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Migration and Viking Dublin: paleomobility and paleodiet through isotopic analyses

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ABSTRACT

During the early medieval period in Ireland, Dublin was established as the largest Viking settlement on the island in the ninth century AD. A previous biodistance study has suggested that the population of the town consisted of a polyethnic amalgam of immigrant and indigenous. In this study, we use biogeochemistry to investigate paleomobility and paleodiet in archeological human remains from the ninth to eleventh century levels at the sites at Fishamble Street II (National Museum of Ireland excavation number E172), Fishamble Street III (E190) and John's Lane (E173), as well as twelfth-century remains from Wood Quay (E132). Through radiogenic strontium isotope, stable oxygen, carbon, and nitrogen isotope, and elemental concentration analyses, we investigate the origins of the individuals who lived and died in early and late Viking Dublin. Mean archaeological human enamel and bone isotope values from Dublin are $^{87}Sr/^{86}Sr = 0.70975 \pm 0.00139$ (2σ, $n = 22$), $\delta^{13}C_{carbonate(V\text{-}PDB)} = -14.8‰ \pm 0.8‰$ (1σ, $n = 12$), and $\delta^{18}O_{carbonate(V\text{-}PDB)} = -7.2‰ \pm 1.0‰$ (1σ, $n = 12$). Archaeological human bone samples exhibit mean $\delta^{13}C_{collagen(V\text{-}PDB)} = -20.8‰ \pm 0.5‰$ (1σ, $n = 12$) and mean $\delta^{15}N_{collagen(AIR)} = +10.0‰ \pm 1.7‰$ (1σ, $n = 12$). Comparing these data with archaeological faunal data from Dublin and published data from northern Europe, we argue that there are no clear immigrants from other parts of the North Atlantic, although there is one clear outlier in both origins and diet. Overall, the relative homogeneity in both paleomobility and paleodiet may support models of acculturation in Viking Dublin, rather than a high number of first-generation immigrants or continued migration from Scandinavia.

1. Introduction

Viking expansion began at the end of the eighth century AD and resulted in the establishment of Scandinavian settlements in northwestern Europe and beyond. In Ireland, Dublin was established in the ninth century AD and became the largest and most powerful Viking settlement on the island. The early medieval core of Viking Dublin has been extensively excavated, and has produced a wealth of information regarding the nature of the early settlement and the daily life of its inhabitants between the ninth and thirteenth centuries. Material culture studies suggest considerable acculturation between colonial and native groups (Fanning, 1994; Hurley, 2010; Hurley et al., 1997; Lang, 1988; Wallace, 1992a,b). This model of interaction has been supported by a bioarcheological biodistance analysis (O'Donnabhain and Hallgrímsson, 2001), which suggested that the town was ethnically mixed with a significant representation of the indigenous population. Despite the evidence for acculturation and admixture, the town of Dublin maintained a distinctive identity from that of its immediate neighbors until its conquest by King Henry II of England in 1170 (Downham, 2007; O'Donnabhain and Hallgrímsson, 2001). Here, we use biogeochemistry to investigate paleomobility and paleodiet in archaeological human remains excavated from four sites from ninth through twelfth century levels in Viking Dublin. More specifically, we include archeological human remains from the ninth to eleventh century levels at the sites of Fishamble Street II (National Museum of Ireland excavation number E172), Fishamble Street III (E190) and John's Lane (E173), as well as twelfth-century remains from Wood Quay (E132). Through radiogenic strontium isotope, stable oxygen, carbon, and nitrogen isotope, and elemental concentration analyses, we investigate the geographic origins and dietary practices of the individuals who lived and died in Dublin through the Viking period.

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We first briefly introduce the use of biogeochemistry to investigate paleomobility and paleodiet. We then discuss expected radiogenic strontium and stable oxygen, carbon and nitrogen values in northern Europe and in the individuals analyzed here, based on published data. We follow these sections with a presentation of our materials, methods, and biogeochemical data from archeological human and faunal remains from Viking Dublin. We conclude with our interpretations of these data.

2. Paleomobility and paleodiet through biogeochemistry

Paleomobility is increasingly measured through isotopic values in archeological human remains. Briefly, radiogenic strontium isotope values ($^{87}Sr/^{86}Sr$) vary based on bedrock age and composition (Dickin, 1997; Faure, 1986). Radiogenic strontium isotopes do not fractionate appreciably in an ecosystem, so that the radiogenic strontium isotope signature in bedrock, soils, and plants will be reflected in the animals and humans that consume strontium from those sources (Bentley, 2006). If an individual consumed and imbibed locally procured strontium, enamel and bone radiogenic strontium isotope values can be used to reconstruct paleomobility (Ericson, 1985; Price et al., 1994a,b). In contrast, oxygen isotope signatures in water sources vary according to environmental factors including the oxygen isotope values in the source area, altitude, latitude, number of precipitation events, and temperature (Bowen and Wilkinson, 2002; Craig, 1961a; Gonfiantini, et al., 2001; Longinelli, 1984; Luz and Kolodny, 1985; Luz et al., 1984). Despite complexities in the movement and treatment of water sources in the past (Knudson, 2009), oxygen isotope analysis can also identify paleomobility (Evans et al., 2006a; White, et al., 2000).

Paleodietary studies using light stable isotopes of carbon utilize the fact that some plants, including tropical grasses, fix carbon using a different photosynthetic pathway (the C_4 or Hatch–Slack pathway) than most other plants, which use the C_3 (Calvin) photosynthetic pathway (Calvin, 1962; Calvin and Benson, 1948; Hatch and Slack, 1966; Hatch et al., 1967; Kortshack et al., 1965; Ranson and Thomas, 1960). Paleodietary analysis of hydroxyapatite carbonate elucidates whole diet carbon sources while collagen largely reflect protein sources in the diet (Ambrose and Norr, 1993; Jim et al., 2004; Kellner and Schoeninger, 2007; Lee-Thorp et al., 1989, Lee-Thorp and van der Merwe, 1991). In addition, marine and terrestrial resources exhibit distinct carbon and nitrogen isotope values (Chisholm et al., 1982; Schoeninger and DeNiro, 1984). Although stable nitrogen isotope values vary according to trophic level and are particularly useful in identifying the use of marine resources (DeNiro and Epstein, 1981; Minagawa and Wada, 1984; Schoeninger and DeNiro, 1984; Schoeninger et al., 1983), we note that there are also climatic factors that affect nitrogen isotope values (Ambrose, 1991; Ambrose and DeNiro, 1987).

Finally, the concentrations of major, minor and trace elements have been used for paleodietary and paleomobility studies (Burton, 1996; Burton et al., 2003, Ezzo et al., 1995; Schoeninger, 1978, 1979; Schutkowski et al., 1999; Shaw et al., 2010). There are clear trophic level differences in barium and strontium concentrations when compared to calcium concentrations (Ba/Ca, Sr/Ca) (Blum et al., 2000; Burton et al., 1999; Elias, 1980; Price et al., 1985, Price et al., 1986). However, geographic variability and dietary sources can complicate the use of trace element concentrations in paleodietary studies (Burton and Price, 2000; Burton et al., 2003, Burton et al., 1999; Burton and Wright, 1995; Ezzo, 1994a,b). Here, we use major, minor and trace element data to evaluate diagenetic contamination and evaluate the presence of marine products in the diet through relative concentrations of barium and strontium (Ba/Sr) (Burton and Price, 1990).

3. Biogeochemical signatures in Northern Europe

3.1. Radiogenic strontium isotope signatures in Northern Europe

The geology of northern Europe contains a highly variable array of radiogenic strontium isotope ratios, although generally speaking some of the oldest rocks on the continent are in Norway, parts of Sweden and the northern parts of the United Kingdom and Ireland. Also in general terms, the oldest rocks and highest radiogenic strontium isotope values are to be found in the more northern parts of these areas (Voerkelius et al., 2010). For example, Scotland, the Northern Isles, and parts of County Antrim in Ireland have varying but generally high $^{87}Sr/^{86}Sr$ values (Voerkelius et al., 2010). Here, we focus on bedrock geology and radiogenic strontium isotope data, when available, from Ireland, the United Kingdom, and parts of Scandinavia, as discussed below, with additional sites included in Fig. 1 (Bendrey et al., 2009; Bentley et al., 2002; Budd et al., 2003; Chenery et al., 2010; Darbyshire and Shepherd, 1985; Gallet et al., 1998; Leach et al., 2010, Leach et al., 2009, Muldner et al., 2011; Negrel et al., 2003; Nehlich et al., 2009; Price et al., 2001; Sykes et al., 2006).

The geology of Ireland is complex and consists, at the base, of the remains of ancient mountain ranges with heavily folded crystalline and metamorphic rocks. These rock formations are exposed as the hills and mountains of the north and the west of the island. These rocks, particularly in the north, are of substantial age and likely have quite high radiogenic strontium isotope ratios. Tertiary basalts in northeast Ireland, on the other hand, are relatively young and low in rubidium and exhibit radiogenic strontium isotope values between $^{87}Sr/^{86}Sr = 0.704$ and $^{87}Sr/^{86}Sr = 0.707$ (O'Connor, 1988; Wallace et al., 1994). Limestone deposits are found in limited areas, largely in the west and southwest of Ireland; these marine sediments will have radiogenic strontium isotope values closer to modern seawater, in which $^{87}Sr/^{86}Sr = 0.709$ (Burke et al., 1982; McArthur et al., 2001; Veizer, 1989). The bedrock under Dublin consists primarily of marine basinal facies and argillaceous and cherty limestone and shale that formed during the late Paleozoic (Geological Survey of Ireland, 2009). However, much of the solid geology of the island is buried under glacial moraine that was deposited during the Pleistocene when the ice sheets covered most or all of Ireland (McCabe, 2007). Some of the glaciated lowlands of Ireland have moraine deposits over 30 m thick and form a landscape independent of the rock formations buried deeply beneath the ground (Clayton, 1963; Geikie, 1910). The material in the glacial moraine likely originated in part from the rocky structures of Ireland as the ice passed over the land surface and in part as detritus from the sea floor and Scandinavia was transported by the ice. Thus, the bedrock geology of much of Ireland, including the Dublin region, is not a good guide to bioavailable radiogenic strontium isotope ratios.

Radiogenic strontium isotope values in England and Scotland in the United Kingdom are better understood (see overviews in Evans et al., 2010; Montgomery et al., 2005, Montgomery et al., 2006). In the United Kingdom, soil leachate values suggest labile $^{87}Sr/^{86}Sr$ variations among soils overlying sedimentary rocks from approximately $^{87}Sr/^{86}Sr = 0.7073$ on Cretaceous chalk to $^{87}Sr/^{86}Sr = 0.7115$ on Triassic sandstone (Budd et al., 2000). Soils formed on igneous and metamorphic rocks as well as rubidium-rich clay soils are likely to have far higher strontium isotope ratios. Finally, Evans et al. (2010) provide bioavailable strontium isotope data from modern plants across the United Kingdom that show a general trend toward values between $^{87}Sr/^{86}Sr = 0.707–0.712$ in the south and east, $^{87}Sr/^{86}Sr = 0.711–0.713$ in the west, and $^{87}Sr/^{86}Sr = 0.712–0.720$ in the north.

Based on bedrock geology, England is dominated by Cretaceous chalks in the south and east and Jurassic clays in the west and north