6. THE HUMAN REMAINS

6.1 Skeletal analysis

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Only some fragments of skull and some teeth were recovered from the cist. The bone surface presented erosion which was graded 3 according to the standards in Brickley & McKinley (2004). The sex of the skeleton was assessed using standards outlined by Buikstra & Ubelaker (1994). Since no pelvic bones were preserved, only the sexual dimorphic traits of the skull were potentially available for observation, and three of them were not observable due to incompleteness or poor preservation. Consequently, only the posterior zygomatic process could be estimated, and this indicated a possible male (?M). However, because of the lack of more visual traits for observation and estimation, it is more appropriate to estimate the sex of the remains as indeterminate.

The degree of dental attrition observed led to an age estimation of 33–45 years (Brothwell 1981). However, since the different attrition stages do not follow a fixed and constant sequence, their accuracy is limited. As a result, a more general age category of 'adult' was estimated for the skeleton, based on the complete eruption of the third molars. No measurements were taken from the skeleton due to the poor preservation of the cranial bones. The non-metric traits, as their name indicates, are traits which are not measurable but are recorded as either present or absent (Table 2). Some of them relate to genetic causes, while others are thought to be linked to environment, occupation and lifestyle (Brickley et al 1999) and are used to identify and compare different genetic groups. Standard traits identified by Berry and Berry (1967) for the cranial bones were studied in this analysis.

The identification of different pathological conditions depends upon the completeness and preservation of the bone. Although this skeleton's incomplete nature makes it difficult to identify evidence of pathology, several conditions were identified.

Caries or tooth decay, caused by bacteria found in dental plaque (Hillson 1996), was recorded on the second and third maxillary left molars. On both teeth the cemento-enamel junction was affected by the caries, distally on the second molar and mesially on the third molar. Calculus or tartar, a hard deposit of mineralised plaque, was recorded on all left molars as well as on the maxillary left second premolar and mandibular left first premolar (Hillson 1996). In archaeological remains, calculus indicates poor oral hygiene, although its presence and severity can be influenced by age, diet, ethnicity and systemic diseases (White 1997). Finally, a dental anomaly, dental pearl enamel, was also identified on the distal aspect of the second maxillary left molar (Illus 10).

Table 2 Non-metric traits identified on the skeleton from Knappach Toll

Trait	Right	Left	Number
Cranial			
Zygomaticofacial foramen	X	P	1 foramen
Tympanic dehiscence	X	P	
Auditory exostosis	X	A	
Mastoid foramen exsutural	X	P	
Mental foramen number	X	A	
Mandibular torus	X	A	
Mylohyoid bridge	X	N/O	

Illus 10 The caries and dental pearl enamel at maxillary left M2. © Northlight Heritage

6.2 Strontium, oxygen, carbon and nitrogen isotope analysis

Jane Evans & Angela Lamb

6.2.1 Method

Samples were submitted for analysis of strontium and oxygen isotopes on tooth enamel, and for analysis of carbon, nitrogen and sulphur isotopes on bone, in order to illuminate the diet and geographical origins of the person buried in the cist.

The tooth enamel samples were prepared by abrading the available enamel surface to a depth of >100 microns, cutting thin slices and cleaning all surfaces. Strontium was collected using Dowex resin columns and loaded onto a single Re Filament with TaF following the method of Birck (1986); the isotope composition and concentrations were determined by Thermal Ionisation Mass spectroscopy (TIMS) using a Thermo Triton multi-collector mass spectrometer. Oxygen isotopes were collected by treating small fragments of clean enamel (15–20mg) to extract PO_4 radicals and precipitated as silver phosphate, using the method of O'Neil et al (1994). Oxygen isotope measurements on each sample were analysed in triplicate by thermal conversion continuous flow isotope ratio mass spectrometry (TC/EA-CFIRMS). Results were converted to SMOW values using a value of 21.7‰ for silver phosphate precipitated from NBS120C (Florida phosphate rock), calibrated against certified reference material NBS127 (assuming $\delta^{18}O$ of NBS127 = +20.3‰ versus V-SMOW) at NIGL using fluorination (see Chenery et al 2010: appendix). The 1σ reproducibility for mass spectrometry controls in this batch of analysis were $\delta^{18}O$ = ±0.20‰ (1δ, n=14) and the mean repeatability of triplicate analyses was $\delta^{18}O$ = ±0.10‰ (1δ, n=12). Drinking water values were calculated using the calibration of Daux et al (2008: equation 4).

The samples for carbon and nitrogen analysis were prepared following a modified Longin method (Brown et al 1988). The collagen samples used for carbon and nitrogen analysis were redissolved in milliQ water and ultra-filtered to remove the <30 kDa component for sulphur isotope analysis. The residue from the filters was freeze-dried and ~12–14mg was weighed into tin capsules. Sulphur, carbon and nitrogen isotope analysis was by continuous flow isotope ratio mass spectrometry (CFIRMS).

6.2.2 Results

The strontium isotope composition is below the value predicted for this part of Scotland (Evans et al 2010), although data from this area are sparse and the geology is complex. The drinking water value is within the expected range for the eastern side of Scotland (Darling et al 2003). Data are presented in Table 3.

The low strontium isotope ratio is indicative of someone raised either on chalk or basaltic terrain and most likely basalt, given the combination of the signature with an elevated S concentration of 212 ppm and by comparison with the very few examples we have of such origins (Culduthel man (J Montgomery, pers comm) and individual Cnip-D (Montgomery et al 2003)). A basaltic origin would be more likely in the Scottish context and, although such rocks are not recorded on the $^{87}Sr/^{86}Sr$ isotope biosphere map of Britain (Evans et al 2010) due to their limited outcrop, such rocks are found locally in the Knappach Toll area. The oxygen isotope composition (–8.3) is also consistent with an eastern Scottish origin. There is thus no evidence that this individual was not local; the data could also be consistent with an origin in Antrim, Ireland, where large areas of basalt exist. Origins on chalk terrain (such as occurs in eastern and southern England and in parts of the Continent) are also possible, especially given other kinds of evidence for close links between north-east Scotland and East Yorkshire (see 7.1 'Report on the Beaker' below; Curtis & Wilkin 2012; Shepherd 2012) and the eventual mass displacement by Beaker-using people of steppe ancestry via the Netherlands (Olalde et al 2018) (see 10 'Discussion' below). The Knappach Toll individual plots on the lower margin of the enamel strontium dataset for individuals analysed across Britain in the Beaker People Project (Parker Pearson et al 2016: fig 6).

The carbon and nitrogen isotope composition for the individual from Knappach Toll suggests that he or she had a diet high in animal protein, but with no evidence of a marine component. The data have been compared with reference data from the Norse-period Scottish sites of Cnip and Galson in the Outer Hebrides (Richards et al 2001), Newark Bay, an Iron Age site on Orkney (Richards et al 2006), and Wetwang, an Iron Age chariot burial in Yorkshire (Jay & Richards 2006). The Scottish data define an array of values that result from a mixed diet of marine and non-marine protein components; the higher nitrogen values typify a marine component. The Wetwang dataset provides a reference set for a

Table 3 Strontium isotope data for the Knappach Toll individual (* A ±0.2 (1σ) blanket error, derived from the reproducibility of the NBS 120 C standard, is considered the best estimate of error for the $\delta^{18}O$ SMOW values and this results in ±0.4 (1σ) error on the calculated drinking water values)

Sample	ppm	$^{87}Sr/^{86}Sr$	Mean δ^{18}*O SMOW	n	Daux equation	Amt% N	Amt% C	at C/N	$\delta^{15}N$ AIR	1 SD	$\delta^{13}C$ P	1 SD	n
KT-09-SK1-e	212.1	0.707949	16.72	3	-8.3	14.9	43.6	3.4	10.14	0.1	-21.56	0.15	3

diet high in animal protein, with no evidence for any significant marine food input (Jay & Richards 2006). The Knappach Toll individual plots on the margin of the Wetwang dataset. In comparison with the Beaker People Project dataset, the Knappach Toll individual's values are slightly higher for carbon isotope ratio than the average range of –21.0±0.4‰ and slightly lower for nitrogen than the average of 10.3±0.7‰ for dentine (Parker Pearson et al 2016).

The application of sulphur isotope analysis to archaeological material is relatively new. A few studies have begun to assess the utility of $\delta^{34}S$ both as an indicator of palaeodiet and as an indicator of residency/mobility (Richards et al 2001; 2003; Privat et al 2007). Sulphur is a vital nutrient for animals, and an animal's sulphur composition derives from its food intake. At the base of the food chain, vegetation will inherit sulphur from the substrate and its $\delta^{34}S$ composition will vary with geology, giving rise to a large variety of terrestrial $\delta^{34}S$ sources (–19 to +30‰). This variety can enable residency/mobility studies as it can identify 'migrants' to an area based on non-local $\delta^{34}S$ signatures. Plant $\delta^{34}S$ will also be affected by soil processes and, near the coast, by sea spray, which can deposit marine sulphur and potentially blur the terrestrial/marine $\delta^{34}S$ distinction. Marine sulphate has a $\delta^{34}S$ value of about +21‰ and primary oceanic producers have +17–21‰, whereas freshwater producers can have a very wide range of $\delta^{34}S$ (–22 to +22‰), reflecting the oxidation state of sulphates. As there is minimal fractionation between trophic levels, this can usefully be applied to compare terrestrial, freshwater and marine consumers. Away from areas affected by sea spray, $\delta^{34}S$ can distinguish between marine and terrestrially based diets. For example, a study of modern fauna from the Canadian Arctic used $\delta^{34}S$ to distinguish between terrestrial mammals (<+10‰) and mammals living close to the coast and consuming marine fauna, such as polar bears (+16–18‰) (Krouse & Herbert 1988). The limitation of $\delta^{34}S$ for archaeological palaeodiet studies is that it may not be able to distinguish between truly marine diets and terrestrial diets in coastal locations due to the issue of sea spray. If it is used in combination with other palaeodietary isotopes (C, N) this may aid interpretations. For example, high $\delta^{13}C$ values (> –17‰) can also suggest a marine protein diet in C_3-plant environments.

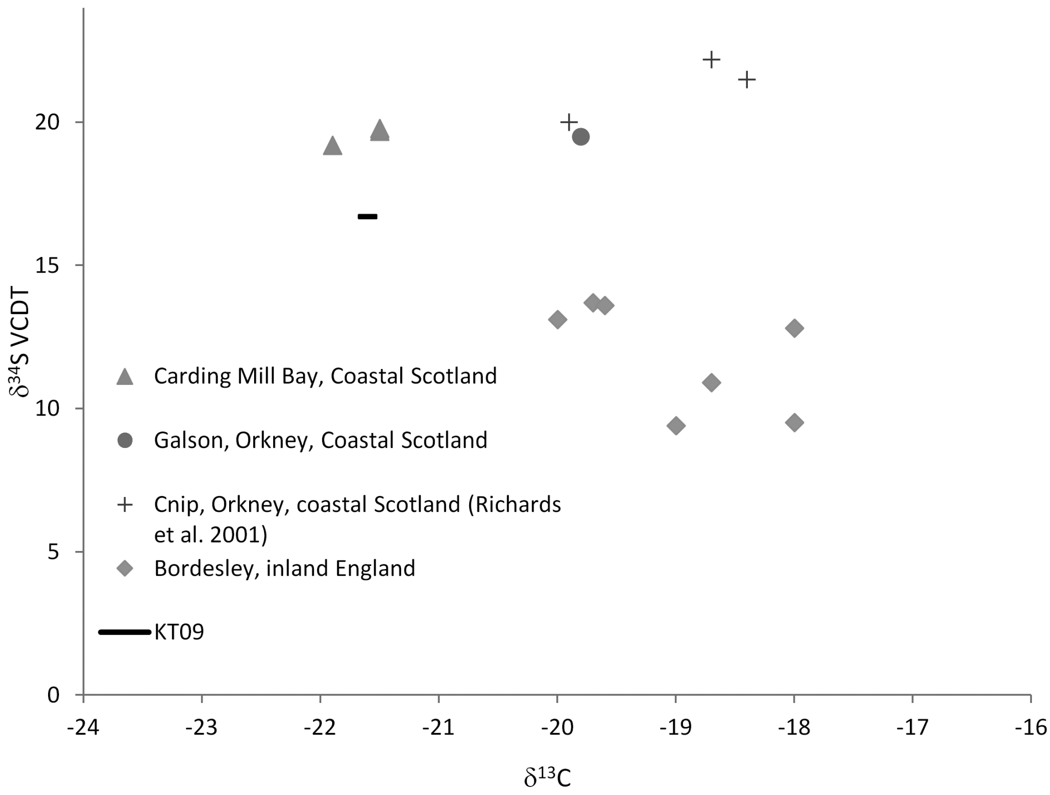
Theoretically, modern bone has a sulphur content of 0.18%. Privat et al (2007) suggest caution if the percentage of sulphur in collagen is greater than 0.6%, which suggests the presence of contaminants. This sample has a percentage of sulphur close to 0.18% and thus appears well preserved. Although still not fully established, it has been suggested that atomic N/S ratios can be used to assess sulphur in collagen quality in the same way C/N ratios

Table 4 Sulphur data for the Knappach Toll individual

Identifier 1	$\delta^{34}S$ VCDT	1 SD	n	% S	Amt% N	Amt% C	Amt% S	at C/N	at C/S	at N/S
KT09-SK1	16.7	0.13	2	0.21	14.9	43.6	0.21	3.4	563	165

are used for C and N analysis. If the atomic N/S ratio is outside the range of modern bone, caution should also be used (modern bone N/S ranges from 61–211 (Privat et al 2007)). The N/S ratio of this sample is 165 and thus well within modern range (Table 4).

The Knappach Toll individual has a relatively high $\delta^{34}S$ value (16.7‰), intermediate between UK coastal and inland archaeological values when compared to data presented in Richards et al (2001) (Illus 11). The $\delta^{13}C$ value (–21.6±0.15‰) and $\delta^{15}N$ value (10.1±0.1) suggest a largely terrestrially based protein diet with possibly some freshwater fish input.



Illus 11 Sulphur data for the Knappach Toll individual (KT09) compared to other UK archaeological data (Richards et al 2001). © Northlight Heritage