Across the Alps in Prehistory

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Editors

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Isotopic Mapping of the Brenner Passage by Bioarchaeology

Springer

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Preface

Understanding the history of anatomically modern *Homo sapiens* requires an evaluation of the multiple factors that determine human population development in time and space. This includes insights into processes such as mobility, migration, population admixture and cultural exchange and transfer. While written documentation and the archaeological remains of the material culture both provide clues to these topics, information contained in the bodily remains of the people who once either took an active part in these processes or were merely confronted with them during their lifetime has yet to be fully exploited. The analysis of preserved DNA molecules permits the evaluation of genetic and genealogical relationships, but the genetic make-up of a past people hardly permits access to behavioural aspects of these once-living individuals and their populations.

The majority of human and animal tissues that are preserved over time consists mainly of skeletal remains which are regularly excavated from burial sites, settlements or other places. Inhumations recovered from large civilian, common burial sites are usually representative of a significant proportion of the past local population and permit the reconstruction of demographic parameters such as age- and sex-specific mortality, life expectancy at birth and stature, amongst others. Special burial constructions, grave goods or different burial rites may be due to biological (age at death, sex) or social features, including different provenance and therefore “foreignness”. For the majority of the dead on a common burial site however, the material culture does not provide this information or may remain ambiguous. As a result, the extent of population admixture in a settlement chamber mostly remains unknown, let alone the assessment of places of provenance of primarily non-local individuals. With regard to the parameters which are of influence on human population development including potential social, cultural and political implications, extent and direction of immigration and emigration are highly significant.

Humans have always been mobile, and exogamy is only part of this behaviour. Based on numerous historical and pre-industrial population studies and census, palaeodemographic studies consider a proportion of up to 10 % as a reasonable figure for the percentage of non-local individuals buried at a common cemetery. Therefore, this figure may also be assumed for prehistoric times, but is it applicable for all times and different populations and social systems? And how did geographic barriers such as large rivers and high mountains influence mobility and migration in the past? What were the implications for import, trade and exchange? These questions need answers formulated under consideration of pertinent circumstances such as time, geography, climate, culture, technology and availability of raw materials, just to name some of the influential parameters that can exercise.

Today bioarchaeological sciences have the ability to analyse human and faunal remains at the elemental and molecular level to achieve a better understanding of life histories, spatial movement and population distributions in prehistory. The desire and related scientific efforts for a better understanding of spatial movements and the resulting distribution of humans, animals and cultural features in prehistory stimulated the bioarchaeological sciences to take a closer look at the bodily relics of former populations in an attempt to decipher individual and collective life histories that are hidden in the chemical composition of skeletal finds. In the course of the last decades, substantial research progress has been achieved in the field of radiogenic isotopes, in particular, the $^{87}Sr/^{86}Sr$ isotopic system examined in bones and teeth. The detection of primarily non-local individuals by stable strontium isotopic ratios was regularly employed, and the method enjoyed high status amongst researchers. It was even occasionally viewed as being superior to every other method for the identification of immigrants or imported animals. While researchers involved in this field rapidly became aware of its limitations, it took again some years until it was generally acknowledged that the spatial variability of stable isotopic ratios of a single element such as strontium can be highly redundant. The elemental concentrations and isotopic ratios in the skeleton are highly dependent on a wide variety of environmental and metabolic parameters, yet the fields of archaeology and bioarchaeology were astonishingly slow in accepting this fact. Hypothesis building and the investigation of tracer systems such as stable isotopic ratios benefited substantially from the understanding that such complex issues necessitate an interdisciplinary networking and discourse.

Parallel to this development, attempts were made to overcome the spatial redundancy of single stable isotopic ratios such as the geodependent $^{87}Sr/^{86}Sr$ by measuring more than one isotopic signature in a skeletal find. Stable lead isotopes also rely on geological features, stable oxygen isotopic ratios are related to hydrological cycles, and stable carbon and nitrogen isotopic ratios reflect environmental conditions including dietary preferences and subsistence strategies. Such "multi-isotope fingerprints" are no doubt informative, but it becomes increasingly more difficult to extract the relevant information. The uptake and turnover of elements in organisms are under physiological control. Due to the rather long biological half-life of skeletal and dental tissue, element uptake and incorporation of stable isotopes not only accumulate over years in large mammals but in addition exhibit considerable reservoir effects in the individual body. Therefore, the evaluation of element source, concentration and proportional contribution to a "global" stable isotopic ratio in a skeleton can be very tricky and necessitates mathematical approaches beyond conservative multivariate statistics.

Bioarchaeology is always confronted with the additional problem of tissue decomposition. Element uptake by contamination and element loss by leaching in the course of long inhumation periods are common processes and may totally obscure the original isotopic signature of a bone or tooth. Mass spectrometers provide very exact measurements, but how can the biological signal be differentiated from the diagenetic one? As long as the research substrate is a biomolecule such as the skeletal structural protein collagen, molecular biological methods such as amino acid sequencing for the purpose of authentication are at hand. Presently, deciphering between local and non-local individuals however is best achieved by stable isotopic signatures in the bioapatite. Methods for the authentication of the mineral integrity of an archaeological skeletal find have been the subject of intense discussion for years, yet still no commonly agreed upon catalogue for quality control criteria exists.

This is an unfortunate knowledge gap, especially with regard to the inhumation practice of cremating the dead, which was performed at different times in prehistory worldwide. On the European continent, cremating the dead was the primary if not exclusive burial custom from the Bronze Age until late Roman Times. The majority of human remains originating from this period, which spans approximately 1500 years are preserved as cremations. Exposure to high temperatures not only leads to a full combustion of all organic skeletal components but at the same time to a high degree of fragmentation and distortion of the remaining mineralized parts. Morphological examinations of cremated bones must be conducted by skilled and experienced osteologists. Archaeometric analyses of cremations still constitute a sort of "terra incognita". Stable isotope analysis of cremated bones and teeth not only requires the differentiation between diagenetic artefacts and original isotopic signals but also an evaluation of possible high temperature artefacts.

In 2012, the project "Transalpine Mobility and Culture Transfer", an interdisciplinary research network, was granted by the German Science Foundation (www.for1670-transalpine.uni-muenchen.de). This project focuses explicitly on some of the pertinent open questions mentioned above: to overcome the spatial redundancy of single isotopic ratios by establishing a multi-isotope fingerprint for archaeological skeletal finds and resolve this multidimensional information in terms of ecogeographic provenance, to subject every sample to an in-depth mineralogical characterization for the authentication of the measured stable isotopic ratios and to specifically investigate the research potential of cremated finds for prehistoric migration research. To accomplish this, a geographical reference area of eminent archaeological importance was chosen, namely, the Inn-Eisack-Adige passage via the Brenner Pass in the European Alps. The multi-isotope fingerprint consists of the following stable isotope ratios measured in the bioapatite of archaeological skeletal finds: $\delta^{18}O_{phosphate}$, $^{87}Sr/^{86}Sr$, $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, $^{208}Pb/^{204}Pb$, $^{208}Pb/^{207}Pb$ and $^{206}Pb/^{207}Pb$. Isotopic mapping was performed by analysis of archaeological bones of large vertebrates, in particular, cattle, pig and red deer, known to have resided in the area. This book summarizes the results achieved after completion of the first three-year phase of this project which are prerequisite for the application of the resulting isotopic map of the specific alpine transect to open questions related to prehistoric mobility and culture transfer. Because of the intended evaluation of the research potential of cremated finds, the project's archaeological sub-groups are dedicated to periods dating from the Urnfield Period until Imperial Roman Times.

While this project does not claim to solve every problem, the interdisciplinary research group aims at a significant contribution with regard to the reference area chosen. Scientific fields involved include archaeology, archaeozoology, computer sciences, crystallography, geology and physical anthropology, which altogether created a network aiming at the establishment of a large database and computational methods which will be made public by worldwide data sharing. The general structure of this network is visualized by Fig. 1 and is reflected in the structure of this book.

Although the European Alps constitute an imposing geographical boundary separating central Europe and the Mediterranean regions, they have nevertheless been crossed by humans since the Neolithic. The reference area chosen in this project was in use since the ninth millennium BCE, evidenced by numerous finds related to hunter/gatherer populations. The fact that resting places and artefacts were found at altitudes exceeding 1800 m a.s.l., and that stone tools had been manufactured from raw material stemming from different regions, is proof for a successful adaptation of Stone Age human populations to these special ecogeographical regions. Archaeological evidence for transalpine mobility and trade since the Mesolithic is the topic of chapter "Transalpine Mobility and Trade

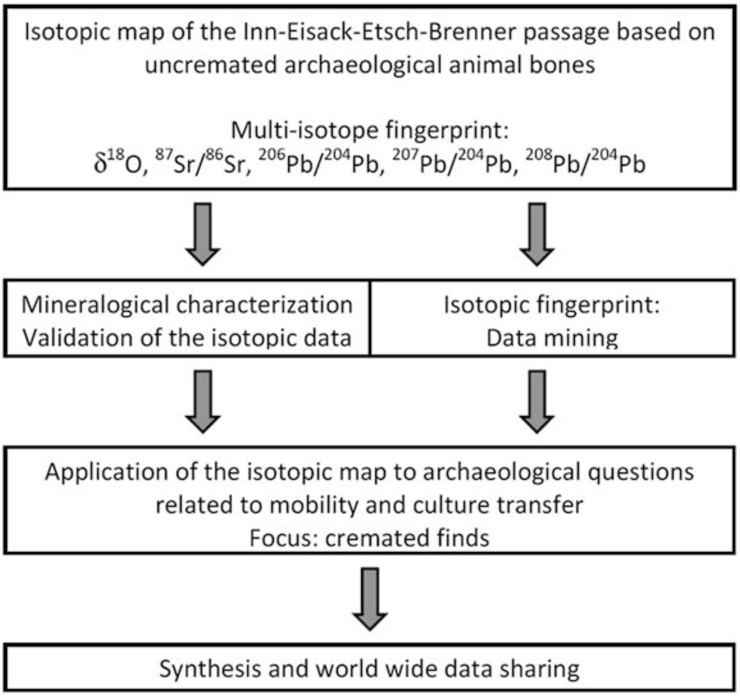

Fig. 1 Contextual and methodological structure of the project

since the Mesolithic". An important and strongly related issue is the archaeological concept distinguishing mobility from migration. Telling local from non-local individuals by stable isotopic signatures in skeletal finds needs to refer to the spatial distribution of geodependent and hydrology-dependent isotopic ratios in the reference area. Isotopic maps give clues to this, but do not yet fulfil the concept of an "isotopic landscape", a valuable tool in modern sciences such as ecogeography, wildlife conservation and others. How modern bioarchaeological research differs from the notion of "isotopic landscapes", and how far bioarchaeology has proceeded to reach this goal, is described in chapter "The Concept of Isotopic Landscapes: Modern Ecogeochemistry versus Bioarchaeology". In our project, isotopic mapping was achieved by stable isotope analysis of contemporary archaeofaunal finds from three different species of large residential vertebra. Drawing upon archaeological and archaeozoological data, chapter "Early Roman Transfer of Animals Across the Alps: Setting the Stage for Interpreting the Results of Isotope Fingerprinting" provides insight into the cultural phenomenon of animal transfer across the Alps in early Roman times. This contribution clearly illustrates that mobility and migration/trade are not only an issue in human population development but are equally important in livestock species valued economically in the northern Alpine foreland. Based on archaeological findings dating to the late first century BCE and the first century CE, the paper also outlines the needs of and the logistical basis for (supra-)regional trade of goods subsequent to the Roman conquest, thereby setting the stage for interpreting the results of isotope fingerprinting scheduled for the second project phase.

Archaeometrical methods such as mass spectrometry produce data which are very exact in terms of measurement precision. As stated above, diagenesis is likely to obscure the original, biological stable isotopic signatures of a find. A mineralogical validation of the quantitative purification of the bioapatite through appropriate sample processing protocols is indispensable. This and the changes induced in the bioapatite by diagenesis and high temperature exposure are addressed in chapter "The Crystalline State of Archaeological Bone Material". A multi-isotope fingerprint necessitates multivariate statistics for its analysis. Chapter "The Isotopic Fingerprint: New Methods of Data Mining and Similarity Search" summarizes the results obtained by application of modern data mining techniques such as EM clustering and its implications for provenance analysis. Such model procedures under consideration of the proxy character of stable isotopic signatures in bioarchaeological finds constitute a valuable tool on the way to the establishment of an "archaeobiological isotopic landscape". Finally, chapter "Isotopic Map of the Inn-Eisack-Adige-Brenner Passage and its Application to Prehistoric Human Cremations" is dedicated to the results achieved after three years of interdisciplinary networking for the isotopic mapping of one of the most important transalpine routes in prehistory. This chapter also shows that cremated skeletal finds, whether human or animal, constitute a suitable substrate for migration research in prehistory. This is the ultimate prerequisite for finding answers to persisting archaeological questions related to human mobility/migration behaviour with or without accompanying culture transfer. How this will be performed, and how the database established in the frame of the project can be made public for users worldwide, is subject of the closing chapter “Current Synthesis and Future Options”.

This project would not have been possible without generous financial support by the Deutsche Forschungsgemeinschaft. Interdisciplinary networking greatly benefited from the specific platform of the ArchaeoBioCenter of the Ludwig Maximilian University in Munich (www.archaeobiocenter.uni-muenchen.de). We are most indebted to Springer Publisher for giving us the opportunity to publish the results achieved in the first phase of our project in the form of this book.

Martinsried, Germany — Gisela Grupe
June 2016

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