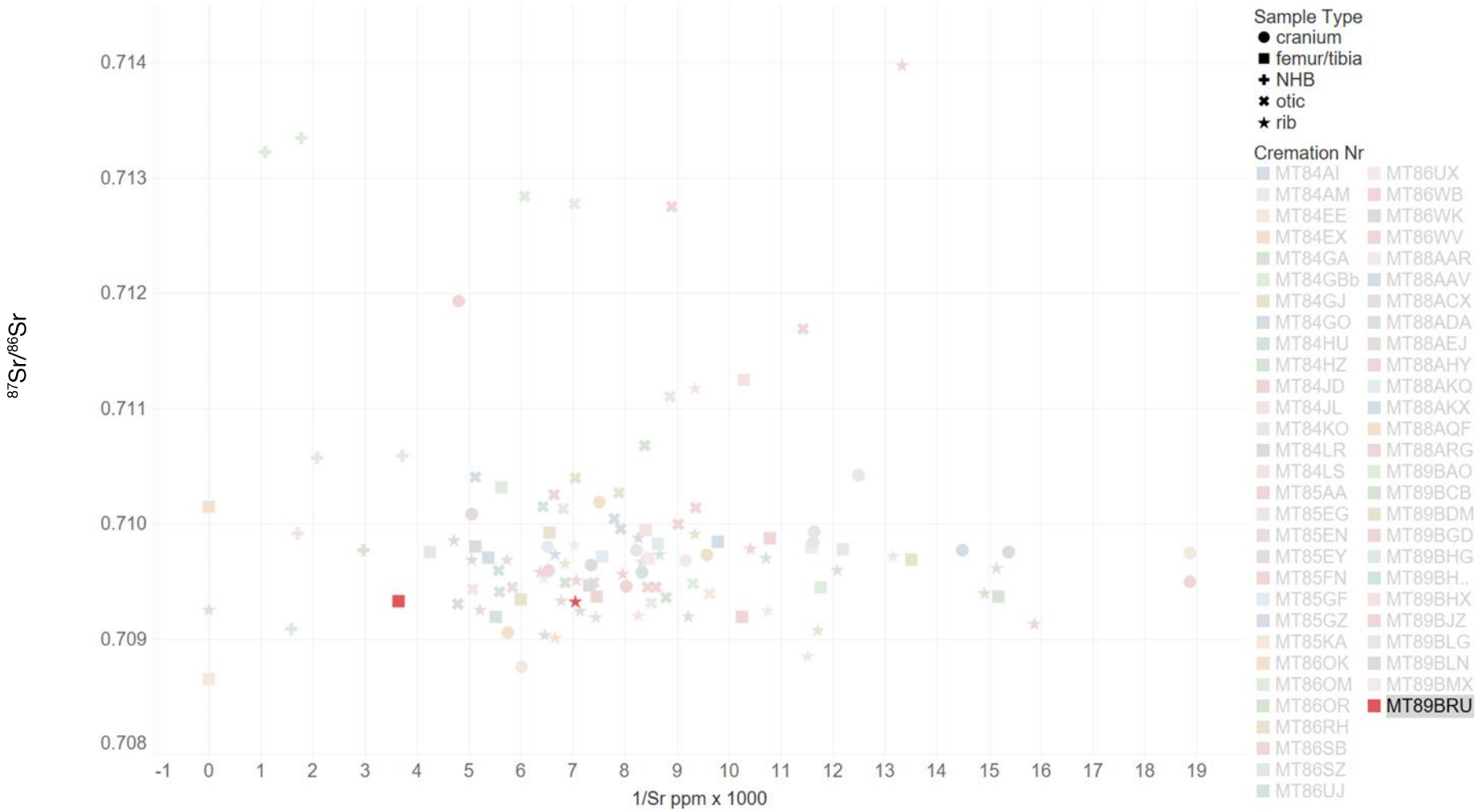
radial head; distal ulna; lunate; hamate hook; L+R distal humerus; radius + ulna shaft fragments; min 10 proximate/intermediate phalanges - distal ends

Lower Limb

distal joint surface of femur; femoral shaft fragments x4 with linea aspera; min 4 tibia shaft fragments; L+R tali; MT1 distal; min 3 distal heads of MTs

Pathology

slight MO on superior dens joint surface; periodontal disease - extensive porosity around sockets where present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0.713
0.712
0.711
0.710
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0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
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MT85FN
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MT88ARG
MT89BAO
MT89BCB
MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 67 – CLEATHAM 1003 – RIB, FEMUR

Cremation Nr	Cremation	Sample ID			
1004	**MT89BMX**			**T036**	**T037**
				Rib	Femur

Age (KS)	YMA	Sex (KS)	F
Age (TL)	YMA?	Sex (TL)	F?/Ind

Justification (age)	Adult individual, based on vertebral bodies - generally in good condition, no degenerative joint changes/DDD - YMA?.	Justification (sex)	Sciatic notch? - not used as not much present; occipital protuberance - F?; orbital rim - ?

X	5.50
Y	64.80

Ctxt relationships

-

Cranial

c 40 cranial vault fragments; otic frags x2 L+R; mastoid processes L+R; L frontal bone including lateral aspect of orbital rim; L+R mandibular condyles; L gonial angle; internal mandible with sockets; superior zygoma

Dentition

roots: 2x frags; max canine x2?; incisor max; the rest are double or multi-rooted teeth (incomplete)

Axial

R auricular surface fragment; patial acromion (lunate surface); inferior anterior illiac crest; c 4 cervical vertebral bodies; 1 lumbar? Vertebra; 2x spinous processes; sciatic notch?; rib x1?

Upper Limb

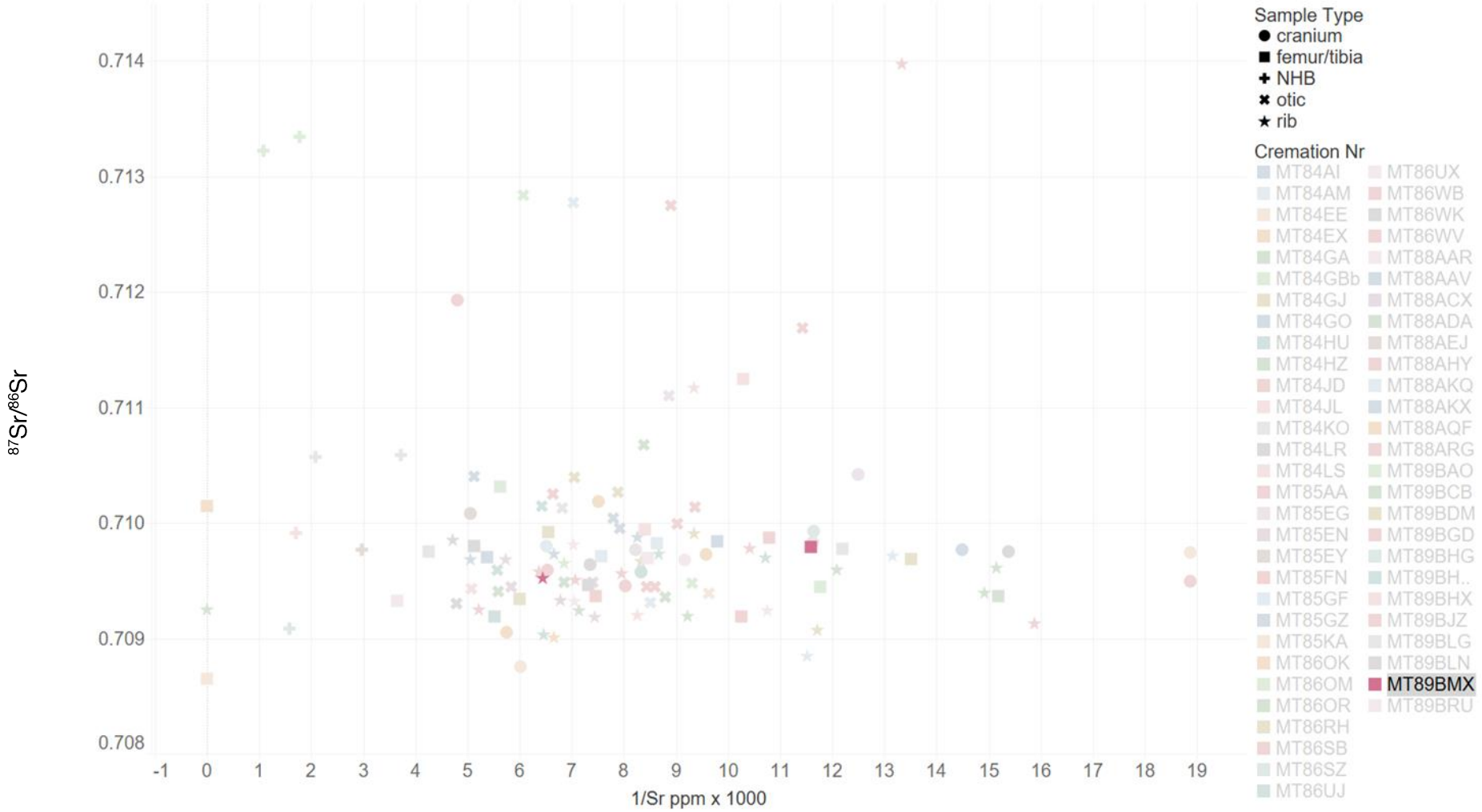
distal humerus joint surface fragment x2; humeral shaft fragemnts; proximal/intermediate phalanges distal x4; distal 1st phalanx; lunate L+R; scaphoid partial

Lower Limb

distal femoral joint surface fragemnt; femoral shaft x4 with linea aspera; distal 1st phalanx; [sesamoid bone - hand/foot?]

Pathology

joints in good condition, no pathology observed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0.712
0.711
0.710
0.709
0.708
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1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
MT84LR
MT84LS
MT85AA
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MT85FN
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 68 – CLEATHAM 1004 – RIB, FEMUR

Cremation Nr	Cremation	Sample ID			
1050	**MT85KA**			**T139**	**T140**
				Cranium	Otic

Age (KS) Adult

Sex (KS) M?

Age (TL) Adult

Sex (TL) ?

Justification (age) Joint fusion appears complete.

Justification (sex) Lateral R orbit of frontal bone - M?; not enough traits to determine.

X 37.90

Y 94.60

Ctxt relationships

cuts urn 416; urn 416 located below urn 1050

Cranial

17x vault fragments; central PP fragment

Dentition

roots: max incisor x1; mand incisor x1; at least 3 molar roots

Axial

vertebral body fragemnts

Upper Limb

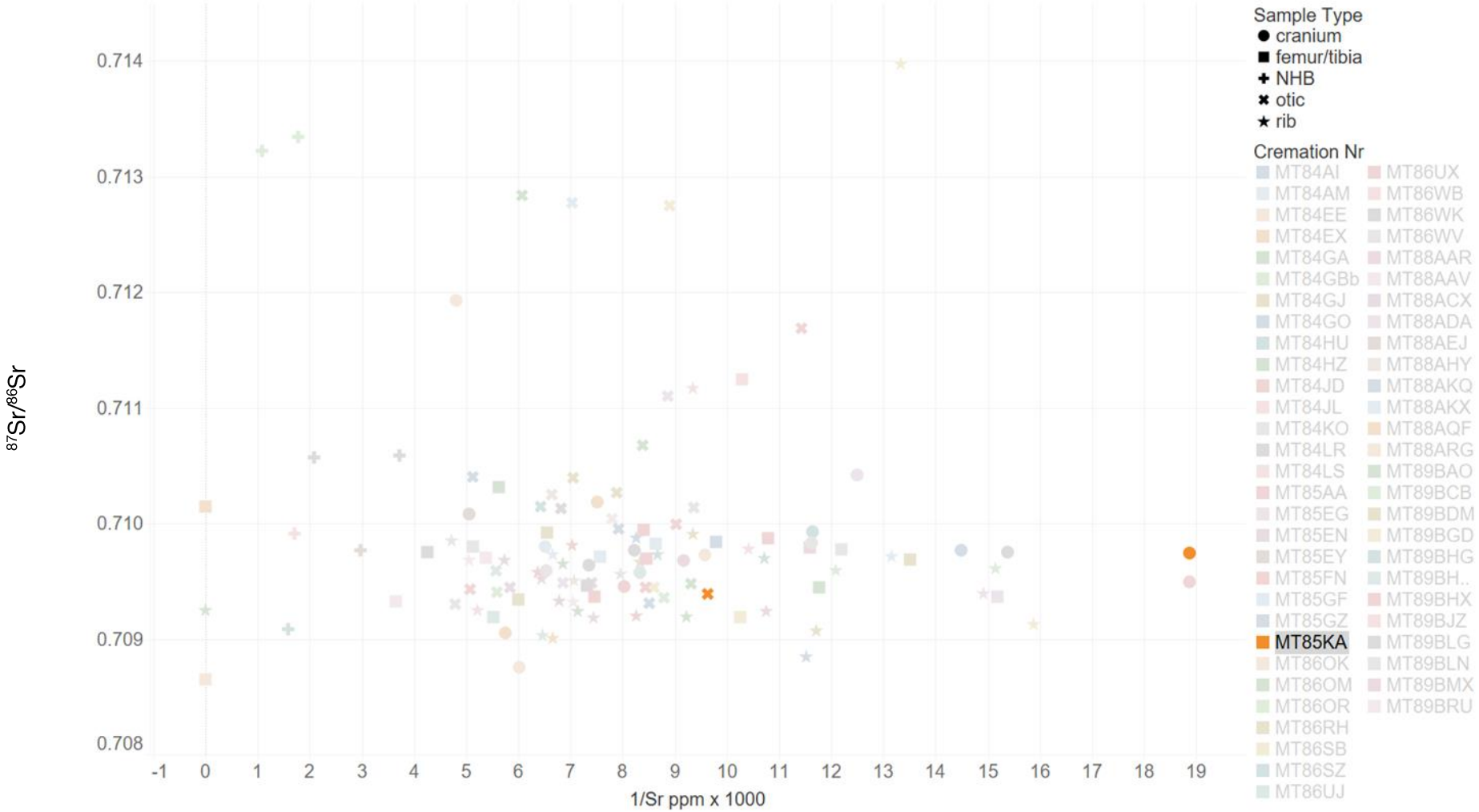
proximal radial fragemnt

Lower Limb

possible fragment of femoral shaft

Pathology

None observed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0.713
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0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
MT84JL
MT84KO
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MT85FN
MT85GF
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MT86SB
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MT88ARG
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MT89BDM
MT89BGD
MT89BHG
MT89BH..
MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 69 – CLEATHAM 1050 – CRANIUM, OTIC

Cremation Nr	Cremation	Sample ID			
1058	**MT86WV**		**T120**	**T121**	**T122**
			Rib	Occipital	Otic

Age (KS)	YA	Sex (KS)	F?
Age (TL)	YMA?	Sex (TL)	M?

Justification (age)	Joint degeneration of rib heads - older adult? YA unlikely.	Justification (sex)	External occipital protuberance, very large - M?; proximal head of radius (surface) small fragment - F?.

X	39.70
Y	87.00

Ctxt relationships

above urn 529; next to urn 520; cut by urn 519

Cranial

60 cranial vault fragments; occipital x4 including foramen magnum; 2x maxillary fragments with palate (including porosity); PP with partial otic

Dentition

-

Axial

11/12th rib; vertebral facet fragments x6

Upper Limb

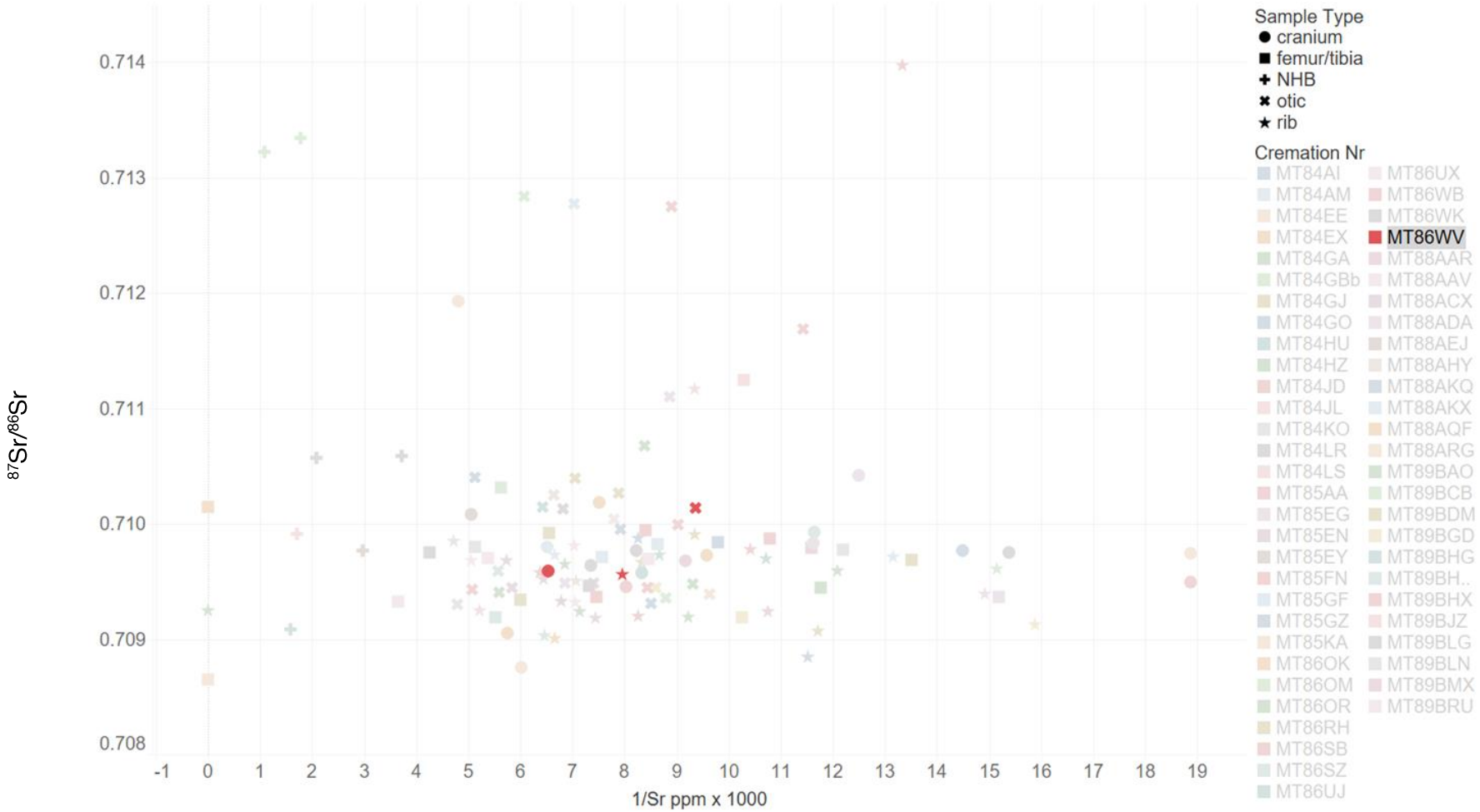
prox radial surface (small size)

Lower Limb

tibial shaft fragments with anterior crest

Pathology

low rib 11/12th head with DJD: MO+P; periodontoal disease mandibular M2or M3 socket - porous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0.713
0.712
0.711
0.710
0.709
0.708
-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
1/Sr ppm x 1000
Sample Type
cranium
femur/tibia
NHB
otic
rib
Cremation Nr
MT84AI
MT84AM
MT84EE
MT84EX
MT84GA
MT84GBb
MT84GJ
MT84GO
MT84HU
MT84HZ
MT84JD
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MT89BHX
MT89BJZ
MT89BLG
MT89BLN
MT89BMX
MT89BRU

FIGURE 70 – CLEATHAM 1058 – RIB, OCCIPITAL BONE, OTIC

A.8 SAMPLE IMAGES: HEATH WOOD, INGLEBY, DERBYSHIRE

The images contained in this section are a selection of the sampled fragments from Heath Wood.

FIGURE 71 – HEATH WOOD 411.2 – ADULT FEMUR

FIGURE 72 – HEATH WOOD 508 – ADULT FEMUR

FIGURE 73 – HEATH WOOD 411.1 – ADULT RIB

FIGURE 74 – HEATH WOOD 411.2 – HORSE RADIUS/ULNA