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From Isoscapes to Farmscapes: Introduction to the Special Issue

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Introduction

This special issue arose from a dedicated session at the European Association of Archaeologists Conference in Glasgow 2015, titled: *From isoscapes to farmscapes: Unlocking the potential and avoiding the pitfalls of integrating isotopic and archaeological data to reconstruct diet and subsistence strategies*. In this we sought to explore the opportunities and challenges offered by the application of isotope data to diet, subsistence and past farming practice through case studies that considered these topics for a multitude of periods and regions. This included an exploration of the specific methodological, or other, limitations that are currently encountered by researchers in attempting to apply isotopic analysis to the questions above. The title reflected that the wealth of isotope data now in existence, and methodological advances (e.g. sample size and throughput) are producing what the ecological and environmental communities are terming 'Isoscapes', or 'isotopic landscapes' (Bowen et al., 2010). This approach integrates isotopic data, either through individual studies, or by combining multiple projects, over particular geographic regions to tackle a problem. 'Farmscapes' was chosen, as the session focussed on food procurement, in particular prehistoric agricultural practice. This is important because the base of the food chain determines the isotopic patterns observed in (for example), human remains, which reflect individual diets. Agricultural practice is also integral to understanding the activities, choices, and environment of so many human communities, over a broad spatiotemporal scale.

The session brought together many colleagues interested in sharing information and hearing about advances in the field. Presentations covered a wide range of geographical areas and periods, from the Neolithic to the Norse, from North Africa to Northern Sweden. A theme that featured prominently in virtually every paper was the fundamental need to integrate isotope analysis with other data sources, both scientific *and* archaeological, in order to derive maximum benefit. Several papers included a comparison of modern analogue material with archaeological samples from the same area, often to provide important data that is absent from the archaeological record, e.g. soft tissues, or to 'fill in' geographic areas. The contributors to this special issue have combined archaeology, ecology, and isotope analyses, to understand crop cultivation and animal husbandry across North Africa, the Near East, Asia Minor, and Western Europe, stretching up to the Scottish North Atlantic Islands. This includes mapping modern agrosystems to reconstruct prehistoric agroecology (Bogaard et al., 2016), combining archaeobotanical and zooarchaeological isotope analyses to examine the effect of crop fertility upon a whole farming system (Aguilera et al., 2017), and integrating archaeology and isotopes to focus on animal husbandry in more marginal environments (Jones and Mulville et al., 2018). Mobile systems are also considered, where pastoralism is practiced over very wide regions (Ventresca Miller et al., 2017). To introduce the work, we briefly summarize the state of play in the research field. This is a vast and growing area, so we focus on specifics that were relevant in developing the session. We then provide a summary of the articles, before finally suggesting some implications and directions for future research.

A Brief Background

Isotope analysis is important and exciting strand in the application of scientific techniques to archaeological questions. The isotope ratios of hydrogen, nitrogen, carbon, oxygen, sulphur, and strontium, form a 'fingerprint' in the tissues of plants and animals (including humans) that identifies the organism's diet, or locates its place of origin/ movement during life (Hobson, 1999). Since these are key in reconstructing past cultural practice, events, and interactions with the environment, isotopic information can be invaluable. However, like any other technique, isotope analysis is a tool, and users of the information provided must be aware of its limitations, along with its great potential. Overcoming these limitations often involves skilful incorporation of isotopic data with archaeological information, and awareness of the continual advances in isotope science, which unlock the potential to make more extensive archaeological interpretations with confidence.

The most common application of isotopes in archaeology has been reconstruction of human diet, particularly via stable carbon and nitrogen isotopes (expressed as $\delta^{13}C$ and $\delta^{15}N$, respectively), (Ambrose and Norr 1993; Jim et al. 2004). The potential of the approach has been recognized since the 1970s (e.g. Parkington, 1972). Different environments (e.g. marine versus terrestrial) show differences in stable isotope signatures that are transferred to the consumer, allowing the diet sources to be pinpointed. Other isotopes such as oxygen or strontium are specific to a geographical region and are 'fixed' in tissues when water or food is taken in, recording where the organism was when body tissues were formed (e.g. Bentley, 2006). Isotopes are very attractive in these applications because the sample is completely associated with the event, i.e. there is no doubt that the $\delta^{13}C$ in a bone reflects, in some way, what the organism consumed; an analogy is radiocarbon dating an outer tree ring when the question is the age of death of the tree (see Aitken et al., 1990). Isotopes are now frequently applied to zooarchaeological and archaeobotanical material to either construct a 'baseline' of the resources or environment in a region or to directly explore past farming practices in the area. Methodological advances such as sequential sampling of dentition (e.g. Balasse 2002), multi-element analysis (e.g. Sayle et al., 2016) and isotope extraction from charred seed assemblages (e.g. Bogaard, et al., 2016) are illustrating the potential for a more nuanced understanding of past subsistence and farming practice. Recent examples include: modelling landscape exploitation (e.g. Newsom et al., 2004), access/control via cultivation practice/grazing regimes (e.g. Brewington et al., 2015); seasonality of farming practice via evidence for manipulation of birthing season (e.g. Towers et al., 2011), and foddering strategies, including mechanisms for enhancing fertility and productivity via manuring and supplementary foddering (e.g. Makarewicz, 2014).

Overview of the Articles

Land management, i.e. manuring, irrigation, tillage and hand weeding, is central to arable farming, itself a lynchpin of human societies across most climatic zones worldwide. These practices form a quantity known as agricultural labour intensity, linked to available arable catchment, climatic conditions, and the size of food resources required. Bogaard et al (2016) seek to identify agricultural labour intensity in the key archaeological zone of (semi-)arid regions. They first develop an isoscape for modern day Morocco using $\delta^{13}C$ and $\delta^{15}N$ of cereal and pulse fields, and combine this plant functional traits (e.g. canopy diameter, thickness) specific to high- and low-intensity cultivation regimes. A GIS survey draws in environmental data, and discriminant analysis is used to identify determining/ driving factors between plant characteristics. Manured and irrigated fields are clearly different from less manured, rain-fed terraces, and weed variation between fields reflects labour intensity. The modern model is then used to investigate arable land management at the third-millennium cal BC site of Tell Brak, an early urban centre in northern Mesopotamia. Applied to archaeobotannical samples, this indicates the city was sustained by extensive, low-intensity regimes, with rain-fed fields and limited manuring. Arable yields would be sufficient (i.e. no need for high intensity efforts), so the city would not need to import crops from afar, instead being self-sustaining.

Land management practice is also explored by Aguilera et al (2017), who identify soil-specific differences in agricultural improvement strategies between the Iron Age (Late La Tène) and Roman period in northern France. They look at how the intensity of approaches varied, and in particular, how soil fertility and type affected the strategy used in the southern Île-de-France, and northern Champagne regions. The former is characterised by deep, fertile, loess soils, which retain water well, but which can be exhausted by intensive cereal cultivation. The latter is covered by 'chalky' soils, from which water easily escapes, and which are frequently deficient in key nutrients. The authors combine new isotope analysis with pre-existing archaeobotannical data, using isotope measurements ($\delta^{13}C$ and $\delta^{15}N$) of cereal grains and wild herbivore bones. The latter identifies the 'natural' (i.e. unmanured) plant $\delta^{15}N$ for the region. Region-specific differences show flexibility in agricultural strategies and understanding of varying ways to maximize productivity. In Île-de-France, cereal $\Delta^{13}C$ values correspond to well-watered soils, but based on $\delta^{15}N$, moderate to intensive manuring was used to correct impoverishment of nutrients (possibly resulting from continued wheat cultivation). In contrast, nutrient limitation and low fertility in Champagne was overcome through selection of crops (e.g. barley), that still grow well in lower nutrient conditions.

Like the La Tène to Roman period of Aguilera et al (2017), the Norse period in the Atlantic saw an increase in population size, accompanied by a boom in trade that included livestock. Coupled with the importance of domesticated animals to the Norse subsistence system, successful animal management was crucial. Jones & Mulville (2018) investigate how this management was practiced in the marginal coastal environments of the Scottish North Atlantic Islands, using animal bone collagen $\delta^{13}C$ and $\delta^{15}N$, set in context of a wealth of existing archaeological information. Sheep, cattle, and pigs were all assessed across three island groups. It is clear from the isotopic data that livestock were carefully managed in these environments across all time periods and across the whole study area, with sheep and cattle being particularly tightly controlled. For example, there is little to no evidence that these animals were free to roam and access coastal areas. The authors suggest that this was essential to protect precious island soil systems from the serious consequences of overgrazing. Pigs on the Western Isles, however, seem to roam more freely, and consumed a diverse diet, indicating management depended on local household circumstances. This suits low numbers of animals, but at the high-status site of Earl's Bu on Orkney, a larger pig population seems to have required more structured husbandry, resulting in more restricted animal diets.

Societies depending upon agriculture include not only those occupying one site continually, and using a tightly-defined zone for arable or pastoral practice, but also groups that are much more mobile, and accessing resources over a wide, loosely-defined area, according to need. Understanding the pattern and extent of this mobility is an important step in reconstructing social development through time. Ventresca Miller et al., (2017) apply isotopes of strontium ($^{87}Sr/^{86}Sr$) and oxygen ($\delta^{18}O$) to pastoralist communities from the Middle Bronze Age (MBA), and Late Bronze Age (LBA) of Northern Kazakhstan (2100–1700 cal BC and 1700–1400 cal BC, respectively). The steppe environments of Bronze Age Eurasia saw complex social development, and a continued increase in geographical spread of technology and material culture. The mechanism for this is unclear; namely to what extent the mobility and migration of pastoral groups drove these changes. Ventresca Miller et al., (2017) focus on the MBA and LBA in their study area, using the clear archaeological transition between these, where planned, fortified MBA settlements with multiple construction stages and enclosures gave way to much smaller, unenclosed LBA communities. The importance of combining modern isotopic landscapes (i.e. 'baselines') is again emphasised; the authors measure modern plants and freshwater to map spatial variation in local bioavailable strontium and oxygen. Comparing these to human teeth from cemeteries in northern Kazakhstan shows that mobility was largely local during both the MBA and LBA, although the use of landscapes and resources did expand over time. The combination of isotopic landscapes with archaeological samples and excavation data therefore enables the interpretation that large-scale mobility and migration is not the main driving force for social sophistication and transmission of material culture. This is important, as it supports the need for a wide research focus in this region to consider a range of further possible types of social interactions.

Concluding observations: Current Trends and Future Directions of the Field

There is a growing realization that studies applying measurement of isotope ratios to answer archaeological research questions requires better integration between archaeologists and isotope specialists not only to help identify relevant questions relating to animal and plant husbandry but to delineate relevant analytical limits in both disciplines. It is through these interactions and integrations that our field will progress dramatically. As significant is the fact that, in order to move beyond simple and often ad hoc dietary reconstructions based on a few individuals, it is apparent that further methodological innovation is required, such as a shift towards larger scale isotope analysis, development of secure modern analogue baselines and isotopic landscapes ('isoscapes') for specific regions and of integrative approaches with palaeoeconomic datasets. We feel that the diversity and quality of papers presented in this special issue will provoke thought and discussion among colleagues, focussing attention on new and exciting research angles.

Notes on contributors

Philippa Ascough is the current Head of the NERC Radiocarbon Facility (Environment), a Lecturer in Environmental Geoscience (SUERC), and an Honorary Research Fellow at the University of Edinburgh. Her research covers work at the interface between environmental and archaeological science, with a particular focus on chronology and the development of novel analytical techniques. In this she is funded through NERC, NSF, AHRC, The Carnegie Trust (Scotland), and the Swiss National Science Foundation. She is a Member of the Royal Society of Chemistry, a Fellow of the Society of Antiquaries Scotland, a peer-reviewer for the European Science Foundation, and an International Expert Reviewer for the Australian National Research Council. She is a member of the Scottish Archaeology Research Framework, and has been a member of the Scientific Committee for the

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Dr. Ingrid Mainland is Senior Lecturer in Archaeology at the UHI Archaeology Institute, University of the Highlands and Islands. Her main focus of expertise lies in zooarchaeology and her research therein has two major themes: sustainability, using environmental data to address long term trajectories of human-environment relations and societal resilience in N. Atlantic island ecosystems; and, palaeodiet, integrating different palaeodietary and zooarchaeological approaches to address animal husbandry practices in the past, including inter alia the impact of grazing animals on the landscapes of the N. Atlantic islands, early Neolithic herding strategies in Southern Europe and pig domestication in Eurasia.

Anthony Newton is a Lecturer in the School of GeoSciences, University of Edinburgh and ian Adjunct Professor (Research), Doctoral Program for Anthropology Graduate Center, City University of New York. He is a Fellow of the Society of Antiquaries Scotland. His research is centred around the application of tephrochronology to a range of archaeological and environmental studies, as well as the development of online resources. He developed and launched the widely used, NERC-funded, Tephrabase tephrochronological database in 1995. He is currently part of NSF-funded dataARC project, which aims to bring together a wide range of archaeological and environmental datasets to aid research in the North Atlantic region. Much of his research has been based in Iceland and includes understanding human-environment interactions since Icelandic settlement 1200 years ago. Other research includes refining radiocarbon chronologies of island colonisation, a DFG-funded project on Norse landing sites, the impact of large Plinian eruptions in Iceland, establishing the relative sea-level history of north-west Iceland and ocean-transported pumice deposits found around the North Atlantic region. He is also Editor of the Journal of the North Atlantic, a multi-disciplinary, peer-reviewed and edited archaeology and environmental history journal focusing on the peoples of the North Atlantic.

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