Who was in Harold Bluetooth's army? Strontium isotope investigation of the cemetery at the Viking Age fortress at Trelleborg, Denmark

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The circular fortress of Trelleborg on Zealand in Denmark is well known as a military camp with a key role in the formation of the Danish state under Harald Bluetooth in the tenth century AD. Taking a sample of 48 burials from the fort, strontium isotope analysis once again demonstrates its ability to eavesdrop on a community: at Trelleborg, the young men in its cemetery were largely recruited from outside Denmark, perhaps from Norway or the Slavic regions. Even persons buried together proved to have different origins, and the three females sampled were all from overseas, including a wealthy woman with a silver casket. Trelleborg, home of Harald Bluetooth's army, was a fortress of foreigners with vivid implications for the nature of his political mission.

Keywords: southern Scandinavia, strontium isotopes, migration, bioarchaeology

Introduction

As one of the most impressive archaeological monuments in Scandinavia, the tenth-century fortress at Trelleborg on the island of Zealand, Denmark (Figure 1), has played a central role

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Figure 1. The Trelleborg fortress in western Zealand, Denmark. The symmetrically arranged longhouses can be seen in four quadrants inside the circular fortifications and above between the two curving walls. The cemetery area lies in the far left centre of the photograph within the angled turn in the outer wall of the fortress (photograph: Moesgaard Museum).

in research on Viking Age society, giving its name to a series of similar constructions found across Denmark and southern Sweden. Interpreted previously as training camps for warriors who were supposed to re-conquer lost Danish territories in eleventh-century England, the Trelleborg fortresses are better understood today as centres of royal power, established as a means to control and administer the provinces of the emerging Danish kingdom under King Harold Bluetooth in the tenth century AD.

The fortresses are unique structures without direct parallels or obvious precursors in the region. Their newness in the landscape alone suggests foreign inspiration and/or expertise. This is underlined by find assemblages from the sites, which contain a significant number of artefacts of foreign provenance, indicating far-reaching contacts and presumably the presence of people from more distant regions.

With this background it is possible to formulate an hypothesis that at least some of the residents at the Trelleborg fortress were of foreign origin, possibly deriving from the central and northern parts of Scandinavia or from regions south of the Baltic (Dobat 2008, 2010; see also Sindbæk 2005: 140). In order to test the hypothesis, isotope analyses were carried out on samples of tooth enamel from burials at the site. We measured strontium isotopes in enamel apatite for information on mobility. The sample included individuals from 30 regular graves with and without grave furnishings, and selected individuals from three mass graves, which obviously reflect violent or catastrophic events.

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In the following paragraphs we describe the Trelleborg fortress to provide the archaeological context for the cemetery. This burial ground is then discussed in terms of the skeletal remains and the grave contents. A brief introduction to the isotopic analysis includes a discussion of local isotope ratios in Denmark and the surrounding region. Within this frame, then, we consider the results of isotope analysis of human tooth enamel from the cemetery in terms of their context and interpretation.

The Trelleborg fortress

Trelleborg is one of five similar structures, known today as the Viking Age 'ring-forts' or 'circular fortresses'. These include Aggersborg in northern Jutland, Fyrkat near Hobro, Nonnebakken in Odense in Denmark and Borgeby near modern Lund in southernmost Sweden. They all share the same uniform appearance, strictly following an architectural master plan in layout and construction. This similarity argues for the almost simultaneous construction of the fortresses towards the end of the tenth century AD. Horizons of extensive burning point towards an abrupt or even violent destruction of some of the structures.

The fortresses' function and background is much debated. They most probably should be viewed as intimately connected with the process of state formation. As centres of royal power they could have been established to control and administer the northern and eastern provinces of the Danish realm under King Harold Bluetooth of the Jelling dynasty. One of their primary functions seems to have been that of military strongholds and barracks. Additionally they must be supposed to have held economic, religious and symbolic significance. At the same time, they might have functioned as defences against foreign enemies (for a general discussion on the fortresses see: Olsen & Schmidt 1977; Roesdahl 1977, 2008; Randsborg 1980; Sindbæk & Roesdahl in press).

The unusual find assemblage at Trelleborg mirrors far-reaching exchange contacts and/or the presence of peoples from more or less distant regions (Andersen, S.W. 1996). A considerable proportion of the ceramic finds from the fortress are paralleled in tenth-century assemblages from the Slavonic settlement zone along the southern coast of the Baltic Sea (Hermann 1974; Brather 2001: 188–201). One can also trace a Slavonic influence in other find categories, such as spindle whorls or combs made of antler (Dobat 2010).

At Fyrkat, one of the two Trelleborg fortresses in northern Jutland, a significant number of the finds have parallels in Eastern Europe or in the eastern part of the Baltic (Roesdahl 1975, 1977: 150). The enormous quantity of soapstone vessel fragments at Fyrkat is unique in a south Scandinavian context (Roesdahl 1977: 20–25) and points to relationships with the Scandinavian peninsula, presumably modern-day Norway (Sindbæk 2005: 140).

The Trelleborg cemetery

The burial ground at Trelleborg was excavated between 1938 and 1940 and published shortly thereafter along with the investigations at the fortress itself (Nørlund 1948). Altogether 133 graves were excavated at the site, containing 157 individuals (Figure 2). Scattered bone fragments indicate that the cemetery originally contained additional burials. The majority of graves held a single individual, while three of the graves must be interpreted as mass

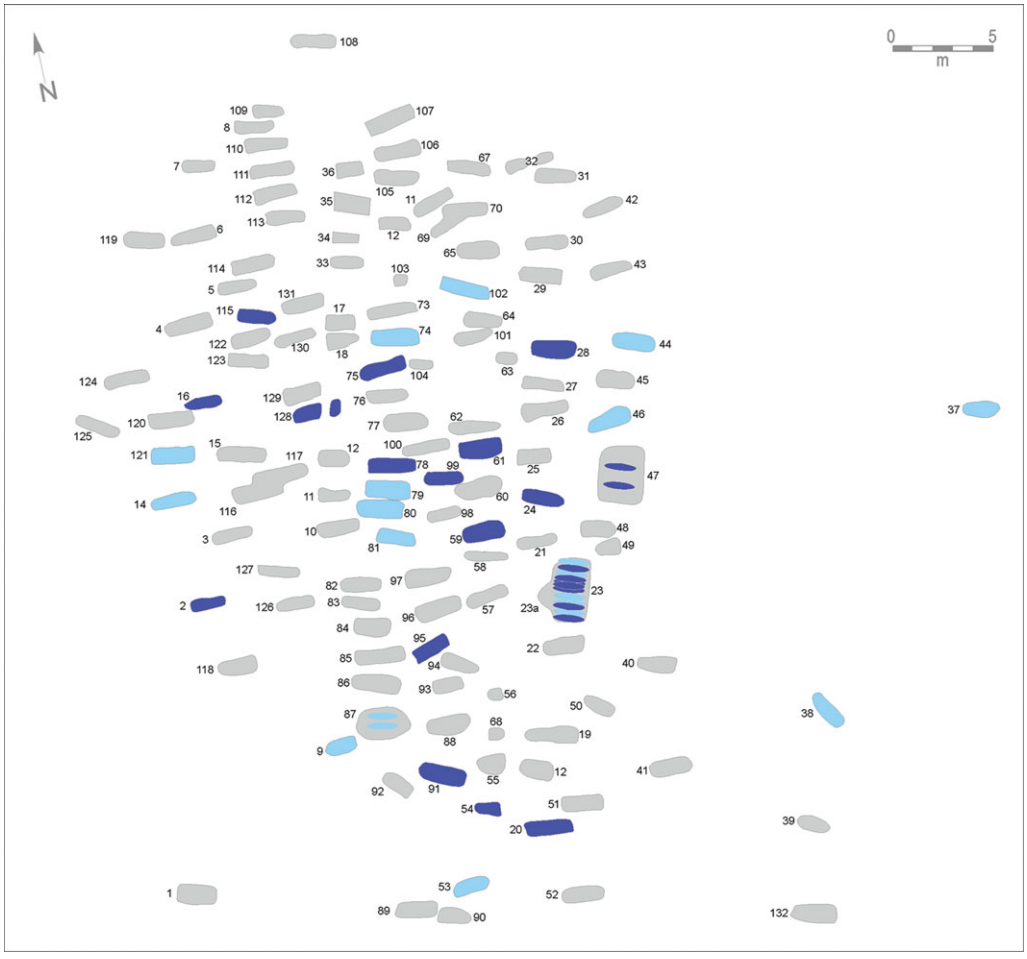

Figure 2. The cemetery at Trelleborg with grave numbers. Mass graves include numbers 23, 47 and 87. The blue graves were sampled for strontium isotope measurement; dark blue graves exhibit non-local values.

burials (grave 23 with 11 individuals, graves 47 and 87 with five individuals each). There are also two double burials (graves 97 and 98). All burials were inhumations in rather shallow graves, originally marked above ground, probably by a small mound. The graves are oriented east-west, with the dead generally facing east (see also the catalogue of the graves at Trelleborg [Petersen & Woller 1989]).

The burial ground is situated outside the eastern entrance of the fortress, with burials scattered on both sides of the main east-west axis that leads to the complex. The burial ground appears consciously integrated into the overall layout of the fortress complex, underlining the synchronic use of fortress and burial ground. The cemetery is assumed to be the burial place for the deceased occupants of the fortress complex (compare also Nørlund 1948: 105; L.C. Nielsen 1990: 137–43).

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In general, the burials at Trelleborg are similar to contemporary cemeteries in tenth-century southern Scandinavia. Burial furnishings are few. A total of 27 graves contain small knives, in nine cases along with whetstones. Other elements of grave furnishings include glass beads in nine burials, as well as a few costume accessories. Only three graves contained weapons in the form of axes.

A few burials are distinct. This is the case for grave 99, a woman between 20 and 35 years old. In the grave a small chest with silver-plated mountings was found, together with a gilded oval brooch and other objects, indicating the high status of the deceased. Among the three graves with weapon axes, the richly furnished grave 128 stands out. While the battle axes in the other two graves are paralleled in tenth-century graves throughout Scandinavia, the one in grave 128 is exceptional — an enormous broad axe with a long, narrow blade and elaborate inlay work in silver and copper alloy. Only two other examples of this specific type of axe are known from burial finds in southern Scandinavia. Similar axes appear rather frequently, however, in north-eastern Germany and Poland (Hermann 1974: 240; B.H. Nielsen 1991; Pedersen 2009). Apart from the axe, burial 128 contains a small bronze bowl, glass beads and a knife with silver wire decoration. As noted, such knives frequently appear in Scandinavia but tend to be more common in female burials. Also the appearance of an amber bead would be rather atypical in the context of a male burial. The skeletal remains are limited and equivocal as to the sex of this individual. The large earthen mound that appears to have originally covered grave 128 adds to its distinction.

The three mass graves at Trelleborg (graves 23, 47 and 87) are without direct parallels, at least in a Viking Age Scandinavian context (Figure 3). Insofar as identification was possible, given the poor conditions of preservation, most of the interred persons were between 20 and 35 years old. Only two slightly older and slightly younger individuals were found in grave 23. Four of the dead in grave 47 were identified as male during the excavations. Today, only remains from three of the individuals are left and it is not possible to check the sex determinations. The lack of finds inside the graves suggests that most were buried in a shroud or simple clothes (an unidentifiable piece of iron was found in grave 47 and grave 87 contained a whetstone). Although the three mass graves obviously differ from the regular burials at the site, the dead were buried in the standard manner, arranged in a row and orientated east-west. Only grave 87 differs in this respect, with the dead being deposited on top of each other, with irregular orientations.

When compared to other known battlefield contexts, the Trelleborg mass grave casualties do not seem to have resulted from violent incidents. Cut-mark lesions were only identified for one of the individuals (left femur). That femur is very poorly preserved today, and it proved impossible to determine whether this was a post- or ante-mortem lesion. We are therefore left to rely on the observations made during excavation. Of course, the overall poor preservation of the skeletons may explain why more cut-marks have not been found on the skeletons. Yet, compared to other well-known battlefield mass graves, cut marks are often more common to the head, arms and lower legs than the femur because of the use of shields for protection. In the absence of other signs of violent death, however, we should consider factors such as endemic disease or accidents such as fire or drowning as possible causes of multiple individuals dying around the same time.

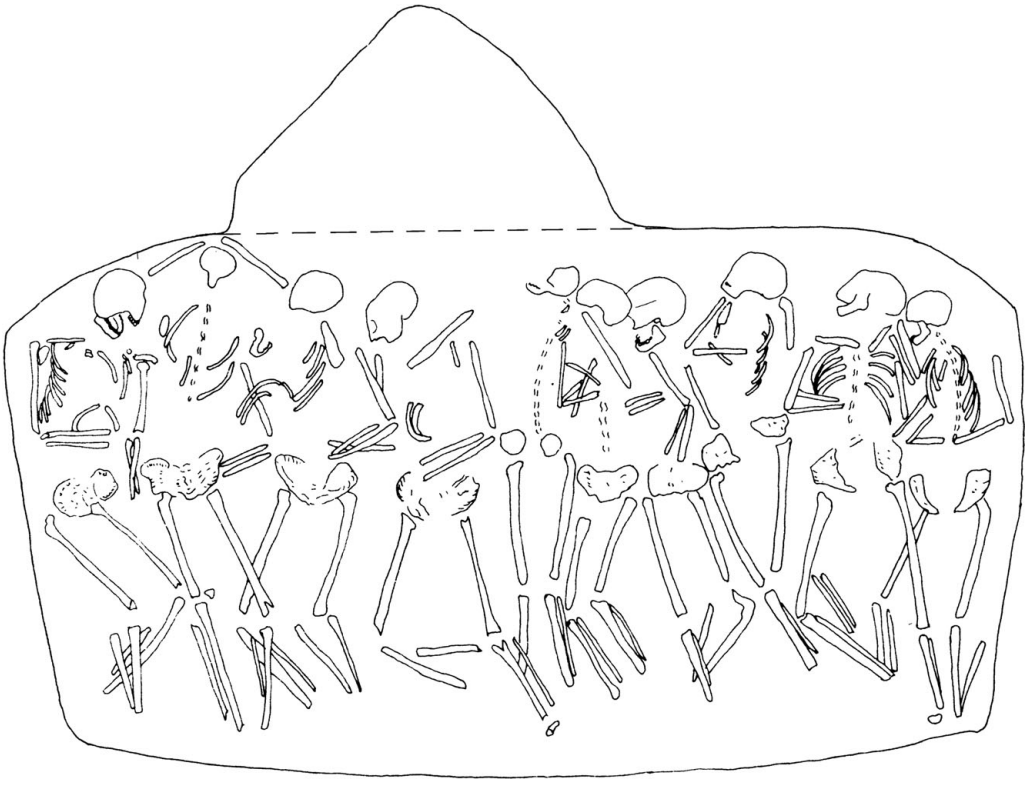

Figure 3. Mass grave 23 with 11 individuals. The burial pit intersects an older grave at the top (23a). (Redrawn from Petersen & Woller 1989 by Jens Kirkeby.)

Bioarchaeology of the burials

The skeletal material, including the dentition, from Trelleborg was originally examined during the excavations. Their study was limited by poor preservation (Nørlund 1948: 105–114). During a recent re-examination, a striking difference was noted between the numbers of bones present in photographs and drawings from the excavation compared to the curated human remains. Mostly jaws and teeth were retained (Christophersen 1940; Nørlund 1948); only a small number of fragmentary skeletal elements were kept.

Sex and/or age could only be identified for a few of the individuals at Trelleborg because of the poor conditions of preservation. The initial anatomical survey by Fischer-Møller determined 30 of the 40 identifiable individuals (75 per cent) to be males (Nørlund 1948: 113). A later reassessment by Sellevold could identify the sex of only 18 individuals; the majority, however, were still determined to be males (Sellevold *et al*. 1984). The relatively high proportion of males at Trelleborg, compared to most contemporary cemeteries in the region, may relate to the specific administrative and military roles of the fortress's occupants. On the other hand, 12 per cent of the skeletons from Trelleborg are sub-adults.

The Trelleborg burial ground is different from normal rural or urban cemeteries of this period, in that there are few female burials, few elderly individuals and few sub-adults. In

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92 cases, the age of the deceased could be estimated, based primarily on the well-preserved dentition. The majority of the individuals were adults, between 20 and 40 years of age at the time of death. Only 12 per cent were *infans* or *juvenis* (0–20 years) (Nørlund 1948: 113; Petersen & Woller 1989: 269), although still a higher proportion than several contemporary cemeteries (Bennike 1994: 172). None of the *juvenis* individuals at Trelleborg were older than 16 years of age.

On the other hand, Trelleborg does not resemble a military mass grave either, characterised almost exclusively by male interments with a high number of unequivocal battle injuries (Thordeman 1939; Fiorato *et al.* 2000; Syse 2003; Bennike 2006). Rather, the Trelleborg cemetery composition more closely resembles Roman military camps and forts found in Britain and elsewhere. Cemeteries connected with these camps also show interment of sub-adults and females, but with a clear preponderance of males (and interestingly, a diversity of burial types, which has been seen as reflecting Roman soldiers recruited both locally and at different localities abroad). This suggests that the Trelleborg fortress population was an army (mostly young adult males), but with a train including family members (resulting in some sub-adults and females in the cemetery).

Strontium isotope analysis

The use of strontium isotopes for provenancing human remains has been ongoing in archaeology for approximately 20 years (e.g. Krueger 1985; Price *et al.* 1994; Budd *et al.* 2004). The basic principles are straightforward and involve comparison of isotope ratios in human tooth enamel with local levels in bone or other materials from the place of burial. Geological formations have distinctive strontium isotope ratios, depending on their age and the original rubidium content of the rock or sediments (Faure & Mensing 2005). These isotopes move from rock into humans through the food chain. Virtually all of the strontium in the human body is deposited in the skeleton as a substitute for calcium in the bone mineral hydroxyapatite. Bone is continually remodelled during the life of an individual, so its chemical composition reflects the later years of life. The enamel in teeth, on the other hand, forms during infancy and early childhood and undergoes relatively little subsequent change. The strontium isotope ratio fixed in enamel thus provides a signature of the place of birth.

The procedure for preparing tooth enamel for strontium isotope analysis has been published elsewhere (e.g. Price *et al.* 2010). Samples are measured in a multicollector VG Sector 54 IT mass spectrometer (Institute of Geography and Geology, University of Copenhagen). Five ng loads of the NBS 987 Sr standard gave $^{87}Sr/^{86}Sr = 0.710236–0.000010$ ($n = 10$, 2*s*). Values from human enamel are compared to the bioavailable values of the place of burial. Bioavailable values reflect the actual sources of $^{87}Sr/^{86}Sr$ available to human populations, not simply the geological levels that may vary for different reasons (Price *et al.* 2002). This information provides a baseline for comparison with human tooth enamel from archaeological contexts. We have begun to measure baseline $^{87}Sr/^{86}Sr$ values for Denmark and the larger region of Northern Europe (Figure 4). This information comes from several sources including archaeological fauna, modern animals and estimates from prehistoric human bone and tooth enamel.

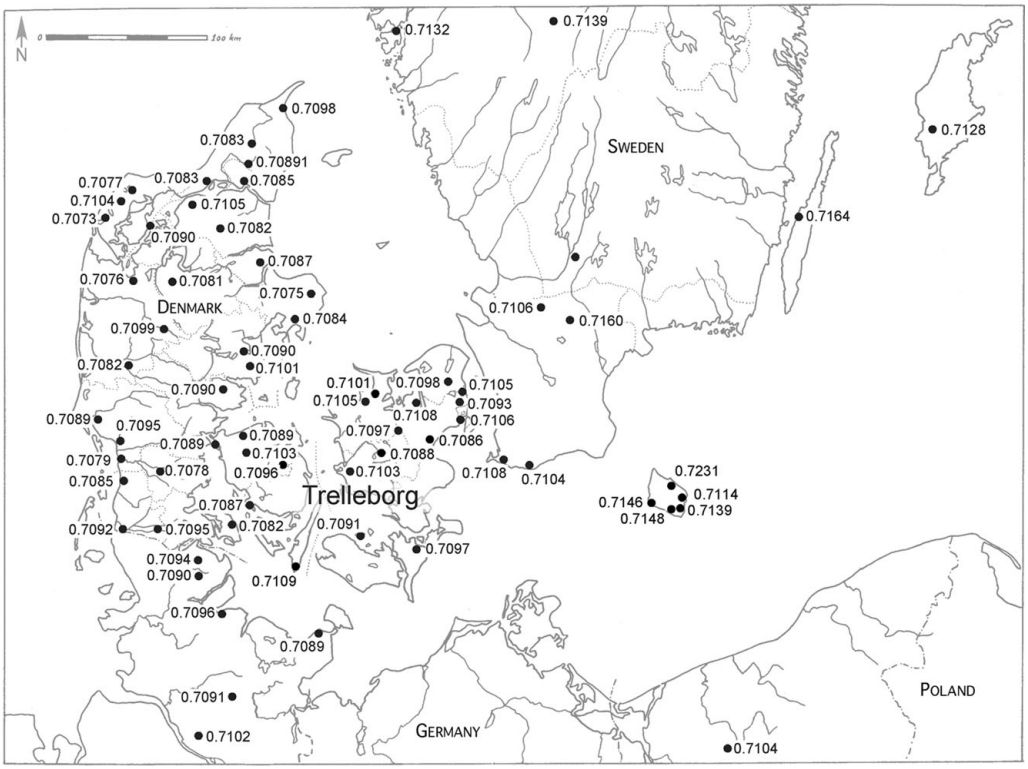

Figure 4. Baseline map of local strontium isotope ratios in Denmark, northern Germany, southern Sweden and northern Poland. These values come from archaeological fauna, human skeletal remains and modern animals and represent best estimates of the local ratio. The range of values for southern Scandinavia lies between 0.7090 and 0.7108.

Consideration of these values and their distribution in Denmark reveals a rather homogeneous area isotopically, with ratios ranging from approximately 0.709 to 0.7108. This is not surprising in many ways as the area is covered by ground and end moraine deposited under the glacial ice of the Pleistocene. This sheet of till extends across southern Scandinavia to northern Germany and northernmost Poland. To the south of the moraine boundary, the North German Plain — composed of late glacial coversands and more recent deposits — appears to share a similar range in isotopic values. This plain extends from the Netherlands west across most of modern Poland. Higher values appear in the older rocks of the Scandinavian Shield to the north and in the diverse geological landscape of Central Europe (e.g. Sjögren *et al.* 2009; Voerkelius *et al.* 2010). $^{87}Sr/^{86}Sr$ values in human tooth enamel outside the range of 0.709 to 0.7108 document individuals born outside of southern Scandinavia and northernmost Germany.

Strontium isotope analysis of the Trelleborg cemetery

One of the first steps in our study of strontium isotopes at Trelleborg was to identify the local baseline at the site itself. To do this we measured archaeological fauna and modern surface water from the site. The isotope ratios measured from the fauna are shown in grey

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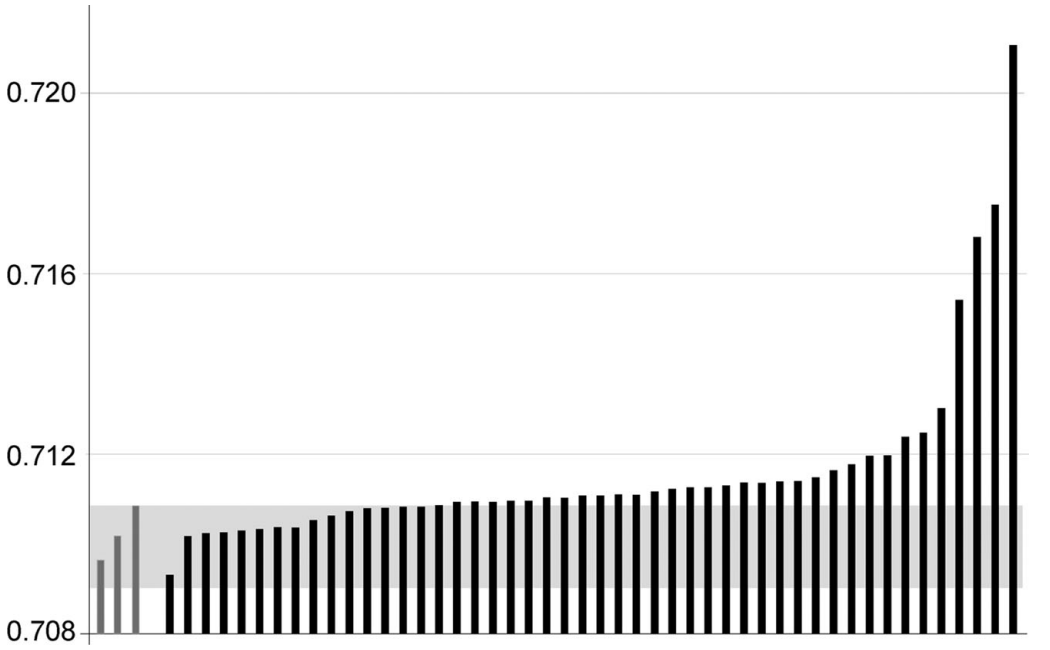

Figure 5. Bar graph of the strontium isotope ratios measured in the fauna and human remains from Trelleborg. The three lighter bars on the left of the graph are fauna. The black bars are human tooth enamel samples arranged in order by value. The grey horizontal band across the graph marks the range of strontium isotope values known from Denmark. Samples that fall outside this range are non-local individuals buried at Trelleborg; 32 of 48 individuals were thus determined to have been born outside of southern Scandinavia.

on Figure 5 and indicate a local value between 0.7096 and 0.7108. The animals include domestic cattle and sheep or goat and might have been brought from some distance. The small wild animal bone measured at the site, European water vole, gave a value of 0.7102. The surface water in the local stream had a value of 0.7098.

Analysis of the human tooth enamel from Trelleborg is of significant interest. We measured $^{87}Sr/^{86}Sr$ in the teeth of 48 individuals. Our sample consisted largely of premolars. Enamel on these teeth begins to form before six months of age and the crown is complete between the ages of five and seven (Smith 1991; Woefel & Scheid 2002). Detailed information on the burials that were sampled and the results of the analysis are provided in Table 1. Ranked $^{87}Sr/^{86}Sr$ values are plotted in black on Figure 5. The grey horizontal band on this graph marks the range for local strontium isotope ratios for Denmark. Samples that occur outside this range are non-local individuals at Trelleborg and very probably were born at some distance, beyond southern Scandinavia. If we use the value of 0.71085 as the highest local value, then 32 of the 48 human samples in this study (67 per cent) appear to be non-local to southern Scandinavia.

Further examination of the graph is revealing. The lowest human value is distinctly below the values of the other samples and may well be non-local. This individual comes from grave 23, the large mass grave. The highest strontium isotope ratio also comes from grave 23. The individuals in this mass grave exhibit a range of values across the entire distribution

Table 1. List of samples (grave numbers after Nørlund 1948) with information on age, sex, presence of grave goods and strontium isotope ratios. Sex is estimated from either grave contents or skeletal anatomy.

Burial	Age	Sex (content)	Sex (anat)	Goods	SrIsoRatio
2	20–35				0.71107
9	8–9				0.71094
14					0.71035
16	35–55	F	F		0.71146
20	35–55				0.71137
24	24–40				0.71195
28	20–35			Y	0.71242
37	20–35		M/F	Y	0.71040
38	35–55		M		0.71053
44	35–55			Y	0.71025
46					0.71094
53	20–35	M	M		0.71028
54	35–55		M		0.71124
59	17–21		M	Y	0.71104
61	20–35			Y	0.71136
71	35–55				0.71073
74	25–40		M		0.71093
78	35–55			Y	0.71179
79	20–35	M		Y	0.71084
80					0.71065
81	20–35		M		0.71041
91	20–35				0.71199
95	20–35			Y	0.71166
99	20–35	F		Y	0.71542
102	20–35				0.71029
115	9–10				0.71119
121					0.71019
128	35–55	M/F	M/F	Y	0.71140
75ø	10–11				0.71102
75v	35–55		M		0.71249
80i				Y	0.71065
XXX	Juv				0.71127
23.1	20–35				0.71082
23.2	20–35				0.71096
23.3	20–35				0.71301
23.4	20–35				0.71108
23.5a	20–35				0.71127
23.5b					0.71679
23.6	17–21				0.70931
23.7	20–35				0.72110
23.8	20–35				0.71111
23.9	20–35				0.71136
23.10	20–35		M		0.71082
23a(11)	25–40				0.71081
47.2	20–35		M		0.71755
47.4	20–35		M		0.71129
87a	25–40				0.71094
87b	25–40				0.71080

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for humans at Trelleborg. As these individuals were buried together in the grave, they could well be members of the same military unit. Thus, the broad range of values was unexpected.

Non-local $^{87}Sr/^{86}Sr$ values above 0.7108 range up to 0.722. The four values above 0.715 probably come from the north and the old rocks of the Scandinavian Shield found in Norway and central and northern Sweden. Values this high are rare to the south in continental Europe. Another option might be the northern parts of the British Isles and Ireland where rocks of similar age with high strontium isotope ratios also tend to occur (e.g. Evans *et al*. 2010). Values between 0.711 and 0.715 are also unusual to the south in continental Europe until the Erzgebirge and Rheinische Schiefgebirge of Germany, the Ore Mountains of southern Poland or the Carpathian Mountains of the Czech Republic. We suspect that northern Scandinavia is the probable home of many of the non-local individuals buried at Trelleborg.

It is important to remember that the range of isotope values that defines Denmark does not exclude other regions. These same values can be found in other parts of Europe. Thus the range of values does not mean that the individuals in the mass grave within the range for Denmark are necessarily from Denmark. It does mean, however, that the members of this burial group originated in a number of different places.

Interpretation

The strontium isotope analysis has provided unexpected new information regarding the place of origin of the individuals buried in the cemetery at Trelleborg. With at least half of the analysed individuals from the cemetery from outside southern Scandinavia, the population of the fortress at Trelleborg appears to have been highly heterogeneous in terms of ethnic or 'national' descent. The variation in the $^{87}Sr/^{86}Sr$ values is in accordance with the large number of foreign artefacts at the site. As noted in the introduction, the fortress at Trelleborg appears to have been incorporated in a far-reaching network, covering not only modern-day Norway and/or western Sweden, but also the entire Baltic Sea region. The isotope analysis thus supports the hypothesis that the high proportion of artefacts deriving from different areas at the fortress can be taken, at least partly, as indicating the presence of foreign peoples from those areas (Dobat 2008, 2010).

Although the group in mass grave 23 probably died at the same time, the broad distribution of $^{87}Sr/^{86}Sr$ values clearly points towards an extremely varied regional background for the respective individuals. If the 11 individuals represent members of some military force connected to the fortress, the varied provenance seems surprising. There are, however, numerous examples of military units in various cultural contexts that were extremely heterogeneous in terms of ethnic and national origin (Burschel 1994; Caferro 2006; Hedenstierna-Jonson & Olausson 2006; Dobat 2010). The distribution of $^{87}Sr/^{86}Sr$ values may be explained as mirroring the mixed makeup of a mercenary unit, with a varying regional background of its members.

In general terms, the analysis sheds light on the mobility of Viking Age societies in Northern Europe, underlining the fact that the far-reaching networks across Scandinavia and the Baltic Sea region, reflected in archaeological find assemblages (e.g. Roslund 2001; Sindbæk 2005), involved the movement of both material goods and peoples. Written sources

related to the process of state formation in Viking Age south Scandinavia, provide some perspectives on the question (Roesdahl 2008). Tenth- and eleventh-century rune stones in south Scandinavia contain references to 'foreigners' coming from Norway, the Slavonic settlement areas, the continent or different regions within southern Scandinavia. Later written evidence documents close political and military contacts between the Danish kings and Norwegian and Slavonic kingdoms during the tenth and eleventh centuries. The famous Danish chronicler Saxo, in his 'Danish History' gives an account of the reign of Harald Bluetooth and repeatedly refers to Norway and the Slavonic areas as associated with his realm. He also reports that the king, towards the end of his rule and in a period contemporary with the Trelleborg fortresses, based his power on an army composed of 'Danes and Slavs'. According to a twelfth-century chronicler, the so-called 'law of the Kings', retainers became necessary because of the heterogeneous ethnic composition of the royal retinue at the beginning of the eleventh century (for a more detailed review of the sources compare M. Andersen 1982; Damgaard-Sørensen 1991; Dobat 2010).

Conclusion

Although other scenarios must be considered, and research continues, the heterogeneous character of the population at Trelleborg, as demonstrated by the $^{87}Sr/^{86}Sr$ analysis clearly documents the fact that a considerable number of the tenth-century Danish royal military forces were foreign. The individuals in the mass grave 23 or other poorly furnished burials at the site may be interpreted similarly as members of the royal forces, who either were recruited in a distant part of the realm (Norway, the Slavonic regions), or who had entered the service of the Danish king as members of personal retinues of royal retainers. Some of these soldiers may have come with their families, which would account for the presence of sub-adults and females in the graveyard. In this context, we note that the strontium values for the three sampled individuals denoted as female (graves 16, 37 and 99) and for the sub-adults (grave 9, 115, 75ø and XXX) all indicate non-local origin. Some of these individuals may also have been foreign slaves, although the young woman in grave 99 was buried with a silver chest.

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