LEAD AND STRONTIUM ISOTOPE COMPOSITIONS OF HUMAN DENTAL TISSUES AS AN INDICATOR OF ANCIENT EXPOSURE AND POPULATION DYNAMICS

The application of isotope source-tracing methods
to identify migrants among British archaeological
burials and a consideration of ante-mortem uptake,
tissue stability and post-mortem diagenesis

Janet MONTGOMERY BSc

submitted for the degree
of Doctor of Philosophy

Department of Archaeological Sciences

University of Bradford

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Janet MONTGOMERY

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Keywords: Lead, strontium, isotopes, archaeological enamel, migration, exposure, diagenesis, TIMS, ICP-MS

Abstract: This thesis employs lead and strontium isotope analysis of teeth by TIMS to identify migrants amongst British archaeological cemetery populations since the Neolithic. The study evaluates the benefits of combining two independent isotope systems with the exposure information obtained from elemental concentrations of lead and strontium. It demonstrates that they provide complementary information about mobility but highlights how their efficacy fluctuates both spatially and temporally in the periods investigated. Strontium was useful in all periods but heavily biased towards maritime $^{87}Sr/^{86}Sr$ (~0.7092) making it a poor discriminant between coastal habitats where lead was superior. Lead utility changes following the advent of large-scale mining and metallurgy, when anthropogenic ore lead severs the link between geographical origin and lead exposure. A cultural focussing of British enamel signatures ensues accompanied by a concomitant rise in lead burdens. British lead exposure during the last two millennia appears more indicative of status and the cultural sphere (e.g. rural/urban) than geographical origin. The results are assessed in the light of migration theory and traditional archaeological and osteological indicators.

Samples used are core enamel and co-genetic primary crown dentine, which neither model nor remodel *in vivo* and thus remain representative of a constrained period of childhood. Modern and archaeological teeth are investigated to assess isotope variability intra-enamel, intra-tissue, intra-antimere, intra-dentition, intra-sibling and between mother/child pairs. Recommendations for future tissue sampling and standardisation are made. The fundamentals of tooth biomineralisation are reviewed and clarified, chiefly that incremental enamel structures relate to initial *formation* not *mineralisation*; lead and strontium are principally incorporated during mineralisation. Macromorphological preservation proved no guide to biogenic strontium or lead isotope integrity. Mature, but not immature, enamel proved highly resistant to diagenesis whether well preserved or not. Dentine was highly susceptible to diagenesis irrespective of preservation state and is proposed as a proxy for the time averaged isotope signature of the soil. Moreover, it is argued that lead and strontium behave differently in teeth; uptake mechanisms are different and they respond independently to subsequent migration. Results suggest soil leaches were useful but complex and the most suitable leach reagent may be specific to the soil type and isotope system.

Two Norse Period immigrants (male and female) were identified at Cnip, Lewis; the $^{87}Sr/^{86}Sr$ signatures constrain their origin to Tertiary volcanics. In the North Atlantic these occur on Iceland, Faeroe Isles, and Antrim in Ireland but not Norway. No indubitable immigrants were identified at the Anglian cemetery at West Heslerton, Yorkshire but soil leaches and juveniles suggested a local $^{87}Sr/^{86}Sr$ signature range. “Non-locals” included both sexes, weapon burials and unaccompanied burials, providing no evidence for an immigrant group composed solely of male warriors. All analysed burials with wristclasps and cruciform brooches were non-local, supporting Hines’ (1984) hypothesis that wristclasps confirm the presence of Norwegian immigrants during this period.

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PREFACE AND ACKNOWLEDGEMENTS

My interest in science was nurtured from an early age by my father, Harold Gordon Keighley, a mountaineer, potholer, pilot and practical scientist who filled our home with books, chemistry sets and microscopes and our holidays with museums, caves and mountains. What drew me to archaeology was the opportunity to study many subjects with time depth and there are surely very few modern disciplines where this remains possible. However, my concern has been that whilst never aspiring to become a polymath in the great tradition of da Vinci, Dürer, Darwin, and Dodgson, I was merely incapable of making up my mind and have inadvertently become a dabbler instead. Throughout, my worry was that I had missed something so fundamental it is left unsaid in the literature of an unfamiliar subject. If I have, it is certainly not the responsibility of the many colleagues from all those disciplines who gave me the benefit of their learning and guidance.

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Janet Montgomery March 12th 2002

LIST OF PUBLICATIONS AND PRESENTATIONS

ACADEMIC PUBLICATIONS

Budd, P., J. Montgomery, A. Cox, P. Krause, B. Barreiro, & R.G. Thomas. 1998. The distribution of lead within ancient and modern human teeth: implications for long-term and historical exposure monitoring. *The Science of the Total Environment* **220**: 121-136.

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Montgomery, J. P. Budd, B.A. Barreiro, C. Chenery, A. Cox, P. Krause. November 30th 1998. Roman or Briton? Identifying migrants with isotopes. Departmental research seminar presented at the *Department of Archaeological Sciences, University of Bradford*.

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Montgomery, J., P. Budd, J.A. Evans, C. Chenery, D. Powlesland. 22nd March 2001. The use of combined Pb, Sr and O-isotope analysis to identify prehistoric migration: an Anglo-Saxon case study from West Heslerton, Yorkshire. Invited seminar given at the *Stable Isotopes in the Marine and Lacustrine Environment, NIGL, British Geological Survey, Keyworth.*

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