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Deposited in DRO:

30 October 2019

Version of attached file:

Accepted Version

Peer-review status of attached file:

Peer-reviewed

Citation for published item:

Jay, Mandy and Montgomery, Janet (2019) 'Isotopes and chariots : diet, subsistence and origins of Iron Age people from Yorkshire.', in *The Arras culture of Eastern Yorkshire - celebrating the Iron Age*. .

Further information on publisher's website:

<https://www.oxbowbooks.com/oxbow/the-arras-culture-of-eastern-yorkshire-celebrating-the-iron-age.html>

Publisher's copyright statement:

This chapter been accepted for publication and will appear or already has appeared in a revised form in a book entitled *The Arras culture of Eastern Yorkshire - celebrating the Iron Age*, edited by Peter Halkon, published by Oxbow Books, 9781789252583.

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Isotopes and Chariots: Diet, subsistence and origins of Iron Age people from Yorkshire

Mandy Jay and Janet Montgomery

Introduction

Isotopic data obtained from skeletal remains can be used to support a narrative about people's lives. The analysis reveals aspects of mobility, diet, subsistence strategy and environment with the data reflecting the food and drink actually consumed by an individual. In contrast, when mobility is discussed in the context of ancient DNA studies it is related to ancestral genetics, so that any movement suggested is not necessarily that of the individual being analysed, but perhaps of earlier generations. The data can be complementary, but they do not necessarily indicate the same thing. Isotopic analysis tells the tale of the individual in their own lifetime based on what they ate and drank and the environments from which those resources were obtained.

In this chapter we discuss isotopic data sets from Iron Age burials, including the cemetery at Wetwang and Garton Slacks on the east Yorkshire Wolds where a number of chariot burials were excavated (Jay *et al.* 2013). Chariot burials are also included from other sites on the Wolds, and from Ferry Fryston (west Yorkshire) which produced one of the few found in Britain outside of east Yorkshire (Jay *et al.* 2007). The analyses include strontium and oxygen from tooth enamel, alongside carbon, nitrogen and sulphur from both bone and dentine collagen.

Isotopic analysis

There are a number of chemical elements which can be analysed from the skeleton, each of which has two or more isotopes (with different masses) which can be compared for their relative presence in a sample. Each element says something different about the source or composition of an individual's diet, so that a study which combines analyses is much more powerful for interpretive purposes than where only one element is used. For instance, strontium isotope analysis relates back to the geology on which plants were grown, but similar rocks can be found in a range of different places, so combining strontium data with oxygen data, which are related to

climate and water sources, can help reduce the field of possible origins when interpreting mobility.

There are also timing differences in the formation periods of the tissues analysed. Strontium and oxygen are from tooth enamel, or more rarely petrous bones, for which the inorganic matrix survives well in the burial environment, unlike for bone. For carbon, nitrogen and sulphur, the analyte is organic collagen, which can be extracted from both bone and dentine. This survives well in British burial environments within the inorganic bone and dentine matrices. The tooth fractions (enamel and dentine) and petrous bones are formed during childhood, the precise period of formation being dependent on the particular tooth analysed. After this, there is little change in these tissues which take their isotope ratios from the food and drink consumed during that formation period. Bone, on the other hand, turns over during life and the rate at which this happens differs for different bones and parts of the bone. For instance, a femur cortical sample will reflect an averaged lifetime dietary input, probably weighted towards adolescence. A rib sample, including trabecular rib, will reflect a signal much closer to the end of the person's life. So comparing a dentine collagen sample with a rib sample effectively compares childhood with the period of life before death.

Each of the isotope systems being discussed has its own set of analytical problems, is affected by different variables and provides different information, but ultimately they all reflect what an individual ate and drank during their lifetime to provide nutrients for body tissue formation.

Mobility can be identified by looking at the isotope ratios which might be expected for a particular region, based on a variety of factors such as geology and climate, and then comparing these with the isotope ratios actually seen in the skeletal remains. There are some generalized maps available for strontium and oxygen, for Britain in particular, to show the ranges of data which might be expected for particular locations (e.g., Evans *et al.* 2010; Pellegrini *et al.* 2016; NERC Isotope Geosciences Laboratories (NIGL) 2018), but such maps must be used with caution; they are not tools for producing definitive answers. It is rarely possible to say that someone clearly originated at a specific location. There may be many regions which support

the data obtained from an individual, but more precision regarding origin may be obtained by looking at a multi-isotope data set and by including the most likely archaeological scenarios.

Data which are consistent with the burial location for an individual do not *necessarily* mean that they were local, or that they had never been mobile. They might have originated from a region where the bioavailable isotopes were very similar to the burial region, or they might, for instance, have moved away from the region after childhood (when tooth enamel formed), lived elsewhere for much of their lives, and then returned to their origin before death, or been brought back to be buried.

Carbon and nitrogen isotope data ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values) from bone and dentine collagen provide some basic information about an individual's diet. There is a trophic level effect for both, although it is larger for nitrogen, which means that the values from a consumer will not be the same as those in the foods they have eaten, but there is a relationship. Individually and in combination these values help with the interpretation of trophic level (herbivore, omnivore, carnivore), the consumption of marine and other aquatic resources, and whether C_4 plant foods (e.g., millet) have been included in the food chain. Sulphur data ($\delta^{34}\text{S}$ values), also from collagen, do not show a significant trophic level effect, but they can be used to consider the consumption of aquatic resources and the distance of food origins from the coast (due to a 'sea spray' effect); there is also likely to be a relationship between local geology and sulphur data, so that these can be used in the discussion of mobility.

All of these values will be affected by local environment as well as the kinds of foods being consumed. If two people were consuming exactly the same types of foods, but they came from very different climates (e.g., cold and wet as opposed to hot and dry), then the signals seen would differ. In order to control for this an ideal study includes animal remains, particularly herbivores, alongside those from a human population. The animals provide a 'baseline' for the local environment from which the foods were obtained. It is not only spatial environment which can have an effect; if climate changes over time, then this may alter the data. If two people consumed

exactly the same types of food, but dated to significantly different archaeological time periods, their signals would not necessarily be the same.

If a population has a relatively consistent diet, as indicated by the collagen values, and they all date to the same period, data outliers in the group may indicate that individuals were mobile. This may be because they had basically the same diet, but from a different environment. It might also be because they came from a different place, where a different consumption pattern was the norm. So, although carbon and nitrogen isotope data are not specifically used to indicate mobility alone, they highlight individuals who are worth further investigation with more expensive techniques, such as strontium and oxygen isotope analysis.

Mobility in the data set

Strontium and oxygen isotope data for Iron Age individuals from the Yorkshire Wolds (east Yorkshire), Ferry Fryston (west Yorkshire) and the hillfort at Fin Cop (Derbyshire Peak District; Waddington and Montgomery 2017) are shown in Figure 1.

INSERT FIGURE 1

The chart shows the horizontal upper limit of $^{87}\text{Sr}/^{86}\text{Sr}$ values expected for the chalk region of the Wolds, which would also be expected to encompass the range for the Magnesian limestone of Ferry Fryston, and the upper limit for the Millstone Grits, Coal Measures and the Bowland Shales that surround the Carboniferous limestone of the White Peak on which Fin Cop is sited. Also shown is the vertical general range of $\delta^{18}\text{O}$ values which would be expected for Britain based on empirical data; the central 'overlap' region is bounded by the 2 sd range for eastern, 'lower rainfall' and more westerly, 'higher rainfall' limits (Evans *et al.* 2012). The majority of the Wetwang individuals fall within the data domain expected for Yorkshire chalk, but most of the Ferry Fryston group (six of eight samples shown) have significantly higher $^{87}\text{Sr}/^{86}\text{Sr}$ values than expected for the Magnesian Limestone region of their burial contexts and at least one of the Fin Cop burials does not fall within the range of values which would be expected within 20 miles of the site. For Ferry Fryston we have other samples from the site from the Early Bronze Age which have much lower

values than those shown on this chart and we also have dentine values from the Iron Age material which reflect a diagenetic trend towards lower values, so we know that the burial site itself does not produce these anomalously high data.

These $^{87}\text{Sr}/^{86}\text{Sr}$ values are exceptionally high in the context of British archaeological samples generally. The group of seven at the top of the chart range from 0.7143 to 0.7164 while the upper end of the range generally expected for English and Welsh humans overall, excluding individuals known to be immigrants, is approximately 0.7145 (Evans *et al.* 2012). Some values from Scotland, where older rocks are present, are higher, but even here human values are rarely as high as environmental samples suggest is possible. This is mainly because human dental enamel reflects overall diet, weighted towards plants, as consumed during childhood. There needs to be a source which is suitable for growing resources which will provide the majority of this diet in order for the human samples to reflect these high values. Many of the high values obtained, for instance from plants growing on old rocks, are not from such sources, but often from places where crops or grazing animals would not flourish.

One of our initial problems with understanding the Ferry Fryston data relates to the cattle remains excavated from the ditch around the chariot burial barrow. These were radiocarbon dated to the Roman period (late first or early second century AD, Orton 2007), so they were several hundred years later than the middle Iron Age central burial. They had $^{87}\text{Sr}/^{86}\text{Sr}$ values which were higher than expected for cattle grazing on Magnesian Limestone and encompassed a large range from 0.7099 up to 0.7202. This not only indicates a non-local origin, but suggests that they did not originate from a herd grazing in a single location. That might mean they came from different places, or that they came from the same place with a high strontium isotope ratio, but were different ages when they travelled over the period of formation of their teeth, so that a mixing effect occurred in the enamel as they grazed in different environments.

The problem, then, is that if the high values from the Iron Age humans are indicative of immigration from outside of Britain, is it also reasonable to say that hundreds of years later cattle were brought to the site from environment(s) with similarly high

$^{87}\text{Sr}/^{86}\text{Sr}$ values outside of Britain and buried at the same site, in the ditch of the same burial? This hypothesis suggests a site used over a long period of time for which there was a strong connection with an overseas location, with people travelling long distances to keep that link alive and bringing cattle with them, with markers to identify the actual burial site. This is possible, but a more parsimonious explanation is that there was somewhere local to the Ferry Fryston site, or at least somewhere in Britain, which was producing these unusually high $^{87}\text{Sr}/^{86}\text{Sr}$ values in both humans and cattle.

A considerable amount of recent research has looked for similarly high strontium isotope ratios in British material, both from skeletal remains and environmental samples such as soils, plants, animal remains and water. There are a number of burials analysed as part of the Beaker People project which have values higher than 0.7145, mostly from the Peak District, but one from east Yorkshire and one from Scotland (Parker Pearson *et al.* 2016; Waddington and Montgomery 2017; Montgomery *et al.* forthcoming). There are also some Neolithic individuals from south east Wales, most of those from the long cairn at Penywyrldod being above 0.714 and going up to 0.717 (Neil *et al.* 2017). The data are not restricted to one period in time, ranging from the Neolithic through to the Roman period. Bioavailable strontium from modern environmental samples with values this high have mainly been found in small numbers from Wales and Scotland up until now (Chenery *et al.* 2010; Evans *et al.* 2010), but plant and animal samples with similarly high values from the Dartmoor area have recently been found for the first time in England (Müldner pers. comm.; Frémondeau *et al.* 2018). Figure 2 is a map with the locations of the high values indicated.

INSERT FIGURE 2

The search for environmental samples with high values in the Ferry Fryston, Peak District and east Yorkshire regions has not produced any results so far. So, despite the most parsimonious explanation for these data being a northern British regional source, no evidence has been found for that. It is concluded then, that the most likely current interpretation of these data is that there was a route through the north of England, connecting Yorkshire and the Peak District, and that movement may have originated in the south west of England and south Wales, with people moving from

the Neolithic through to the Roman period. The research will continue, however, so that this explanation may be revised as the evidence develops.

Returning to the Iron Age data from the Wolds, the majority of individuals analysed fall into the band that would be expected for chalk. Those who plot above that range are not significantly high in the context of some of the other data shown in Figure 1. The highest Wetwang $^{87}\text{Sr}/^{86}\text{Sr}$ value is for sample 14 who is an unexceptional burial from this cemetery, being a secondary burial in a barrow ditch and without any grave goods (male, over 45 years). The male chariot burial from Kirkburn, buried with an iron mail tunic, has a higher strontium isotope ratio than Wetwang 14, but even he falls within the range obtainable from the Millstone Grit Coal Measures to the west and so could have been mobile regionally within Britain within a relatively short distance.

Figure 3 compares the Iron Age strontium data from the Wolds with the later Neolithic and early Bronze Age burials from the same region which were analysed for the Beaker People Project (Parker Pearson *et al.* 2016; Montgomery *et al.* 2019).

INSERT FIGURE 3

The variation in the data sets is different. The Neolithic and Bronze Age samples include individuals who have strontium isotope ratios well above the range expected for chalk, thus suggesting that the earlier people were relatively mobile across longer distances and were not living all of their lives here. The Iron Age people appear to be much more settled. This is consistent with how groups are expected to have been living at these different times; the late Neolithic and Bronze Age people are likely pastoralists, moving around in their landscapes, whilst the Iron Age people were agriculturalists and occupying a specific area.

General diet for the data set

Figure 4 shows the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values for Wetwang and some chariot burials from other sites on the Wolds.

INSERT FIGURE 4

The data are mainly from rib samples and so are indicative of the situation towards the end of an individual's life. The Wetwang group shows a relatively tight cluster of

data for the adults, except for three individuals (14, 431 and the Kirkburn chariot burial). When compared to animals from the site the data suggest a diet which is relatively high in animal protein, with no marine resource consumption visible, no indication of aquatic resources generally and no C₄ plants in the food chain. This is normal for the British Iron Age and is consistent with data sets for this period outside of Yorkshire (Jay and Richards 2007). The general pattern excludes the consumption of significant levels of aquatic resources, even at coastal sites, and there is usually consistency within a group where cemeteries are available for a larger population to have been analysed, although this is obviously relatively rare for this period in Britain.

Wetwang 14 and 431 both have higher $\delta^{15}\text{N}$ values than the rest of the data shown, and the Kirkburn chariot burial looks a little unusual in the context of the Wetwang data. These three individuals also have strontium isotope ratios which are not consistent with the local chalk environment. So it is likely that the reason they stand out in the dietary data set is either that their foods were being obtained from a different environment, but weren't necessarily different types of food, or that they were eating different foods because they came from a different place, where they did things differently. Or it could, of course, be a combination of the two. The important thing to understand is that the reason they stand out in this group is not necessarily simply that their diets were composed of different foods, or different proportions of foods, from the others; they probably stand out because they were mobile.

Another factor to notice in the Wetwang adult group is the trend suggesting an inverse relationship between the $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values. This is very unusual in carbon and nitrogen isotope data sets and it is driven here mainly by the mature adult males. The other adults on here do follow that trend, but the relationship is strongest in the older men. The reason for this is currently unclear, but it may be related to local, regional movements between isotopically different environments which rarely get picked up in British archaeological populations. There are a number of reasons why we would not normally see such movement in this way; normally, analysis is undertaken on groups where it is expected to find something unusual. The expense of analysing a group who will look 'boring' (they all look the same, the

diet has few variables, they are not moving around long distance) generally mitigates against the work being done. But in order to find the 'subtle' patterns which might indicate regional or local movement on a seasonal or other regular basis, such 'boring' data sets will be the requirement in order to exclude other variables which muddy the waters of interpretation.

The carbon and nitrogen data for Ferry Fryston is shown in Figure 5 alongside Wetwang and a number of Continental data sets.

INSERT FIGURE 5

Ferry Fryston looks very similar to Wetwang and this is another reason why it is difficult to understand the strontium data if they were indicative of immigration rather than a British origin. In general $\delta^{13}\text{C}$ values from mainland northern Europe at this time are higher than those from Britain. There are two likely reasons for this; firstly, millet (a C_4 plant) had been introduced into the Continental food chain by this time, while it was not present in Britain (Le Huray and Schutkowski 2005; Laffranchi *et al.* 2016; Goude *et al.* 2017). Secondly, climate and vegetation environments will have been different. The Ferry Fryston samples are mainly rib, which means that they represent the period towards the end of life, so it is possible that if they were immigrants then they had spent long enough in Britain to equilibrate to the British environment. A dentine value for the chariot burial is available which provides a childhood signal which is 0.6‰ lower than the rib, although it is still within the range of the Wetwang data. It is possible, however, that dentine values produce lower values for reasons other than mobility or dietary differences (e.g., physiological, see the Beaker People data set, Jay and Richards, 2019) and the majority of dentine values obtained from Wetwang are lower than the bone values even where individuals are expected to be local and settled in their environment based on the isotope data overall (Figure 6).

INSERT FIGURE 6

Wetwang sulphur isotope data ($\delta^{34}\text{S}$ values) are shown alongside $\delta^{15}\text{N}$ values in Figure 7. The herbivore data indicates the level of $\delta^{34}\text{S}$ values expected for the site and the humans are expected to be similar. Most of them are, but there is a trend in the data showing that the higher $\delta^{15}\text{N}$ values are correlated with the lower $\delta^{34}\text{S}$ values. There are two herbivores from the site (one horse and one sheep) which also

have very low $\delta^{34}\text{S}$ values compared to the others. It is again currently unclear what these data mean, but the authors hypothesize that the correlation is a mixing line indicative of regional movement to and from a location which is affected by aquatic resources (e.g., the Humber estuary, freshwater spring sources local to the Wolds, or the east Yorkshire coast). Further research is in progress in order to clarify this.

INSERT FIGURE 7

It should be noted here that using the British Geological Survey domain mapping (NERC Isotope Geosciences Laboratories (NIGL) 2018), which is mentioned above for strontium and oxygen as requiring care, is even more problematic for sulphur. Many of the values obtained from archaeological skeletal material found on chalk, both in Yorkshire and southern England (e.g., Gron *et al.* 2018; Jay *et al.* 2019) are high (in the case of Wetwang over 13‰) and do not show on this map as being 'local'; such high values appear to be consistent only with coastal locations rather than marine-derived limestones. The biosphere mapping is, however, based on modern plant values and one issue which might be raised about using the map for archaeological material is whether these plants have been affected by atmospheric pollution. Analysis of 19th and 20th centuries UK herbage by the Rothamsted project – a facility located on the same Upper Cretaceous White Chalk subgroup geology as the Yorkshire Wolds - shows that at the start of the project in the 1860s $\delta^{34}\text{S}$ were much higher than they are today (and more comparable with prehistoric values). From this date they show a long term downward trend in the $\delta^{34}\text{S}$ values which is negatively correlated with SO_2 emissions (Rothamsted Research 2006, p. 47). At the point in the 1970s where emissions started to decrease, the $\delta^{34}\text{S}$ values of hay start to increase again, but they have not returned to the values obtained at the beginning of the archival period in the 1860s. The plants used for the biosphere mapping, therefore, are unlikely to reflect the situation in prehistory. In addition, the plants used for the mapping are limited in number and there is only one sampling site which is actually on the Wolds. These maps must be used with great care, avoiding the temptation to simply 'plug in' numbers obtained from an analytical facility with the expectation that the results are easy to interpret without a detailed understanding of the underlying issues.

Advances in techniques

Our work at Iron Age sites in Yorkshire continues and our understanding of the data already obtained changes over time. Isotope analysis techniques are continually evolving, leading to improvements in precision, accuracy and detail of interpretation. For instance, the latest work on dentine collagen allows analysis of very small incremental samples which are 'sliced' from a tooth root and which provide a series of data for an individual which can provide a 'life-history' data set from before birth up to around the age of 23 years in increments of 2 to 3 months. Such analysis is changing our previous understanding of weaning and breastfeeding which had been based on much less precise bulk collagen data (Beaumont *et al.* 2015). Previous work at Wetwang looking at this issue using bone samples from infant burials suggested that breastfeeding at the site was minimal (Jay *et al.* 2008), but incremental analysis of adults (currently in progress) may change our understanding of this.

Working with isolated amino acids from collagen, looking at serial analyses from teeth, comparing different fractions of the skeleton which have formed at different times, using multi-isotope studies to refine data interpretation and adding to the arsenal of chemical elements available for study are all pushing the field forward, as is the comparison of isotope data with DNA results. Isotope analysis can be compared realistically to radiocarbon dating in terms of its development. The early days were an exciting start, opening up a field of possibilities, but it is the long-term development which will continue to make the techniques of lasting and important value.

Conclusions

The Iron Age population at Wetwang and Garton Slacks, on the Yorkshire Wolds, appears to be a generally settled community with no long-distance mobility currently in evidence. This is in contrast to the Early Bronze Age people who have been analysed from the Wolds who show evidence of a generally mobile lifestyle. This is likely to be a clear comparison between an earlier pastoral subsistence pattern and that of the Iron Age agricultural way of life.

Where individuals amongst the Wetwang population have been identified as unusual and probably mobile to some degree, it is possible that they were only moving around in the regional landscape. Although some of them look quite distinct in the context of the local cemetery, they are not unusual in the wider context of Yorkshire. This is likely to reinforce the fact that this was a settled community, such that even regionally mobile individuals stand out as unusual in that group.

Some of the trends in the existing data sets may represent regular, perhaps seasonal, movement between places in the regional landscape with different environmental backgrounds. Possibilities may include movement between the chalk of the Wolds and other surrounding regional geology, perhaps to and from water sources. Future work will look at serial and incremental analyses of teeth in order to obtain precision 'life histories' which may give us more information about these journeys.

The Ferry Fryston Iron Age individuals from west Yorkshire, which is not on the chalk, show a very different range of strontium isotope ratios. Most of the data are not consistent with the location of the site or region. A conclusive interpretation for these people as long-distance immigrants has been delayed in order to consider the possibility that this signal might be identified somewhere in Britain, or that issues such as transported glacial drift or the use of imported quern stones might have affected the results (Johnson *et al.* forthcoming). Extensive mapping and experimental research undertaken since the original analyses has not revealed any such causes, although bioavailable strontium from south west England and south Wales may suggest movement from the south west, through the Peak District and into Yorkshire over a long period of time from the Neolithic through to Roman times.

The Iron Age in Yorkshire has received some of the most extensive isotope study in Britain and we have found data patterns which are interesting, unusual and require further research to understand. The findings so far can be considered a work in progress; the research continues using new and evolving techniques to build on the foundations already in place, with interpretation being refined and new questions being directed by previous results. An increasing range of data types and their

synthesis into multi-isotope studies pushes the boundaries of what it is possible to understand about an individual's life.

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