MOBILITY IN 10/11TH CENTURY GAMMERTINGEN – AN ISOTOPIC APPROACH

Lisette M. Kootker

INTRODUCTION

During the Medieval period, burial inside a church signified reconciliation with the holy faith and was enforceable only by the highest noble families; hence it was assumed that the individuals found in and near St. Michael in 1981 and 2009 were early members of the family later known as the Counts of Gammertingen.[521] Based on the stratigraphy of the burials, initial theories about possible relationships were proposed.[522] Through the application of novel bioarchaeological analyses, more insight can be provided into kinship, palaeomobility and palaeodiet of ancient populations. In addition, the life histories of archaeological individuals can be elucidated. Such a multidisciplinary bioarchaeological approach has proven to be successful in gaining a more accurate understanding of the identities of individuals and social groups in archaeological contexts.[523] Therefore, in order to gain more insight into their provenance, strontium isotope analyses are conducted on two females, I ib 1 and I ib 5. The results of the supplementary aDNA analyses are published in Mazanec/v. Grumbkow/Hummel, p. ####.

STRONTIUM ISOTOPE ANALYSIS

The application of strontium isotope analyses in archaeology (^{87}Sr/^{86}Sr) has been proven to be a successful tool in demonstrating palaeomobility and tracing migration events in both man and livestock.[524] Strontium has four naturally occurring isotopes: ^{84}Sr, ^{86}Sr, ^{87}Sr and ^{88}Sr. ^{87}Sr is radiogenic and produced by the β-decay of ^{87}Rb. The spatial variations in the initial amount of ^{87}Rb in the geological bedrock and the age of the lithology result in the geographical variation in the distribution of ^{87}Sr. Combined with the fact that strontium isotopes do not undergo fractionation due to their large atomic mass makes the ratio ^{87}Sr/^{86}Sr very useful as a geochemical proxy for palaeomobility.

Strontium is released into the biosphere by natural processes (e. g. weathering of rocks, rainwater and sea-spray). However, the ^{87}Sr/^{86}Sr available to plants, or bioavailable strontium, is substantially deviated from the expected ratios based on geological conditions.[525] It is the bioavailable strontium that is eventually taken up in our food chain and incorporated in keratine, bone, dentine and enamel through our diet where it substitutes for calcium in the structure of carbonate hydroxyapatite.[526]

Bone is a dynamic tissue and subject to constant remodelling. The ^{87}Sr/^{86}Sr from bone samples would therefore theoretically reflect the average of the dietary strontium intake of the last years of an individuals' life. Like dentine, bone is very susceptible to diagenetic alterations, which obscure the biogenic signal.[527] The large phosphate crystals in enamel and its compact structure make enamel quite resistant to diagenesis.[528] Enamel is formed during childhood and undergœs barely any change after mineralisation. Hence, the ^{87}Sr/^{86}Sr ratio in tooth enamel reflects the strontium intake during childhood.[529] However, although enamel cannot remineralise due to the loss of the enamel forming cells (ameloblasts) after eruption, enamel remineralisation dœs take place at locations where enamel demineralisation has taken place, such as the abrasive (i. e. the occlusal, distal and mesial sides) and caries surfaces.[530]

---

[521] This contribution has been adapted with textural changes from Grumbkow et al., Kinship.

[522] Schmidt, Michaelskapelle.

[523] See Zvelebil/Weber, Bioarchaeology, for a detailed overview.

[524] For example Bentley, Strontium isotopes; Pye, Forensic Purposes; Schwarcz et al., Isotopes; Slovak/Paytan, Applications.

[525] Price/Burton/Bentley, Characterization.

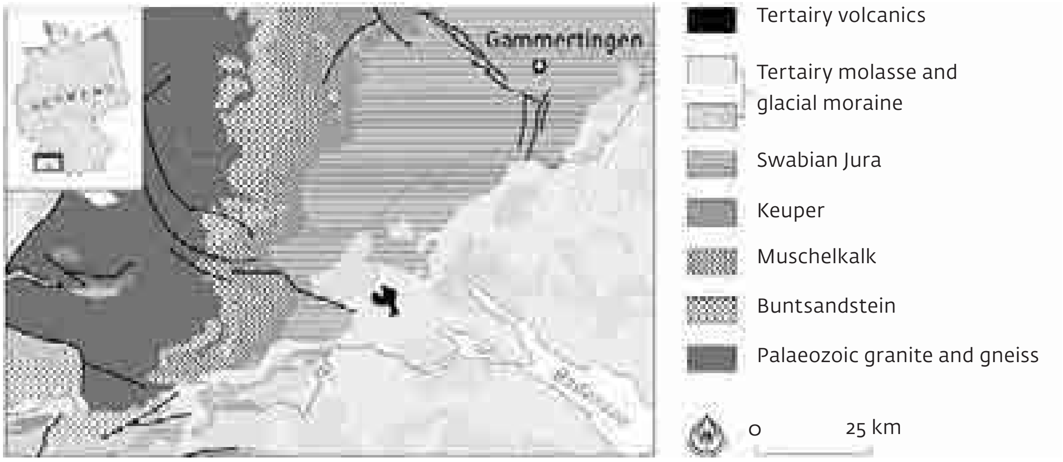
[526] Rosenthal, Stable strontium; Schroeder et al., Trace metals.

[527] Trickett et al., Solubility.

[528] For example Nelson et al., Diagenesis; Budd et al., Diagenesis; Hoppe et al., Preservation.

[529] Bentley, Strontium isotopes; Hillson, Teeth; Woefel/Scheid, Dental anatomony.

[530] Selwitz et al., Dental caries; Franklin/Hicks, Enamel remineralization.



175 The geology of southern Germany. Rivers and lakes are shown in white.

GEOLOGICAL SETTING AND LOCAL STRONTIUM SIGNATURE

The state of Baden-Württemberg is part of the upper Rhine Valley (Abb. 175). The geological setting and its related strontium isotope values (both archaeological and direct biosphere measurements) is thoroughly described by many other authors and shortly summarized here.[531] The geology of southwest Germany, and in specific the geology of Baden-Württemberg, is very diverse and rather complex. The pre-Alpine lowlands yield $^{87}Sr/^{86}Sr$ ranging from 0.708–0.710.[532] A similar range is defined for the alluvial deposits in the Upper Rhine Valley.[533] More radiogenic values can be found in the Black forest and in the adjacent the Triassic red sandstone (Buntsandstein) area. These uplands exhibit $^{87}Sr/^{86}Sr$ values ranging from 0.7085 up to 0.725 in the Black Forest and Vosges.[534] The uplands Keuper sandstones with approximate $^{87}Sr/^{86}Sr$ values of 0.7076–0.7108, overlap significantly with the defined lowland range.[535] Gammertingen is located in the uplands within the Swabian Jura (Schwäbische Alb). The geology of this specific part of the uplands appears to be dominated by ratios varying between 0.707 and 0.7097, thus isotopically overlapping with the lowland range.[536]

This overlap makes the interpretation of the data more difficult: a distinct boundary between 'local strontium values' and the 'non-local' values cannot be easily made.[537] The $^{87}Sr/^{86}Sr$ range between 0.7068 and 0.7114 covers all geological units. Values higher than 0.7114 can theoretically have contributed to the more radiogenic uplands (i. e. Buntsandstein, granite and gneiss areas).[538]

MATERIAL AND METHODS

Human and background data

Due to limited sample availability, only two teeth and two bone fragments from the two females (I ib 1 and I ib 5) were available for investigation. In addition, to complement the available geological and bioavailable background data and to gain the bioavailable strontium signal from the immediate surroundings of Gammertingen, three teeth of domestic pigs were analysed. In general, animal tissues show homogeneous values within a given region and therefore provide a „regional average" of bioavailable strontium, which should be comparable to the human values.[539] It is assumed that these pigs have been husbanded locally and have been partially fed with the human primary waste products, such as plate and kitchen waste, and therefore exhibit a local bioavailable strontium signature against which the human values can be compared. Recent studies, however, showed that pigs and/or porcine products are subject to significant movement, even though pigs were thought to be less suited to be driven over large distances compared to cattle and sheep/goat.[540] This should be taken into account when interpreting the background data.

---

[531] Bentley/Knipper, Geographical patterns; Bentley et al., Vaihingen; Price et al., Linearbandkeramik; Price/Burton/Bentley, Characterization; Price et al., Talheim; Knipper, Linearbandkeramische Rinderhaltung; Oelze et al., Singen.

[532] Grupe et al., Bell Beaker people; Bentley/Knipper, Geographical patterns; Oelze et al., Singen.

[533] Bentley/Knipper, Geographical patterns.

[534] Tricca et al., Rare earth elements.

[535] For example Oelze et al., Singen.

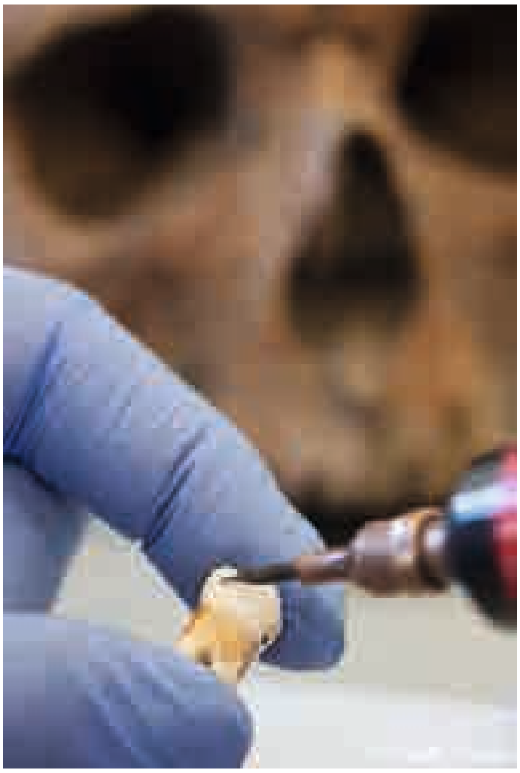
[536] Bentley et al., Vaihingen; Bentley/Knipper, Geographical patterns; Oelze et al., Singen.

[537] See Bentley et al., Vaihingen; Price et al., Linearbandkeramik; Price/Burton/Bentley, Characterization; Price et al., Talheim; Bentley/Knipper, Geographical patterns.

[538] Oelze et al., Singen.

[539] Price/Burton/Bentley, Characterization.

[540] Madgmick et al., Porcine Enamel; Van der Jagt et al., Animal exchange.



176 Sampling a human molar for Sr isotope analysis at the VU University Amsterdam.

Analytical techniques

The teeth were mechanically cleaned, by removing the surface of the enamel using an acid-leached diamond tipped dental drill. Next, samples of ca. 1–3 milligram were collected and sealed in acid pre-cleaned 2 ml polyethylene Eppendorf centrifuge tubes (Abb. 176). The samples were leached with 0.1N acetic acid (CH_3CO_2H), subsequently rinsed with Milli-Q water and eventually dissolved in 3.0N HNO_3. The human bone samples were subjected to similar procedures, but leached with 1.0N acidic acid. The leachate was collected, dried down and taken up in 3.0N HNO_3. Strontium was isolated by ion exchange chromatography using Sr-Resin (EIChroM©) and collected in acid-leached teflon vials (Savillex). Blanks were spiked with ^{84}Sr. All samples were nitrated twice with concentrated HNO_3.

The Sr isotope compositions were measured on a MAT-Finnigan 262 RPQ-plus multicollector mass spectrometer (Finnigan Corp., San Jose, CA) at the VU University Amsterdam. The samples were loaded on single annealed rhenium filaments with $TaCl_5$. The strontium ratios were determined using a static routine and were corrected for mass-fractionation correction. All measurements were referenced to the NBS987 standard, which gave a mean ^{87}Sr/^{86}Sr value of 0.710228. The samples were run to an internal precision of ± 0.0000055 (1SE) or better. The total procedural blanks provided a negligible contribution ($\leq$ 60 pg).

RESULTS AND DISCUSSION

The results of the Sr isotope analyses are given in Tabelle 10 and Abb. 177. The pig teeth that were analysed to complement the available biosphere data give a wide variety of values, ranging from 0,70740 to 0,71094. Samples 1269J and 1269K are compatible with the expected local geological strontium background of the Swabian Jura. The ^{87}Sr/^{86}Sr ratio of 1269L (0,71094), however, is foreign to the Swabian Jura, but compatible with the expected local background values of respectively the Tertiary volcanic areas and the Keuper and Riss moraine areas.[541] These results demonstrate that pigs and/or porcine product moved substantial distances during the medieval period in southwestern Germany, and, therefore, are not ideal proxies for mapping the local bioavailable strontium ratios in the investigated area. The non-local pig might have been brought to the Gammertingen castle as manorial dues. Trade in pigs or porcine products in the pre-Alpine lowlands in prehistoric Germany has been demonstrated before.[542] Hence it seems that in Germany pigs have been traded or have been considered as dues from the prehistoric times onwards.

Based on only ^{87}Sr/^{86}Sr ratios, it is difficult to pinpoint both females to a specific location of origin due to the diverse geological setting of the study area.[543] The ^{87}Sr/^{86}Sr value of female I ib 5, 0,70919, is compatible with the local background signal of the Swabian Alb.[544] However, the overlapping strontium ranges between the diverse geological units dœs not allow the unambiguous conclusion that I ib 5 is from local decent. The ^{87}Sr/^{86}Sr ratio of the dietary average of I ib 1 (0,71022) is significantly higher compared to I ib 5. The consumption of higher isotope ratio food, which possibly originates from the adjacent Keuper or lœss areas, may have raised the isotopic ratio. Whether female I ib 1 is actually born in a higher isotopic area or had access to higher isotopic ratio food is unknown. Hence, the higher isotopic ratio in female I ib 1 might reflect a different birthplace or a difference in diet, which may point towards difference in social status or social background.

---

[541] For example Oelze et al., Singen.

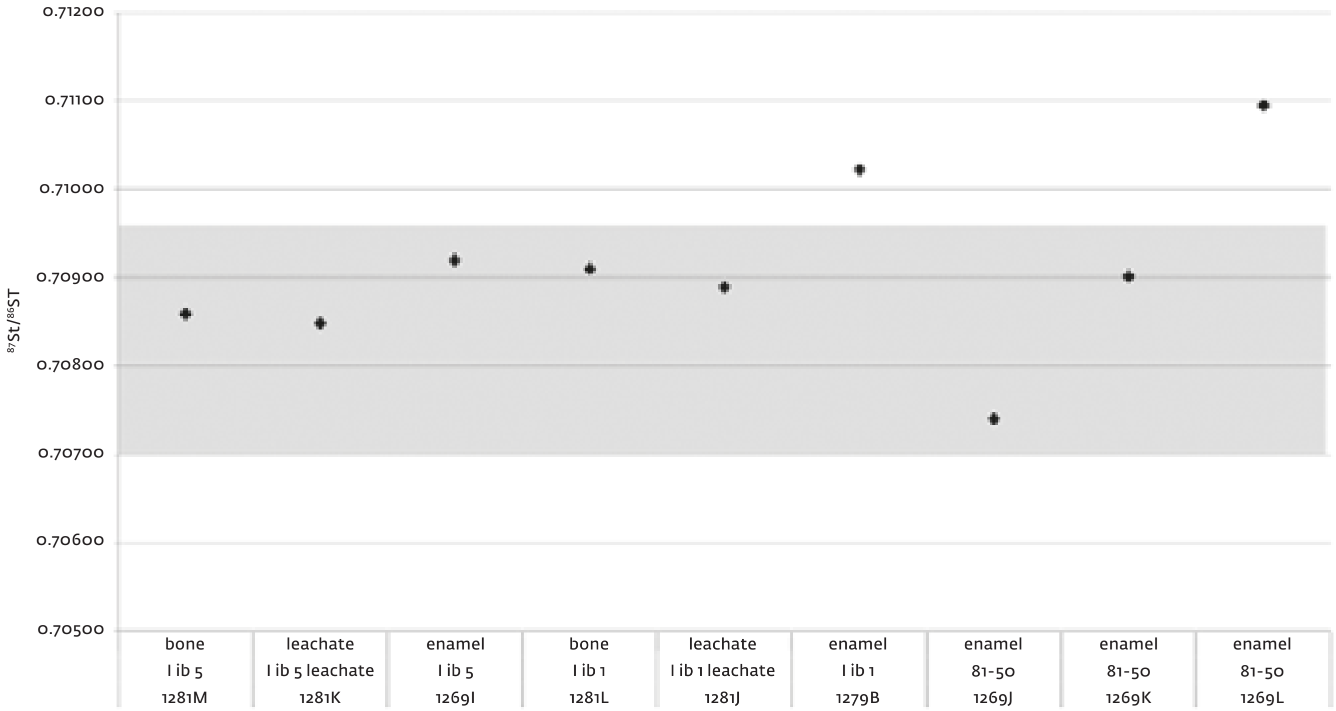
[542] Bentley/Knipper, Geographical patterns; Oelze et al., Singen.

[543] Bentley/Knipper, Geographical patterns; Bentley et al., Vaihingen; Price et al., Linearbandkeramik; Price/Burton/Bentley, Characterization; Price et al., Talheim; Knipper, Linearbandkeramische Rinderhaltung; Oelze et al., Singen.

[544] Bentley et al., Vaihingen; Bentley/Knipper, Geographical patterns; Oelze et al., Singen.

Tabelle 10 $^{87}Sr/^{86}Sr$ ratio for different samples of the individuals I ib 1 and I ib 5 and three procine teeth (81-50). SE = standard error.

ID	Labnumber	Sample	Human/animal	Species	Material	Element	Sex	$^{87}Sr/^{86}Sr$	2SE
1281M	S581	I ib 5	human	Homo sapiens	bone	Humerus	Female	0.70858	0.00001
1281K	S613	I ib 5 leachate	human		leachate			0.70848	0.00001
1269I	S489	I ib 5	human		enamel			0.70919	0.00001
1281L	S580	I ib 1	human	Homo sapiens	bone	Tibia	Female	0.70910	0.00001
1281J	S612	I ib 1 leachate	human		leachate			0.70889	0.00001
1279B	S560	I ib 1	human		enamel			0.71022	0.00001
1269J	S488	81-50-068	animal	Sus domesticus	enamel	molar		0.70740	0.00001
1269K	S487	81-50-059	animal	Sus domesticus	enamel	molar		0.70901	0.00001
1269L	S486	81-50-143	animal	Sus domesticus	enamel	molar		0.71094	0.00001



177 Strontium isotope ratios of two medieval individuals (I ib 1 and I ib 5) and three porcine teeth (81–50) from Gammertingen. The grey horizontal band marks the local range. of strontium isotope values (wo.707eo.7097). The ratios of the enamel of I ib 1 and of one porcine tooth are greater than the local ratio.

The bone samples yield similar strontium values compared to the expected local background. The isotopic differences between the leachates and the actual bone samples indicate that the weak acid removed at least some of the diagenetic strontium. It is unsure, however, whether the isotopic ratios of the bone sample reflect the biogenic strontium or the diagenetic signal. In case of the former, female I ib 1 possibly has spent the last years of life in the Gammertingen area.

CONCLUSION

Strontium isotope analyses show that the females may originate from different locations. The results for the female I ib 5 reveals that she was born and lived in or around the area of Gammertingen, while the more radiogenic strontium ratio of female I ib 1 suggests the consumption of higher isotope ratio food. This might imply that I ib 1 was not part of the local Gammertingen population and therefore might have become a member of the Counts of Gammertingen through, for instance, marriage. The absence of samples for strontium isotope analyses, unfortunately, disabled the possible unique opportunity to provide an estimation of the variation of strontium isotope ratios within a genetically related group. Future research into the bioarchaeology of groups that are shaped by kinship relations might be able to further explore this approach.